

Ontario Provincial Standards for Roads and Public Works



- Volume 6 -

PROVINCIAL-ORIENTED

MATERIAL SPECIFICATIONS



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MANUAL REVISION RECORD

Provincial-Oriented

Volume 6 – Material Specifications

This record should remain in the manual at all times. Revisions are numbered sequentially. This sheet should be filled in after each revision has been placed into the manual. It will quickly indicate to users whether the contents of the manual are up-to-date.

REVISION NUMBER	REVISION DATE	ENTERED BY	REVISION NUMBER	DATE	ENTERED BY
1	Apr 2010	Included in new manuals	26		
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MATERIAL SPECIFICATION FOR AGGREGATES - GENERAL

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1001.01	SCOPE

This specification covers the source, processing, and testing requirements for aggregates and provides for the use of reclaimed asphalt pavement and reclaimed concrete material.

1001.02	REFERENCES

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-602	Sieve Analysis of Aggregates
LS-609	Petrographic Analysis of Coarse Aggregate
LS-616	Petrographic Analysis of Fine Aggregate

Assessment of Potential for Acid Rock Drainage in Highway Construction, Materials Engineering and Research (MERO) Report (Unpublished), Smith, S.J., Rogers, C.A and Senior, S.A., March 2007 (See Note 1)

Note 1: Some of the applicable sections within this report may be obtained upon request from the Head of the Soils and Aggregates Section, Materials Engineering and Research Office, MTO, at the following address:

Room 220,
145 Sir William Hearst Avenue,
Toronto, Ontario
M3M-0B6
Telephone: 416-235-3734

Canadian General Standards Board

8.1-88 Sieves, Testing, Woven Wire, Inch Series

ASTM International

D 5744 Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell from SAI Global
E 11 - 09e1 Woven Wire Test Sieve Cloth and Test Sieves

Others

ADTI-WP2 Leaching Column Method for Overburden Analysis and Prediction of Weather Rates, Hornberger, Roger J., et al., 2004.

DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, British Columbia Ministry of Employment and Investment, Energy and Minerals Division; Smithers, BC; Price, W.A., April 1997

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Toxicity Characteristic Leaching Procedure, Method 1311; United States Environmental Protection Agency, Publication SW-846, July 1992

1001.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Aggregate means natural mineral materials such as sand, gravel, and crushed bedrock. Reclaimed materials may substitute for aggregates when allowed by the appropriate specification.

Boulder means a detached rock mass with a diameter greater than 200 mm.

Clay means a fine-grained soil with particles smaller than 2 µm that exhibit plasticity over a range of water contents.

Coarse Aggregate means that portion of aggregate material retained on the 4.75 mm sieve when tested according to LS-602.

Cobble means a rounded or semi-rounded rock fragment with an average dimension between 75 mm and 200 mm.

Crushed Material means aggregate particles having at least one well-defined face resulting from fracture. Particles with smooth faces and rounded edges or with only small chips removed are not considered crushed.

Deleterious Material means materials that include, but not limited to, the following: wood, clay brick, clay tile, plastic, gypsum, gypsum plaster, wallboard, roots, and all other organic matter.

Fine Aggregate means that portion of aggregate passing the 4.75 mm sieve when tested according to LS-602.

Flat and Elongated Particles means aggregate particles whose greatest mean dimension in the longitudinal axis compared to the least mean dimension in a plane perpendicular to the longitudinal axis exceeds a ratio of 4:1.

Granular means any processed or natural aggregate material with less than 35% by mass passing the 75 µm sieve.

Gravel means rounded, water-worn rock fragments retained on the 4.75 mm sieve and passing through the 75 mm sieve.

Iron Blast-Furnace Slag means the material resulting from solidification of molten blast-furnace slag under atmospheric conditions. Subsequent cooling may be accelerated by application of water to the solidified surface.

Manufactured Sand means sand produced by the crushing and further processing, i.e., washing, grading, classifying of quarried rock, boulders, cobbles, or gravel from which the natural fine aggregate has been removed. Natural sand may be added to optimize properties.

Mine By-Product Rock means rock which is removed during an ore mining process and has not been subjected to any sort of chemical processing.

Natural Sand means naturally formed sand found in unconsolidated deposits.

Nickel Slag means the non-metallic product resulting from the production of nickel.

Quarried Rock means the material that has been or is being removed from an open excavation made in a solid mass of rock, which was integral with the parent mass prior to removal.

Reclaimed Asphalt Pavement (RAP) means the processed hot mix asphalt material that is recovered by partial or full depth removal.

Reclaimed Concrete Material (RCM) means removed or processed hardened Portland cement concrete.

Sand means fine aggregate passing the 4.75 mm sieve and retained on a 75 µm sieve resulting from natural disintegration of rock or from crushing.

Screened Sand means natural sand obtained from gravel deposits that is screened only.

Screenings means the fine aggregate produced by the crushing of quarried rock, boulders, cobbles, or gravel.

1001.04 DESIGN AND SUBMISSION REQUIREMENTS

1001.04.01 Submission Requirements

The Contract Administrator shall be advised in writing of each intended aggregate source, prior to its use in the Work.

The Contractor shall provide all test results, either individual or mean values, which demonstrate conformance of the material with the requirements of the appropriate specification.

Test results shall be made available at the Contract Administrator's request.

1001.04.02 Report for Aggregates Produced from Mine By-Product Rock

If an aggregate produced from mine by-product rock is being proposed for use, then, at least 20 Business Days prior to its intended use, a written report, henceforth referred to as the Mine By-Product Rock Aggregate Assessment Report (MRAAR), signed by an Engineer or a licensed Professional Geoscientist (P.Geo.), shall be submitted to the Contract Administrator.

Prior to beginning the Work, the Engineer or licensed Professional Geoscientist (P.Geo.), described above, shall submit sufficient relevant qualifications and past project experience in Acid Base Accounting, NAG testing, metal leachate testing, physical property and any other related testing and analysis, acceptable to the Owner.

The report shall include, but not be limited to, the following:

- a) Petrographic test results according to LS-609, Part A and LS-616, Part A carried out by a licensed Professional Geoscientist (P.Geo.). When sulphur minerals or non-iron bearing sulphides are found, sulphur mineral speciation and associated reactivity shall be determined using X-Ray Diffraction and/or Scanning Electron Microscopy.
- b) An Acid Rock Drainage (ARD) investigation, carried out by a licensed Professional Geoscientist (P.Geo.) including, but not limited to, the following:
 - i. Acid Base Accounting and Net Acid-Generating (NAG) tests. If either the neutralization potential ratio or the NAG tests indicate that the tested material is respectively not shown to be "Non-Acid Generating" or "Non-Acid Forming" according to the "DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia", then kinetic testing shall also be carried out using either humidity cells according to ASTM D5744 or columns according to ADTI-WP2 Leaching Column Method for Overburden Analysis and Prediction of Weather Rates.
 - ii. pH testing and any other chemical analyses considered necessary by the licensed Professional Geoscientist (P.Geo.).
 - iii. An assessment of all the test results and an identification of any potential impacts of the use of acid-generating materials on surface and groundwater, any proximate aquatic ecosystems as well as any other environmentally sensitive areas. When potential impacts are found, recommendations to eliminate or reduce those impacts to acceptable levels including an acceptable monitoring plan shall be included in the assessment.
- c) Metal leachate testing using Shake Flash Extraction, as described in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Toxicity Characteristic Leaching Procedure" or any other method acceptable to the Owner;
- d) An assessment of the suitability of the aggregate for its intended use, by assuring that the aggregate:
 - i. meets all applicable safety regulations, guidelines and procedures;
 - ii. meets all applicable environmental regulations, guidelines and procedures and will not cause any adverse environmental effects;
 - iii. meets all current physical and production property requirements required for that aggregate;
 - iv. does not cause undue discolouration of the pavement or structure in which the aggregates will be used; and

- v. otherwise provides long term field performance at least as well as any other aggregates that are currently acceptable for the same application.
- e) Specified minimum sampling & testing rates, the location where the samples shall be taken and the recommended tests to be carried out, as well as any special recommendations outlining the handling and placement of aggregates produced from mine by-product rock during construction to ensure that all of the requirements specified in the Contract Documents will continue to be met during the Contract.

The sampling, testing and analyses required for parts a) to d) of the MRAAR shall be based on a minimum of 3 or 8 samples for up to 10,000 or 100,000 tonnes respectively, of crushed mine by-product rock that is intended for use on the Contract. All samples used for testing and assessment purposes required for parts a) to d) shall be obtained from stockpiles of at least 1000 tonnes of the crushed mine by-product rock which is intended for use in the Work. The details regarding the sampling and testing carried during construction shall be as specified in the MRAAR, according to part e) listed above.

In any case, the sampling & testing rates and the types of tests specified above in parts a) to d) for the preparation of the MRAAR and in part e) to be conducted during construction, shall only be considered minimums and the actual amount of sampling, testing and types of tests carried out anytime during the Contract will depend on the variability of the source, the Contractor's ability to control that variability as well as any other relevant recommendations that the MRAAR provides.

In addition to the sampling and testing already described and as specified elsewhere in the Contract Documents, the Owner may require additional sampling and testing during construction. Such sampling and testing shall be carried out at no additional cost to the Owner. If, however, the Owner deems that sufficient testing is being done to adequately monitor changes within the aggregate source during construction, according to the recommendations given in the MRAAR, then the Owner shall be responsible for the costs of that additional testing.

All testing carried out for the preparation of the MRAAR as well as during construction shall be conducted by laboratories that are acceptable to the Owner.

Within 15 Business Days after submission of the MRAAR, the Contractor shall be notified as to whether the mine by-product rock is acceptable for use.

In addition to the MRAAR and within 20 Business Days of using aggregate produced from mine by-product rock, an Aggregate Management Plan shall also be submitted to the Contract Administrator detailing how the Contractor intends to ensure that the aggregates that are produced will continue to remain acceptable during aggregate production for the contract.

1001.05 MATERIALS

1001.05.01 Aggregates

1001.05.01.01 General

Aggregates shall be composed of hard, durable fragments that are clean and free of clay coatings and other deleterious material.

1001.05.01.02 Fine Aggregates

Fine aggregates shall be according to the appropriate specifications and, unless otherwise provided therein, shall be one or a blend of the following:

- a) Natural sand.
- b) Manufactured sand.
- c) Screenings produced during crushing.
- d) Iron blast furnace slag or nickel slag.
- e) Reclaimed asphalt pavement.
- f) Reclaimed concrete material.

1001.05.01.03 Coarse Aggregates

Coarse aggregates shall be according to the appropriate specifications and, unless otherwise provided therein, shall be one or a blend of the following:

- a) Crushed particles of consistent quality throughout produced from bedrock formations or boulders.
- b) Uncrushed material of consistent quality produced from gravel formations.
- c) Iron blast furnace slag or nickel slag.
- d) Reclaimed asphalt pavement.
- e) Reclaimed concrete material.

1001.07 PRODUCTION

1001.07.01 Stripping of Aggregate Source

Prior to excavating materials for aggregate production, the area to be worked shall be cleared of shrubs and trees, grubbed of roots, and stripped of all unsuitable surface materials and weathered zones. The area open ahead of the quarrying or excavating operation shall be of sufficient size to prevent contamination of the aggregate source working face.

1001.07.02 Processing

1001.07.02.01 General

When necessary to conform to the type of materials specified, aggregates shall be screened, crushed, washed, classified, or otherwise processed with suitable equipment to meet specification requirements.

Washed materials or materials excavated from underwater shall be stored for at least a 24 hours or longer period to allow all free water to drain and for the materials to attain uniform water content.

1001.07.02.02 Washing

When specified in the Contract Documents, aggregates shall be washed in washing plants, or otherwise processed to meet specification requirements. Truck or mixer washing and other similar methods shall not be permitted.

Water used for washing aggregates shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

1001.07.02.03 Blending

Blending of aggregates including reclaimed materials that meet the physical requirements of the appropriate specification shall be permitted in order to satisfy the gradation requirements for the material to be provided. The blending shall produce a consistent and acceptable product. Except where noted elsewhere in the Contract Documents, blending to improve the physical requirements shall not be permitted, except to increase the percentage of crushed particles or decrease the percentage of flat and elongated particles.

1001.07.03 Handling and Transporting

At all times, aggregates shall be handled and transported in a manner and with equipment that avoids segregation of the material, excess loss of fines, and contamination by any deleterious material.

1001.07.04 Stockpiling

Stockpile sites shall be level, well drained, free of all foreign materials, and of adequate bearing capacity to support the mass of the materials to be placed thereon. Stockpiles shall be either far enough apart or separated by substantial dividers to prevent intermingling.

For all coarse aggregates, except when stockpiled on Portland cement concrete or asphaltic concrete foundations or on an uncontaminated durable surface, a compacted granular pad of material with a maximum particle size no larger than that of the material being stockpiled and not less than 0.3 m in depth shall be provided to prevent contamination of the piled material.

For fine or combined aggregate stockpiles, the foundation shall be as specified above for coarse aggregates or the material may be placed on the ground provided that the bottom 0.3 m of the pile is not incorporated into the Work.

When samples are obtained for acceptance purposes from stockpiles of combined fine and coarse aggregate material for gradation testing, the stockpile shall be constructed in layers not exceeding 1 m in depth, and spilling of material over the edge of the stockpile shall not be permitted. These stockpile construction requirements shall not apply to separate stockpiles of fine and coarse aggregates and shall not apply to stockpiles of combined fine and coarse aggregate when the gradation acceptance samples are obtained after the material has been removed from the stockpile.

1001.08 QUALITY ASSURANCE

1001.08.01 General

Irrespective of compliance or non-compliance with the gradation and physical requirements of the applicable specification, aggregates may be accepted or rejected on the basis of past field performance, as determined by the Owner.

When a change in the character of the material occurs or when the performance of the materials is found to be unsatisfactory, use of those materials shall be discontinued until the Contractor can prove to the satisfaction of the Contract Administrator that the source remains acceptable or can be made acceptable.

1001.08.02 Sampling

1001.08.02.01 General

Quality assurance samples shall be obtained, handled, and stored as specified in the Contract Documents. The Contract Administrator shall be allowed to access all sampling locations and reserves the right to request quality assurance samples at any time.

1001.08.02.02 Mix Design

Samples obtained by the Contractor for the purposes of mix design shall be representative of the materials to be placed in the Work.

1001.08.03 Testing

1001.08.03.01 General

Tests on aggregates shall be as specified in the Contract Documents. The most recent published test method shall be used.

1001.08.03.02 Testing Sieves

Gradation analysis shall be based on the designated sieves shown in Table 1. As indicated, sieves complying with the alternative shown are compatible and may be used interchangeably with the MTO sieve designation shown.

TABLE 1
Laboratory Testing Sieves

MTO Sieve Designation	Alternate Sieve Standards, CAN/CGSB 8.1 and ASTM E 11
150 mm	6 inch
106 mm	4.24 inch
75.0 mm	3 inch
63.0 mm	2-1/2 inch
53.0 mm	2.12 inch
37.5 mm	1-1/2 inch
26.5 mm	1.06 inch
25.0 mm	1 inch
22.4 mm	7/8 inch
19.0 mm	3/4 inch
16.0 mm	5/8 inch
13.2 mm	0.530 inch
12.5 mm	1/2 inch
9.5 mm	3/8 inch
6.7 mm	0.265 inch
4.75 mm	No. 4
2.36 mm	No. 8
1.18 mm	No. 16
600 µm	No. 30
425 µm	No. 40
300 µm	No. 50
150 µm	No. 100
75 µm	No. 200



MATERIAL SPECIFICATION FOR AGGREGATES - CONCRETE

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1002.09	OWNER PURCHASE OF MATERIAL - Not used

1002.01 SCOPE

This specification covers material requirements for aggregates for use in hydraulic cement concrete.

1002.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1001 Aggregates - General

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

- LS-412 Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals
- LS-601 Material Finer than 75µm Sieve in Mineral Aggregates by Washing
- LS-602 Sieve Analysis of Aggregates
- LS-604 Relative Density and Absorption of Coarse Aggregate

LS-606	Soundness of Aggregate by Use of Magnesium Sulphate
LS-608	Percent Flat and Elongated Particles in Coarse Aggregate
LS-609	Petrographic Analysis of Coarse Aggregate
LS-610	Organic Impurities in Sands for Concrete
LS-613	Determination of Insoluble Residue of Carbonate Aggregates
LS-614	Freezing and Thawing of Coarse Aggregate
LS-615	Determination of Potential Alkali-Carbonate Reactivity of Carbonate Rocks By Chemical Composition
LS-618	Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-619	Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-620	Accelerated Detection of Potentially Deleterious Alkali-Silica Reactive Aggregate by Expansion of Mortar Bars
LS-625	Guidelines for Sampling of Granular Materials

MTO Aggregate Sources Lists (ASL):

Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates

Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates

MTO Forms:

PH-D-10 Aggregate Sample Data Sheet

CSA Standards

A23.2-1A	Sampling Aggregates for Use in Concrete *
A23.2-12A	Relative Density and Absorption of Coarse Aggregate *
A23.2-14A	Potential Expansivity of Aggregates; Procedure for Length Change Due to Alkali-Aggregate Reaction in Concrete Prisms *
A23.2-23A	Method of Test for the Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus *
A23.2-24A	Method of Test for Resistance of Unconfined Coarse Aggregate to Freezing and Thawing
A23.2-25A	Test Method for Detection of Alkali-Silica Reactive Aggregate by Accelerated Expansion of Mortar Bars *
A23.2-26A	Determination of Potential Alkali-Carbonate Reactivity of Quarried Carbonate Rocks by Chemical Composition *
A23.2-27A	Standard Practice to Identify Potential for Alkali-Reactivity of Aggregates and Measures to Avoid Deleterious Expansion in Concrete *
A23.2-29A	Method of Test for the Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus *

* [Part of A23.1-09/A23.2-09 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

ASTM International

C 87/C 87M-10	Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
C 330/C 330M-14	Lightweight Aggregates for Structural Concrete
C 666/C 666M-15	Resistance of Concrete to Rapid Freezing and Thawing

1002.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Alkali-Aggregate Reaction (AAR) means a chemical reaction that occurs in concrete between alkalis in the cement (e.g., sodium and potassium) and minerals in the aggregate. This reaction may cause deleterious expansion and cracking of the concrete. AAR includes alkali-carbonate and alkali-silica reactions.

Air-Cooled Blast Furnace Slag means the material resulting from solidification of molten blast furnace slag under atmospheric conditions. Subsequent cooling may be accelerated by application of water to the solidified surface.

Bench means a ledge parallel to stratigraphic bedding that, in quarries, forms a single level of operation above which rock is excavated from a contiguous face.

Duplicate QA Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Manufactured Sand means fine aggregate produced by crushing bedrock or containing crusher screenings.

Mineral Filler means a finely pulverized, inert, inorganic mineral or rock (e.g., limestone powder) having physical and mineralogical properties suitable for use in concrete.

Nominal Maximum Aggregate Size means the largest sieve listed in the applicable specification upon which any material is permitted to be retained.

Physical Property means an inherent attribute or feature of an aggregate material. Tests are carried out to determine a material's resistance to weathering or degradation or both. Physical properties are generally not affected by aggregate production processes.

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that Materials received from the Contractor meet the requirements specified in the Contract Documents.

Self-Consolidating Concrete means a highly flowable, yet stable concrete that can spread readily into place, fill formwork, and encapsulate the reinforcement without any mechanical consolidation and without undergoing segregation or excessive bleeding.

Siliceous Aggregates means rock particles containing or composed of silica (SiO_2) or minerals with silica in the crystal structure as silicate (SiO_4).

1002.05 MATERIALS

1002.05.01 General

Aggregates shall be according to OPSS 1001. Aggregates shall be according to this specification when tested according to the MTO, CSA, and ASTM test methods identified herein.

Except as noted below or elsewhere in the Contract Documents, aggregates may be sands, gravel, quarried rock, or air-cooled blast furnace slag; provided the source is of such nature and extent to ensure acceptable processed aggregates of a consistent grading and quality. When any change in the character of the aggregate occurs or when the performance of aggregate meeting the requirements of this specification is found to be unsatisfactory, use of the aggregate shall be discontinued until a reappraisal by the Contractor, with the approval of the Contract Administrator, proves the source to be satisfactory.

Steel slag is prohibited for use as aggregate in hydraulic cement concrete. Air-cooled blast furnace slag is prohibited for use as aggregate in concrete pavements.

Irrespective of compliance with all of the physical property requirements stated in this specification, at the discretion of the Owner, aggregates may be accepted or rejected for use based on demonstrated past field performance in hydraulic cement concrete.

The field performance of a concrete structure or pavement using aggregates, accepted on the basis of demonstrated past field performance, shall be evaluated according to CSA A23.2-27A, Attachment A2, Guidelines for Evaluating the Field Performance of Aggregates: Field and Laboratory Testing, with the exception that the structure or pavement shall be at least 15 years old. In addition, the concrete being evaluated to determine the field performance of an aggregate shall:

- a) Have been used for equivalent or more severe applications;
- b) Have been subjected to equivalent or more severe exposure conditions;
- c) Not contain supplementary cementing materials that may have mitigated or improved things like freeze/thaw performance, scaling resistance or alkali-aggregate reactivity of aggregates in concrete, and;
- d) Contain the equivalent cement and alkali content, as the laboratory tests stated in this specification for the evaluation of alkali-aggregate reactivity.

The Owner may reject the use of any concrete aggregate on the basis of past field performance in any structure or pavement of any age.

1002.05.02 Fine Aggregate

1002.05.02.01 General

Fine aggregates used in concrete pavement surfaces and exposed concrete bridge deck driving surfaces shall have a minimum insoluble residue (IR_{R75}) of 60%. Where a fine aggregate proposed for use does not meet this requirement, one or more fine aggregates from an alternate source may be blended with the proposed aggregate to meet this requirement.

1002.05.02.02 Grading Requirements

Unless the Contract Administrator has agreed to allow a special grading, fine aggregates shall meet the requirements shown in Table 2. The fineness modulus for any sample shall not vary by more than 0.20 from the sample upon which initial acceptance was based.

1002.05.02.03 Mineral Filler

Mineral fillers shall be limited to use in self-consolidating concrete. When mineral fillers are added to the mix, they shall be inert, non-plastic, free of clay, and added as a separate ingredient to the mix.

1002.05.02.04 Physical Property Requirements

The fine aggregate shall meet the physical property requirements specified in Table 3.

1002.05.03 Coarse Aggregate

1002.05.03.01 Grading Requirements

1002.05.03.01.01 General

Coarse aggregate grading requirements shown in Tables 4 and 5 represent the upper and lower limits allowed.

1002.05.03.01.02 Concrete Structures, Sidewalks, Curb and Gutter

The nominal maximum aggregate size shall be 19.0 mm, unless specified elsewhere in the Contract Documents. Grading of the coarse aggregate shall meet the requirements shown in Table 4. Stockpiling aggregates in individual size fractions and blending them to meet the grading requirements, shown in Table 4, shall be permitted.

1002.05.03.01.03 Concrete Pavement and Concrete Base

The grading bands for the individual coarse aggregate components used in concrete pavement and concrete base are shown in the first two columns of Table 5, for information purposes only. Aggregates shall be stockpiled as individual size fractions and blended in the mix. The blended aggregates shall meet the combined grading requirements specified in the last column of Table 5.

1002.05.03.01.04 Concrete Patches, Refacing, and Overlays

The nominal maximum aggregate size shall be 13.2 mm for concrete patches, refacing, and overlays 100 mm or less in thickness. When the thickness of the repair exceeds 100 mm, the nominal maximum aggregate size shall be 19 mm. Grading of the coarse aggregate shall be within the limits shown in Table 4.

1002.05.03.02 Physical Property Requirements

The coarse aggregate shall meet the physical property requirements specified in Table 6.

1002.05.03.02.01 Scaling Resistance

Coarse aggregate composed of at least 80% siliceous aggregates as determined by LS-609, shall be tested in a salt scaling test according to LS-412 together with either the fine aggregate that the coarse aggregate is intended to be used with, or a fine aggregate from the same geographic area as the coarse aggregate.

For the purposes of this specification, the concrete for LS-412 shall be proportioned with 355 kg/m³ of Type GU hydraulic cement and shall have a plastic air content of $7.0 \pm 1.5\%$ and a slump of 80 ± 20 mm.

Testing shall be performed, according to LS-412, on the finished surface of the slabs and the maximum permitted loss shall be as specified in Table 6. Such testing shall not be performed on formed surfaces.

Testing shall be done prior to the first use of an aggregate from a pit or quarry in concrete.

For quarries, the bench from which the aggregate is selected for testing shall be identified and approval of the aggregate shall only apply to the bench from which the aggregate was tested. Aggregate processed from other benches within the same quarry shall also require the same testing prior to use.

Once an aggregate has been approved for use in concrete, the test results shall remain valid for that use, as long as the aggregate is still being extracted from the same bench and/or geological formation within the quarry.

For a pit or quarry, and at the discretion of the Owner, the approval shall remain valid provided that the aggregate is still representative of the original aggregate that was tested and approved.

In addition, once a pit source, and for quarries a bench/formation and lithology, is listed on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates or the Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates and, at the discretion of the Owner, the same aggregate type being respectively produced from the same pit

source or bench/formation and lithology from the same quarry, have not changed, then the need for further testing according to LS-412, shall be waived by the Owner.

Irrespective of the waiving of these requirements, the warranty provisions of the Contract Documents shall apply.

However, if in the opinion of the Owner the extraction conditions within a pit or quarry have changed significantly so that the original test results are no longer representative of the same aggregate type currently being produced, then at the Owner's discretion, LS-412, shall be repeated for that aggregate.

1002.05.03.02.02 D-Line Cracking

Coarse aggregate from pit sources or from carbonate (e.g. limestone and dolostone) bedrock quarries used for concrete pavement and concrete base, except for aggregate produced from the Oxford, Gull River, or Bobcaygeon Formations, shall be tested for resistance to freezing and thawing according to ASTM C 666/C 666M Procedure A.

For the purposes of this specification, ASTM C 666/C 666M shall be conducted using the following parameters:

- a) The concrete for the test shall be proportioned to the combined grading shown in Table 5, with 325 kg/m³ of Type GU hydraulic cement, a plastic air content of $6.5 \pm 1.5\%$, and a slump of 50 ± 20 mm.
- b) The fine aggregate shall be that which is intended for use with the coarse aggregate or a fine aggregate from the same geographic area as the coarse aggregate.
- c) A minimum of three beams shall be tested.
- d) Procedure A shall be modified so that each freeze cycle takes 10.5 ± 1 hour.
- e) The test shall be conducted for 350 cycles.

The average change in length of the beams tested shall be no more than $\pm 0.0350\%$. The average fundamental transverse frequency (FTF) shall not be less than 90% of the FTF at an age of 14 Days.

Testing, according to ASTM C 666/C 666M Procedure A and as modified above, shall be done prior to the first use of an aggregate from a pit or quarry source in concrete pavement or concrete base.

For quarries, the bench from which the aggregate is selected for testing shall be identified. Approval of the aggregate shall only apply to the identified bench from which the aggregate was tested. Aggregate processed from any other benches within the same quarry shall also require the same testing prior to use. Once an aggregate has been approved for use in concrete pavement or base, the test results shall remain valid for that use as long as the aggregate is still being extracted from the same bench and/or geological formation within the quarry.

For a pit or quarry and at the discretion of the Owner, the approval shall remain valid provided that, the aggregate is still representative of the original aggregate that was tested and approved.

In addition, once a pit source and, for quarries a bench/formation is listed on the current Ontario Ministry of Transportation Regional Concrete Aggregate Sources List for Concrete Base/Pavement Coarse Aggregate, the need for further testing according to ASTM C 666/C 666M Procedure A shall be waived by the Owner. Irrespective of the waiving of these requirements, the warranty provisions of the Contract Documents shall apply. However if, in the opinion of the Owner the extraction conditions within a pit or quarry have changed significantly so that the original test results are not representative of the aggregate currently being produced, then at the Owner's discretion, ASTM C 666/C 666M Procedure A, as modified above, shall be repeated for that aggregate.

1002.05.03.03 Lightweight Aggregate

Lightweight aggregate shall be according to ASTM C 330/C 330M.

1002.05.04 Deleterious Expansion Other than Alkali Aggregate Reaction

Aggregates that produce excessive expansion or cracking of concrete through reactions other than AAR shall not be used in concrete.

The combined coarse and fine aggregate used in a concrete mix shall a total of less than 0.001% by mass of lime (CaO) or periclase (MgO); a total of less than 1.0% by mass of gypsum, anhydrite or other sulphate minerals; no steel slag or glass; and based on chemical analysis such as combustion/infrared absorption using a Leco sulphur analyzer, a total of less than 1.0% by mass of sulphur.

1002.07 PRODUCTION

1002.07.01 Aggregate Processing, Handling, and Stockpiling

Processed aggregates shall be separated into fine and coarse aggregates and stockpiled separately. Aggregates separated during processing, aggregates secured from different sources, aggregates from the same source but of different gradings, or from a new bench in a quarry, or aggregates resulting from a significant change in production that affects physical quality shall be stockpiled separately.

For sampling and testing purposes, separate stockpiles of at least 1000 tonnes shall be provided for:

- a) The fine aggregate grading shown in Table 2 and for each different coarse aggregate grading shown in Tables 4 or 5 that will be used in the mix; and
- b) Each different aggregate component within the coarse and fine gradings referred to above, if one or more of the individual aggregate components are derived either from a different source location or from a different lithology within the same source location.

Where blended aggregates are allowed as specified in the General clause of the Fine Aggregate subsection then, one of the following shall also be provided:

- a) A single stockpile of at least 1000 tonnes of uniformly-blended fine aggregate that will be used in the mix; or
- b) The proportions of each fine aggregate component in the mix.

Where a blended coarse aggregate is used in the mix, then one of the following shall also be provided:

- a) A single stockpile of at least 1000 tonnes of uniformly-blended coarse aggregate that will be used in the mix; or
- b) The proportions of each individual aggregate component in the blended coarse aggregate that will be used in the mix.

For small quantities, such as for concrete repairs, being placed in isolated areas, where enough space may not be available, the 1000 tonne minimum stockpiles required, in the statements listed above, may be reduced to 500 tonnes, upon request and at the discretion of the Contract Administrator.

Where blended fine or coarse aggregates are to be used in the work, the proportions shall be submitted at the same time as Form A of the concrete mix design. If the proportions are changed, then the revised proportions and a new Form A shall be submitted.

Aggregates that have become mixed with foreign matter of any description, or aggregates that have become mixed with each other, shall not be used and shall be removed from the stockpile immediately.

Aggregate shall be retained in stockpiles for at least 24 hours before use. Suitable stockpile locations include the construction site and the site of batching of the concrete. Other locations may be used for stockpiles provided they are acceptable to the Contract Administrator.

1002.08 QUALITY ASSURANCE

1002.08.01 General

The laboratory designated by the Owner shall carry out QA testing for purposes of ensuring that aggregates used in the Work are according to the physical property and grading requirements of this specification. Individual test results shall be forwarded to the Contractor as they become available.

The Owner shall be responsible for all costs associated with testing for QA purposes, unless otherwise specified in this specification.

1002.08.02 Alternative to LS-614

LS-614 shall be used for acceptance, unless written notification to the Contract Administrator to replace it with LS-606 for acceptance is received prior to sampling of the applicable materials for QA purposes. Provided the Contract Administrator has received such a request, LS-606 shall be used. Otherwise, conformance to LS-614 shall be required.

When notification is provided after QA testing using LS-614 has been initiated, the Contractor shall then be charged \$750.00 for each test initiated, which includes the cost of the testing using LS-614, administrative charges, and additional sampling, if required.

1002.08.03 Special Grading for Fine Aggregate

Prior to samples being taken for QA purposes, the Contractor may submit a written request to the Contract Administrator to use a fine aggregate with a grading that falls outside the limits shown in Table 2. This request shall include test data necessary to demonstrate that the material shall produce concrete of acceptable quality and meet all relevant requirements specified elsewhere in the Contract Documents. The assessment of performance shall include, but not be limited to, the following tests: compressive strength, splitting tensile strength, and drying shrinkage.

1002.08.04 Sampling

Sampling shall be according to CSA A23.2-1A and LS-625. QA samples shall be randomly taken during production from stockpiles located at the concrete plant, or in the absence of a stockpile at the plant, from stockpiles at the aggregate source.

The Contractor shall provide new or clean sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. Sample containers shall be securely fastened. Metal or cardboard containers are unacceptable. The sample shall be identified both inside and outside of the sample container. Data to be included with the sample shall be according to MTO form PH-D-10.

For physical properties, at least one set of duplicate QA samples of each coarse and each fine aggregate component from each individual source shall be randomly sampled from lots according to the schedule shown in Table 1.

For gradation, separate sets of lots shall be developed, according the schedule shown in Table 1, for each:

- a) Individual coarse aggregate component being used for structural concrete in this Contract.
- b) Individual coarse aggregate component being used for concrete pavement and base in this Contract or, at the discretion of the Contract Administrator, for the combined coarse aggregate being used in concrete pavement and base for this Contract, if a stockpile of such aggregate has been provided.
- c) Individual fine aggregate component being used in this Contract or, at the discretion of the Contract Administrator, for the combined fine aggregate being used for this Contract, if a stockpile of such aggregate has been provided.

Each of the gradation lots shall be divided into two sublots of approximately equal tonnage or cubic metres, as applicable, and one set of duplicate QA samples shall be randomly obtained from each sublot.

In the event that the Contractor is unavailable to take samples, no further material shall be placed in the Work until the required QA samples have been taken. The Contract Administrator shall seal each sample container at the time and place of sampling.

One of the duplicate QA samples shall be randomly selected for testing by the QA laboratory. The QA laboratory shall retain the remaining sample for referee testing purposes.

1002.08.04.01 Sample Size

The mass of each QA sample shall meet the requirements of Table 7. When more than 30 kg is required, the total sample shall be recombined by the QA laboratory prior to testing.

1002.08.05 Acceptance

The aggregates within a lot of concrete shall be deemed to be acceptable if all of the test results for the samples of aggregates representing that lot meet all applicable requirements of this specification.

Irrespective of the negotiation of a reduced price payment, the warranty provisions of the Contract Documents shall apply.

1002.08.05.01 Acceptance for Physical Properties

The physical properties of a lot of aggregates shall be deemed to be acceptable if all of the test results for the sample representing that lot meet all of the requirements shown in Tables 3 and 6, for the fine and coarse aggregates, respectively.

If the tested sample of aggregates representing a lot of concrete does not meet all of the requirements of this specification, then a reduced price payment of 5% of the tender price shall be given for each cubic metre of concrete left in the work that includes any of the aggregates within that lot, as long as the applicable results for that sample:

- a) Do not exceed the requirement for LS-614 or LS-606 if it has been accepted by the Owner as an alternative to LS-614, by more than 25% of the specified value.
- b) Do not exceed a petrographic number of 135 for concrete pavement and 150 for structural concrete when tested according to LS-609;

- c) Do not exceed the requirement for LS-618 by more than 10% of the specified value; and
- d) Meets all other requirements of this specification.

For concrete tender items with units of measurement other than m^3 or m^2 , the 5% reduced price payment, mentioned above, will be based on the portion of the bid price represented by the volume, in m^3 , of the tender item or items that the deficient aggregate sample represents.

Should the test results for any sample of aggregates representing a lot of concrete not meet the requirements listed above, then all of the aggregates within that lot shall be considered rejectable and any concrete that includes those aggregates shall be removed from the Work at no cost to the Owner.

1002.08.05.02 Acceptance for Gradation

The gradation of a lot shall be deemed to be acceptable, based on LS-602, if the test results for the samples representing that lot meet all of the requirements of the specification.

The percent passing each sieve shall be computed to one decimal place for each individual test result representing a subplot and the average of the two test results within an aggregate lot.

1002.08.05.02.01 Acceptance of Special Grading for Fine Aggregate

If the Owner has accepted a fine aggregate for a lot according to the Special Grading for Fine Aggregate subsection, then, for each individual sieve within the gradation accepted by the Owner, the percent passing for at least one of the two test results as well as the average of the two test results shall both be within 5% of the target percent passing for that sieve.

However, if both of the requirements given above are not met, then all of the aggregates within the affected lot shall be considered rejectable.

1002.08.05.02.02 Acceptance of Gradation for All Other Fine and Coarse Aggregates

With the exception of a fine aggregate accepted by the Owner, according to the Special Grading For Fine Aggregate subsection, a complete or incomplete lot shall be deemed to meet the applicable requirements for gradation if, for each individual sieve, the percent passing for at least one of the two test results as well as the average of both test results representing the two sublots within an aggregate lot, shall be within the acceptable limits shown in Table 2 for a fine aggregate and the applicable limits shown in Tables 4 or 5, for the applicable coarse aggregate.

Should the test results for any sample of aggregates representing a lot of concrete not meet the requirements listed above, then all of the aggregates within that lot shall be considered rejectable.

1002.08.06 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator within 5 Business Days following notification that the aggregate does not meet the requirements of this specification.

Referee testing shall be carried out as specified herein and elsewhere in the Contract Documents.

The retained duplicate QA sample shall be used for referee testing.

All referee test results shall replace the respective QA test results for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, then the Contractor shall be responsible for the cost of referee testing of that lot including the costs for transportation of the referee samples at the rates specified elsewhere in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples representing that lot.

TABLE 1
Lot Schedule for Sampling and Testing

Total Quantity of Each Tender Item With the Same Concrete Mix Design		Minimum Lot Schedule (Notes 2 and 3)
Concrete Pavement and BaseTender Items (m ²)	Structural and all Other Concrete Tender Items (m ³) (Note 1)	
< 150	< 15	Sampling and testing may be waived at the discretion of the Contract Administrator, except for concrete repairs or critical structural elements, as described in Note 2.
150 to 10,000	15 to 500	One lot
>10,000	> 500	Concrete Pavement: 10,000 m ² lots Structural and all Other Concrete: 500 m ³ lots
Notes: 1. For tender items with units of measurement other than m ³ , the quantities shall be converted to m ³ , in order to establish the lot schedule. At the discretion of the Contract Administrator, some tender items constructed using the same mix design may be combined together to meet the specified quantities. 2. At the discretion of the Contract Administrator, concrete repairs, individual sections of bridge decks or critical structural elements such as cast-in-place girders, cantilever extensions etc., may have their own lot or lots, regardless of the tender item quantity. 3. Where the remaining quantity of the applicable tender item is insufficient to form a complete lot and is: a) Less than one-half the quantity of a complete lot, then that quantity shall be added to the previous lot, or b) Greater than or equal to one-half the quantity of a complete lot, then that quantity shall form its own lot.		

TABLE 2
Grading Requirements for Fine Aggregates, LS-602 (Note 1)

MTO Sieve Designation	Percent Passing
9.5 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-85
600 µm	25-60
300 µm	10-30
150 µm	0-10
75 µm	0-3 (Natural Sand) 0-6 (Manufactured Sand)
Note: 1. Fine aggregates shall have no more than 45% passing any sieve and retained on the next consecutive sieve. The fineness modulus shall be a minimum of 2.3 and a maximum of 3.1.	

TABLE 3
Physical Property Requirements for Fine Aggregate(s)

MTO or CSA Test Number (Note 1)	Laboratory Test	Acceptance Limit (Note 2)
LS-610	Organic Impurities, Organic plate number	3 (Note 3)
LS-613	Insoluble Residue, (IR _{R75}) minimum % retained on the 75 µm sieve	60 (Note 4)
LS-619 or CSA A23.2-23A	Micro-Deval Abrasion, % maximum loss	20
LS-620 or CSA A23.2-25A (Note 5)	Accelerated Mortar Bar, % maximum at 14 Days	0.150 (Note 6)
CSA A23.2-14A (Note 5)	Concrete Prism Expansion, % maximum at 1 year	0.040 (Note 7)
CSA A23.2-26A or LS-615	Potential Alkali-Carbonate Reactivity of Quarried Carbonate Rock (Note 8)	Chemical composition shall plot in the non-expansive field of Fig. 1 of test method

Notes:

- LS-615 (or CSA A23.2-26A), LS-619, LS-620 (or CSA A23.2-25A) and CSA A23.2-14A shall apply to each individual fine aggregate component in the mix. LS-610 and LS-613 shall be carried out either on samples taken from a stockpile of the blended fine aggregate intended to be used in the mix or from samples taken from stockpiles of each individual fine aggregate component and later combined in the laboratory to the proportions provided with Form A, prior to testing. All sampling and blending shall be as specified in the Aggregate Processing, Handling, and Stockpiling subsection.
- If the fraction of a coarse aggregate passing the 4.75 mm sieve represents more than 10% of the grading of that aggregate, by mass, then that fraction of the individual coarse aggregate shall also meet these requirements.
- Blended fine aggregate that produces a colour darker than standard colour No. 3 shall be considered to have failed this requirement. However, a failed blended fine aggregate may be used if comparative mortar specimens prepared according to ASTM C 87/C 87M meet the following requirements:
 - Mortar specimens prepared using unwashed fine aggregate shall have a 7-Day compressive strength that is a minimum of 95% of the strength of mortar specimens prepared using the same fine aggregate washed in a 3% sodium hydroxide solution. Type GU Hydraulic cement shall be used.
 - The setting time of the unwashed fine aggregate mortar specimens shall not differ from the washed fine aggregate mortar specimens by more than 10%.
- This requirement shall apply to all fine aggregates used in hydraulic cement concrete pavement and exposed concrete bridge deck driving surfaces (parking lots are excluded). Fine aggregates not meeting the IR_{R75} requirement may be uniformly blended with other suitable fine aggregate(s), in order to increase the IR_{R75} to a minimum of 60%.
- The need for data to demonstrate compliance with this test shall be waived by the Contract Administrator, if the fine aggregate component is from a source listed on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates.

Note that, if the fine aggregate in the mix is comprised of one (or more) individual fine aggregate component(s) which come from a source location or from a lithology within a source which is not listed as acceptable on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates, then the requirements for this test shall not be waived for each of the unlisted aggregate component(s).
- An aggregate that fails this requirement may be accepted, provided the requirements of CSA A23.2-14A are met.
- An aggregate need only meet this requirement if it fails the requirements of CSA A23.2-25A. Test data shall have been obtained within the past 18 months from aggregate that is from the same source and processed in the same manner as the material intended for use.
- This requirement only applies to an aggregate produced from quarried Gull River and Bobcaygeon Formations of southern and eastern Ontario. These dolomitic limestones outcrop on the southern margin of the Canadian Shield from Midland to Kingston and in the Ottawa-St. Lawrence Lowlands near Cornwall.

TABLE 4
Grading Requirements for Coarse Aggregate, LS-602
Structural Concrete, Sidewalks, Curb and Gutter, Patches, Refacing and Overlays

Nominal Maximum Size	19.0 mm	16.0 mm	13.2 mm	9.5 mm	6.7 mm
MTO Sieve Designation, mm	Percent Passing				
26.5	100	-	-	-	-
19.0	85-100	100	100	-	-
16.0	65-90	96-100	-	-	-
13.2	-	67-86	90-100	100	100
9.5	20-55	29-52	40-70	85-100	-
6.7	-	-	-	-	75-100
4.75	0-10	0-10	0-15	10-30	40-80
2.36	-	-	-	0-10	0-20

TABLE 5
Grading Requirements for Coarse Aggregate, LS-602
Concrete Pavement or Concrete Base

Nominal Maximum Size	For Information Purposes Only		Combined Grading Used For Acceptance (Note 1)
	37.5 mm	19.0 mm	
MTO Sieve Designation mm	Percent Passing		
53.0	100	-	100
37.5	90-100	-	95-100
26.5	20-55	100	-
19.0	0-15	85-100	35-70
9.5	0-5	20-55	10-30
4.75	-	0-10	0-5
Note: 1. The grading shown here shall be determined either from a sample of blended coarse aggregate intended for use in the mix, or from separate samples of the individual coarse aggregate components which are combined in the laboratory according to the proportions provided along with the mix design submission, as specified in the Aggregate Processing, Handling, and Stockpiling subsection.			

TABLE 6
Physical Property Requirements for Coarse Aggregate(s)

MTO,CSA or ASTM Test Number (Note 1)	Laboratory Test	Acceptance Requirements (Notes 2 and 3)	
		Pavement	Structures, Sidewalk, Curb and Gutter, and Concrete Base
LS-412	Scaling Resistance Due to De-Icing Chemicals, maximum loss after 50 cycles of freezing and thawing. (Notes 4 and 5)	0.80 kg/m ²	
LS-601 (Guideline A)	Wash Pass 75µm, % maximum - for gravel - for crushed rock	1.0 2.0	1.0 2.0
LS-604 or CSA A23.2-12A	Absorption, % maximum	2.0	2.0 (Note 6)
LS-608	Flat and Elongated Particles, % maximum	20	20
LS-609	Petrographic Number, Concrete, maximum	125	140
	Contamination and Unacceptable Minerals	Note 7	
	Siliceous Aggregates Related to LS-412	Note 4	
LS-614 or CSA A23.2-24A	Unconfined Freeze-Thaw, % maximum loss (Note 8)	6	6
LS-618 or CSA A23.2-29A	Micro-Deval Abrasion, % maximum loss	14	17
LS-620 or CSA A23.2-25A	Accelerated Mortar Bar Expansion, % maximum at 14 Days (Notes 9 and10)	0.150 (Note 11)	0.150 (Note 11)
ASTM C 666/C 666M	D-Line Cracking, Average change in length of 3 tested beams,% Average FTF. (Note 12)	no more than ± 0.0350%, ≥ 90% of the FTF at 14 days	<u>For Concrete Base Only:</u> no more than ± 0.0350%, ≥ 90% of the FTF at 14 days
CSA A23.2-14A	Concrete Prism Expansion Test, % maximum at one year (Notes 9 and 13)	0.040	0.040
CSA A23.2-26A or LS-615	Potential Alkali-Carbonate Reactivity of Quarried Carbonate Rock (Note 14)	Chemical composition shall plot in the non-expansive field of Fig. 1 of test method	
Alternative Requirement for LS-614			
LS-606	Magnesium Sulphate Soundness Loss, 5 Cycles, % maximum (Note 8)	12	12
Notes:			
1. LS-412, LS-618, LS-620 (or CSA A23.2-25A), ASTM C 666/C 666M, CSA A23.2-14A and CSA A23.2-26A shall apply to each individual coarse aggregate component in the mix. The remaining tests shown in this table shall be carried out either on samples taken from a stockpile of the blended coarse aggregate intended to be used in the mix or from samples taken from stockpiles of each individual coarse aggregate component and later combined in the laboratory to the proportions provided with Form A, prior to testing. All sampling and blending shall be as specified in the Aggregate Processing, Handling, and Stockpiling subsection.			
2. If the fraction of any coarse aggregate component, passing the 4.75 mm sieve represents more than 10% of the grading of that aggregate by mass, then that fraction of the individual coarse aggregate component shall also meet the fine aggregate requirements given in Table 2.			

3. When a concrete surface including pavements and exposed bridge decks is subject to vehicular traffic, the physical requirements for "Pavement" shown in this table shall apply to the aggregates used in the mix.
4. As specified in the Scaling Resistance clause, LS-412 shall be conducted on any aggregate component of a mix which has at least 80% siliceous aggregates as determined by LS-609. However, this testing will be waived if the aggregate is from the same bench/formation in a quarry which the Owner has already tested once and approved or, is listed on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates or the Aggregate Sources List of Concrete Base/Pavement Coarse Aggregates – See Note 5., AS LONG AS, at the discretion of the Owner, the aggregate under consideration is still representative of the aggregate that the Owner originally approved.
5. Note that, if the coarse aggregate in the mix is comprised of one (or more) individual coarse aggregate component(s) which come from a source location or from a lithology within a source which is not listed as acceptable on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates, then the requirements for this test shall not be waived for each of the unlisted aggregate component(s).
6. Where an air-cooled blast-furnace slag aggregate is used, the allowable maximum value for Micro-Deval shall be 21% for structures and the allowable maximum value for Absorption shall be according to the Owner's requirements for slag aggregate.
7. The coarse aggregate shall contain:
 - a) No steel slag or glass; and
 - b) Less than 1.0% by mass of gypsum, anhydrite or other sulphate minerals.
8. The requirement for this test shall be waived provided that the Contractor has submitted a written request that the coarse aggregate meet the alternative requirements for LS-606, magnesium sulphate soundness, as specified in the Alternative to LS-614 clause.
9. The need to demonstrate compliance with this requirement shall be waived by the Contract Administrator, if the aggregate component:
 - a) Is from a source on the current Ontario Ministry of Transportation Regional Aggregate Sources List (ASL) for Structural Concrete Fine and Coarse Aggregates or the Aggregate Sources List of Concrete Base/Pavement Coarse Aggregates – see Note 5.; and
 - b) In accordance with the requirements of Note 13., the aggregate is NOT found to be potentially expansive due to alkali-carbonate reaction, as determined by CSA A23.2-26A or LS-615.
10. An aggregate that fails to meet these requirements shall be accepted by the Contract Administrator, provided that the requirements of CSA A23.2-14A are met.
11. If the aggregate is produced from quarried sandstone, siltstone, granite or gneiss, the expansion shall be less than 0.080% after 14 Days. If an aggregate is produced from quarried Gull River, Bobcaygeon, Verulam, or Lindsay Formations, the expansion shall be less than 0.100% after 14 Days.
12. As specified in the D-Line Cracking clause, this test shall be conducted on any aggregate component of a mix that will be used in concrete pavement or base which has been produced either from a pit source OR, with the exception of the Oxford, Gull River or Bobcaygeon Formations, from quarried carbonate (e.g. limestone and dolostone) bedrock. However, the testing will be waived if the aggregate is from the same bench/formation in a quarry which the Owner has already tested once and approved or is listed on the current Ontario Ministry of Transportation Regional Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates – See Note 5. AS LONG AS, at the discretion of the Owner, the aggregate under consideration is still representative of the aggregate that the Owner originally approved.
13. An aggregate needs to meet this requirement only if it fails the requirements of either CSA A23.2-25A, or CSA A23.2-26A or LS-615. The test data shall have been obtained within the past 18 months from aggregate from the same location within the source as that to be used in the Work. If this test is conducted to show that an aggregate deemed potentially expansive by CSA A23.2-26A or LS-615 does not exceed 0.040% after one year, then chemical analysis, CSA A23.2-26A or LS-615, shall be provided to show that the aggregate intended for use has the same chemical composition as the material tested in CSA A23.2-14A.
14. This requirement only applies to an aggregate produced from quarried Gull River and Bobcaygeon Formations of southern and eastern Ontario. These dolomitic limestones outcrop on the southern margin of the Canadian Shield from Midland to Kingston and in the Ottawa-St. Lawrence Lowlands near Cornwall.

TABLE 7
Sample Size

Material	Minimum Mass, kg (Note 1)
Fine aggregate	15
19 mm coarse aggregate	25
37.5 mm coarse aggregate	50
Note: 1. Individual sample containers shall hold no more than 30 kg of aggregate. When more than 30 kg is required, additional sample containers shall be used.	



MATERIAL SPECIFICATION FOR AGGREGATES - HOT MIX ASPHALT

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1003.01 SCOPE

This specification covers material requirements for aggregates for use in hot mix asphalt (HMA).

1003.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt - End Result

Ontario Provincial Standard Specifications, Materials

OPSS 1001 Aggregates - General

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-282 Quantitative Extraction of Asphalt Cement and Analysis of Extracted Aggregate From Bituminous Paving Mixtures

- LS-312 Fractionation of Unextracted Reclaimed Asphalt Pavement (RAP) and Hot Mix Aggregates for Testing or Incorporation in Other Test Samples.
- LS-600 Dry Preparation of Aggregates For the Determination of Physical Constants
- LS-601 Material Finer than 75µm Sieve in Mineral Aggregates by Washing
- LS-602 Sieve Analysis of Aggregates
- LS-604 Relative Density and Absorption of Coarse Aggregate
- LS-606 Soundness of Aggregate by Use of Magnesium Sulphate
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- LS-618 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- LS-619 Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- LS-625 Guidelines for Sampling of Granular Materials
- LS-629 Uncompacted Void Content of Fine Aggregate
- LS-631 Qualitative Determination of Presence of Plastic Fines in Aggregates

Designated Sources for Materials (DSM)

DSM #3.05.25 Aggregates: Surface Friction Courses

ASTM International

- D 4791-10 Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- D 5821-01(2006) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

American Association of State Highway and Transportation Officials (AASHTO)

- T176-08 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

1003.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Aggregate means as defined in OPSS 1001.

Air-Cooled Blast Furnace Slag means the material resulting from solidification of molten blast-furnace slag under atmospheric conditions. Subsequent cooling may be accelerated by application of water to the solidified surface.

Bench means a relatively horizontal ledge or platform in a quarry that forms a single level of operation above which rock is excavated from a contiguous face.

Chip Product means an aggregate co-product from the crushing operation with 100% passing the 9.5 mm sieve, predominantly passing the 4.75 mm sieve and retained on the 2.36 mm sieve.

Coarse Aggregate means that portion of aggregate material retained on the 4.75 mm or larger sieve when tested according to LS-602.

Consensus Property means an aggregate property required for use in a Superpave mix.

Copper Slag means the non-metallic product resulting from the production of copper.

Duplicate Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Fine Aggregate means that portion of aggregate material passing the 4.75 mm sieve when tested according to LS-602.

Hot Mix Asphalt (HMA) means as defined in OPSS 313.

Nickel Slag means the non-metallic product resulting from the production of nickel.

Physical Property means an inherent attribute or feature of an aggregate material. Tests are carried out to determine an aggregate's resistance to weathering or degradation or both. Aggregate production processes generally do not affect physical properties.

Primary Coarse Aggregate means the aggregate component that represents the greatest proportion of the coarse aggregate in the mix design. For Superpave 12.5 FC1, Superpave 12.5 FC2 and SMA mixes, the Primary Coarse Aggregate may be identified as Type (D), (G), (M) or (T), as listed in DSM List #3.05.25.

Quality Assurance (QA) means as defined in OPSS 313

Reclaimed Asphalt Pavement (RAP) means as defined in OPSS 313.

Roof Shingle Tabs (RST) means as defined in OPSS 313.

Steel Slag means the non-metallic product resulting from the production of steel in a basic oxygen furnace or an electric arc furnace.

Stone Mastic Asphalt (SMA) means as defined in OPSS 313.

Superpave (Superpave™) means as defined in OPSS 313.

1003.05 MATERIALS

1003.05.01 General

Aggregates shall be according to OPSS 1001 and shall meet all of the requirements of this specification when tested using the applicable MTO, AASHTO, and ASTM test methods identified herein.

Except as noted below or elsewhere in the Contract Documents, aggregates may be sands, gravels, quarried rock, the aggregate portion of RST, or the aggregate portion of RAP, provided that the source or sources are of such nature and extent to ensure acceptable processed aggregates of a consistent gradation and quality. When any change in the character of the aggregate occurs or when the performance of aggregate meeting the requirements of this specification is found to be unsatisfactory, use of the aggregate shall be discontinued until a reappraisal by the Contractor, with the approval of the Contract Administrator, proves the source to be satisfactory.

Steel slag, air-cooled blast furnace slag, nickel slag and copper slag shall not be used in HMA. RAP containing steel slag aggregate, RST containing asbestos, and post-consumer shingle material shall not be permitted.

RAP used in an HMA surface or binder course mix shall be comprised of aggregates that, when combined with all of the other aggregates in the mix, will meet the Owner's physical property requirements specified in Table 4.

The need for, type of and application of anti-stripping additive shall be as specified in the Contract Documents.

For Superpave 12.5FC 1, the coarse aggregates in the mix shall be produced from crushed bedrock material or gravel supplied from sources named on the DSM #3.05.25.

For Superpave 12.5FC 2, both the coarse and fine aggregates in the mix shall be produced from crushed bedrock material supplied from sources named on DSM #3.05.25. Coarse aggregate for Superpave 12.5FC 2 may be obtained from a different source than the fine aggregate. When RAP is used in Superpave 12.5FC 2, the coarse aggregate portion of the RAP may be derived from different sources. In all other cases, blending of coarse aggregates for Superpave 12.5FC 2 from different sources shall not be permitted. Blending of fine aggregates for Superpave 12.5FC 2 from different sources is permitted provided that aggregate fraction retained on the 4.75 mm sieve as part of the blended fine aggregate comprise less than 20% by mass of the total amount of coarse aggregate.

For SMA surface courses, both the coarse and fine aggregates shall be produced from crushed bedrock supplied from sources shown in DSM #3.05.25. Both the coarse and fine aggregates shall be obtained from the same source except where aggregate is derived from RST.

Chip products shall be derived:

- a) For Superpave 12.5FC 2, SMA 12.5 or SMA 9.5, from the same source as the primary coarse aggregate used in the mix; or
- b) For Superpave 12.5FC 1, from an aggregate source listed on DSM #3.05.25; or
- c) For all other mixes, either from an aggregate source listed on DSM #3.05.25 or from the same source and of the same lithology as a coarse aggregate that is being used the mix.

Filler shall consist of mineral filler, hydrated lime, Portland cement, or other material as specified and currently approved by the Owner for use in HMA. For SMA, the filler shall be mineral filler.

Mineral filler shall meet the following requirements:

- a) Be produced from quarried rock from the same bench that is also used to produce a screenings co-product that is shown to have a Micro-Deval of no more than 30%, when determined in accordance with LS-619, in lieu of the requirements shown in Note 2 of Table 1.
- b) Be sufficiently dry so that it flows freely.
- c) Be free from agglomerations.
- d) Be non-plastic according to LS-631.
- e) Be inert.
- f) Mineral filler shall also meet the following gradation requirements according to LS-602:
 - i) 100% passing the 600 µm sieve.
 - ii) Not less than 70% passing the 75 µm sieve.

In addition, the mineral filler for SMA mixes shall be of gradation and properties to be capable of producing asphalt mortar properties meeting the appropriate requirements as specified in the Contract Documents.

1003.05.02 Gradation

Each individual fine and coarse aggregate component shall be graded so that when combined with all other aggregates including RAP and/or RST, the overall gradation of the HMA specified in the Contract Documents is consistently being met.

1003.05.03 Physical Property Requirements

Each aggregate component of the mix shall be composed of clean, hard, durable particles.

With the exceptions of RAP and RST, the individual aggregate components of the mix shall be properly proportioned and blended, in accordance with the mix design.

The fraction of the combined aggregates passing the 4.75 mm sieve shall meet the physical property requirements specified in Table 1.

The fraction of the combined aggregates retained on the 4.75 mm sieve shall meet the physical property requirements specified in Table 2 for surface course mixes and Table 3 for binder or levelling course mixes, respectively.

In addition to the physical property requirements for the combined aggregate components described above, the combined fine and coarse aggregate fractions extracted from samples of HMA shall also meet the applicable physical property requirements specified in Table 4.

1003.05.04 Consensus Property Requirements

The fraction of the combined aggregates passing the 4.75 mm sieve, including aggregates derived from RAP or RST or both, each of which have been properly fractionated in accordance with LS-312 then proportioned and blended in accordance with the mix design, shall meet the consensus property requirements for AASHTO T 176 and LS-629 given in Table 5 for the traffic category specified in the Contract Documents. However, for AASHTO T 176 only, any fine aggregate that is derived from RAP or RST or both shall be excluded.

The fraction of the combined aggregates retained on the 4.75 mm sieve, including aggregates derived from RAP or RST or both, each of which have been properly proportioned and blended in accordance with the mix design, shall meet the consensus property requirements according to ASTM D4791 and ASTM D5821 given in Table 5, for the traffic category specified in the Contract Documents.

1003.07 PRODUCTION

1003.07.01 Aggregate Processing, Handling, and Stockpiling

Aggregates separated during processing, aggregates secured from different sources, and aggregates from the same source, but of different gradation, shall be stockpiled separately. When screenings from primary and secondary crushers are produced separately, they shall be stockpiled separately.

Aggregates that have become mixed with foreign material of any description, or aggregates from different stockpiles that have become mixed with each other, shall not be used and shall be removed from the stockpile immediately.

Aggregates shall be retained in stockpiles for at least 24 hours prior to use. Suitable stockpile locations are the site of mixing of the HMA, the aggregate source, or any other location acceptable to the Contract Administrator.

1003.08 QUALITY ASSURANCE

1003.08.01 General

A laboratory designated by the Owner shall carry out QA testing for purposes of ensuring that the aggregates used in the Work conform to the physical property, gradation and, at the discretion of the Contract Administrator, the consensus property requirements of this specification.

With the exceptions of RAP and RST and unless otherwise noted, QA testing will be conducted on combined samples prepared from individual QA samples by splitting off sufficient quantities of each individual aggregate component, based on percentages stated in the HMA mix design and the overall combined quantity required for testing.

When an anti-stripping additive is used, test samples for physical property requirements shall be taken prior to the addition of the anti-stripping additive. If this is not practical for samples that are coated in hydrated lime, the lime shall be removed by washing prior to testing. In this case, the requirements for LS-601 are waived.

The Owner shall be responsible for all costs associated with testing for QA purposes, unless otherwise indicated in this specification. Test results shall be forwarded to the Contractor, as they become available.

1003.08.02 Alternative to LS-614

LS-614 shall be used for acceptance, unless written notification to the Contract Administrator to replace it with LS-606 for acceptance is received prior to sampling of the applicable materials for QA purposes. Provided that the Contract Administrator has received such a request, LS-606 shall be used. Otherwise, conformance to LS-614 shall be required.

When notification to replace LS-614 is received after QA testing using LS-614 has been initiated, the Contractor shall be charged \$600.00 for each test initiated, which includes the cost of the testing using LS-614, administrative charges, and additional sampling, if required.

1003.08.03 Sampling

Unless otherwise specified, all QA aggregate samples shall be taken at the hot mix plant from individual stockpiles, according to the Stockpile Method clause. Each QA sample shall be treated as discrete samples and not combined or blended with any other sample. In the absence of individual stockpiles at the plant, QA samples shall be taken at the aggregate source.

For physical properties, the following minimum number of random QA samples shall be obtained for every lot of 20,000 tonnes or part thereof of each HMA mix produced:

- a) One duplicate set of samples of all other primary coarse aggregates as well as all other aggregates used in the mix, including chip products;
- b) One sample of RAP, if RAP is used in the mix, for information purposes only;
- c) One sample of RST, if RST is used in the mix, for information purposes only;
- d) One duplicate sample of HMA during placement; and
- e) For Superpave 12.5FC 1, Superpave 12.5FC 2, SMA 9.5 and SMA 12.5 surface course mixes with a Type (D) primary coarse aggregate: two sets of duplicate samples of the primary coarse aggregate obtained from separate sampling pads constructed from aggregate obtained within the stockpile.

The aggregate samples described in part e) above, shall be taken during the same HMA production shift represented by the duplicate sample listed in d). If the Contract Administrator determines that this is not possible, then the samples described in part e) shall be taken within 24 hours or within no more than two HMA production shifts, represented by the duplicate sample listed in d), whichever is longer.

In the event that the Contractor is unavailable to take any of the samples, no further materials shall be placed in the Work until the samples have been taken.

In addition to the duplicate samples taken for QA purposes, at the request of the Contract Administrator, a third sample shall be taken for Superpave 12.5FC 1, Superpave 12.5FC 2, SMA 9.5, and SMA 12.5 aggregates at the time the QA samples are taken.

During the production of each lot of SMA surface course mix, at the request of the Contract Administrator, random samples of both the mineral filler and the baghouse fines, shall also be taken. Each sample shall be placed in a triple-sealed metal container of suitable size, which shall be properly identified, and shall include the contract number, name of the Contractor, highway number, lot number, and the contact information of the person who conducted the sampling.

One of each of the duplicate QA samples shall be randomly selected for testing by the QA laboratory. The QA laboratory shall retain the remaining samples for referee testing, if required.

1003.08.04.01 Sample Size

The mass of the each QA sample shall meet the requirements shown in Table 6. When more than 30 kg of material is required, the total sample shall be recombined prior to testing.

1003.08.04.02 Stockpile Method

The stockpiles from which the QA samples are to be taken shall contain a minimum quantity of 500 tonnes of each aggregate, or at least 10% of the total quantity of aggregate needed for each HMA mix, unless otherwise directed by the Contract Administrator. QA sampling from stockpile shall be according to LS-625.

1003.08.05 Acceptance

The aggregates within a lot of HMA shall be deemed to be acceptable if all of the test results for the aggregates representing that lot meet all applicable requirements of this specification.

If QA test results of an aggregate sample representing a lot of HMA do not meet all of the requirements of this specification, then a reduced price payment of 10% of the tender price shall be given for each tonne of HMA left in the Work that includes any of the aggregates within that lot, as long as the applicable test results for that sample:

- a) Do not exceed the requirement for LS-614, or LS-606 if it has been accepted by the Owner as an alternative to LS-614, by more than 25% of the specified value.
- b) Do not exceed the requirement for LS-618 by more than 10% of the specified value.
- c) Do not exceed the requirement for LS-619 by more than 15% of the specified value.
- d) Meet all other requirements of this specification.

If QA test results of an aggregate sample representing a lot of HMA do not meet the requirements listed above, then all of the aggregates within that lot shall be considered rejectable and any HMA that includes those aggregates shall be removed from the Work at no cost to the Owner.

Irrespective of a reduced price payment, the warranty provisions of the Contract Documents shall apply.

1003.08.06 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator, within 5 Business Days following notification that an aggregate sample representing a lot of HMA does not meet the requirements of this specification.

Referee testing shall be carried out, as specified herein and elsewhere in the Contract Documents.

The retained duplicate QA samples shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, then the Contractor shall be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates specified in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

Table 1
Physical Property Requirements for Combined HMA Aggregates in
Surface, Binder and Levelling Courses - Fraction Passing the 4.75 mm Sieve (Note 1)

MTO Laboratory Test Number	MTO Laboratory Test	SMA 9.5 & 12.5; and Superpave 12.5FC 2	Superpave 12.5FC 1	SMA 19.0 and Superpave 4.75, 9.5, 12.5, 19.0, 25.0 & 37.5
LS-619	Micro-Deval Abrasion, % maximum loss	(Note 2)		
		15	20	25
LS-631	Plastic Fines	NP	NP	NP
Notes for Table 1: 1. As specified in LS-600, the aggregate used for the following tests shall be prepared by first splitting off sufficient quantities of each of the aggregate components, based on their individual percentages stated in the mix design and the overall blended quantity required for the test(s). Then, with the exceptions of RAP and RST, the split portions of each of the other aggregate components shall be placed in a vessel of appropriate size and blended together by mixing. The blended aggregate shall then be split on the 4.75 mm sieve and the portion passing the 4.75 mm sieve set aside for testing. 2. In addition to the requirements shown below, the Micro-Deval Abrasion loss for any individual aggregate component where the aggregate passing the 4.75 mm sieve represents more than 5% of the overall mix design gradation, by mass, shall not exceed 35%.				

Table 2
Physical Property Requirements for Combined HMA Aggregates in Surface Courses
- Fraction Retained on the 4.75 mm Sieve (Note 1)

MTO Laboratory Test Number	Laboratory Test	Superpave 9.5 and 12.5	Aggregate Type (Note 2)			
			Type (G)	Type (D)	Type (M)	Type (T)
			Superpave 12.5FC 1 Only	Superpave 12.5FC 1 and 12.5FC 2, and SMA 9.5 and 12.5		
LS-601	Wash Pass 75µm sieve, Guideline B, % maximum loss	1.3 (Note 3)	1.0	1.0	1.0	1.0
LS-604	Absorption, % maximum	2.0	1.0	1.0	1.0	1.0
LS-609	Petrographic Number, (HL) maximum	-	(Note 4)			
			120	145	145	120
LS-613	Insoluble Residue, retained 75µm sieve, % minimum	-	-	45 (Note 5)	-	-
LS-614	Unconfined Freeze-Thaw, % maximum loss	6 (Note 6)	(Note 4)			
			6	7	6	6
LS-618	Micro-Deval Abrasion, % maximum loss	17 (Note 7)	(Notes 4 and 7)			
			10	15	15	10
Alternative Requirement for LS-614						
LS-606	Magnesium Sulphate Soundness, % maximum loss	12 (Note 6)	-			

Notes for Table 2:

1. As specified in LS-600, the aggregate used for the following tests shall be prepared by first splitting off sufficient quantities of each of the aggregate components, based on their individual percentages stated in the mix design and the overall blended quantity required for the test(s). Then, with the exceptions of RAP and RST, the split portions of each of the other aggregate components shall be placed in a vessel of appropriate size and blended together by mixing. The blended aggregate shall then be split on the 4.75 mm sieve and the portion retained on the 4.75 mm sieve set aside for testing.
2. Aggregate Types (G), (D), (M) and (T) refer to the Designation Type included in the "Product Description and Designation Type" column for each source listed on DSM #3.05.25.
3. When quarried rock is used as a source of at least one coarse aggregate in the mix, a maximum of 2.0 percent passing the 75 μ m sieve shall be permitted.
4. When this test is being carried out on the coarse aggregate fraction of a Superpave 12.5FC 1 that contains coarse aggregates from more than one source, the minimum value of the % maximum losses shown below for the coarse aggregate categories that are included in that mix shall be used for acceptance.
5. The following requirements shall be met:
 - i) The average value of two test results carried out on separate samples shall have a minimum insoluble residue of 45%. Each of the two samples shall be prepared by blending one of the two primary coarse aggregate stockpile samples, specified in part a) of the Sampling subsection with each of the remaining aggregates in the mix, excluding RAP and/or RST, according to Table 2, Note 1.
 - ii) The insoluble residue, determined from part i) above, minus the insoluble residue from the aggregates extracted from the HMA sample, shall meet the requirements specified in Table 4, Note 8.
6. For Superpave 9.5 and Superpave 12.5, the Owner shall waive the requirements for LS-614, Unconfined Freeze-Thaw, provided the Contractor has submitted a written request that the coarse aggregate meet the alternative requirements for LS-606, Magnesium Sulphate Soundness.
7. In addition to the requirements shown below, the Micro-Deval Abrasion loss for any individual aggregate component where the aggregate retained on the 4.75 mm sieve represents more than 5% of the overall mix design gradation, by mass, shall not exceed 25%.

Table 3
Physical Property Requirements for Combined HMA Aggregates in Binder and Levelling Courses
- Fraction Retained on the 4.75 mm Sieve (Note 1)

MTO Test Number	Laboratory Test	Superpave 9.5, 12.5, 19.0, 25.0, & 37.5 and SMA 19.0
LS-601	Wash Pass 75µm sieve, Guideline B, % maximum	1.3 (Note 2)
LS-604	Absorption, % maximum	2.0
LS-614	Unconfined Freeze-Thaw, % maximum loss (Note 3)	15
LS-618	Micro-Deval Abrasion, % maximum loss	21 (Note 4)
Alternative Requirement for LS-614		
LS-606	Magnesium Sulphate Soundness, % maximum loss (Note 3)	15

Notes for Table 3:

1. As specified in LS-600, the aggregate used for the following tests shall be prepared by first splitting off sufficient quantities of each of the aggregate components, based on their individual percentages stated in the mix design and the overall blended quantity required for the test(s). Then, with the exceptions of RAP and RST, the split portions of each of the other aggregate components shall be placed in a vessel of appropriate size and blended together by mixing. The blended aggregate shall then be split on the 4.75 mm sieve and the portion retained on the 4.75 mm sieve set aside for testing.
2. When quarried rock is used as a source of at least one coarse aggregate, a maximum of 2.0 percent passing the 75µm sieve shall be permitted.
3. The Owner shall waive the requirements for LS-614, Unconfined Freeze-Thaw, provided that the Contractor has submitted a written request that the coarse aggregate meet the alternative requirements for LS-606, Magnesium Sulphate Soundness.
4. In addition to the requirements shown below, the Micro-Deval Abrasion loss for any individual aggregate component where the aggregate retained on the 4.75 mm sieve represents more than 5% of the overall mix design gradation, by mass, shall not exceed 25%.

Table 4
Physical Property Requirements for Aggregates Extracted From HMA (Note 1)

MTO Test Number	Laboratory Test	Surface Course			Binder and Levelling Course
		Superpave 12.5FC 2, SMA 9.5 and 12.5	Superpave 12.5FC 1	Superpave 9.5 and 12.5	Superpave 9.5, 12.5, 19.0, 25.0, 37.5, and SMA 19.0
Passing the 4.75 mm Sieve / Retained on the 2.36 mm Sieve					
LS-613	Acid Insoluble Residue, retained on 75 µm sieve, % minimum (Note 2)	-	-	60.0	-
LS-616, Part B	Category 1 aggregates, % minimum (Note 3)	90.0	-	-	-
Retained on the 4.75 mm Sieve					
LS-608	Flat and Elongated Particles, % maximum (4:1)	15	15	20	20
LS-609, Part B	Category 1 aggregates, % minimum (Note 3)	90.0	90.0	-	-
	Category 2 aggregates, % maximum (Notes 2, 4)	-	-	40	
	Category 2 AND Category 5 aggregates, % maximum (Note 5)	5.0	5.0	-	
	Category 3 Contaminants, % maximum (Note 6)	0.5	0.5	0.5	
LS-613	Acid Insoluble Residue, retained on 75 µm sieve, % minimum	Types (G), (M) or (T) Primary Coarse Aggregate		-	-
		90.0 (Note 7)			
		Type (D) Primary Coarse Aggregate			
		45.0			
		15, 12, 10 (Note 8)			

Notes for Table 4:

1. Aggregates used for the following tests shall be extracted from hot mix using LS-282 and then split on the 4.75 mm sieve, prior to testing.
2. This requirement is only applicable to surface courses placed on the Thousand Islands Parkway; Highway 33 from west of Bath to Picton; Highway 35 from County Road 121 northerly to Norland; and in the area to the north and west of a boundary defined by the north shore of Lake Superior, the north shore of the St. Mary's River, the south shore of St. Joseph Island, the north shore of Lake Huron easterly to the north and east shore of Georgian Bay (excluding Manitoulin Island), along the Severn River to Washago and a line easterly passing through Norland, Burnt River, Burleigh Falls, Madoc, and hence easterly along Highway 7 to Perth and northerly to Calabogie and easterly to Arnprior and the Ottawa River.
3. Category 1 aggregates shall include:
 - a. For the fraction passing the 4.75 mm sieve and retained on the 2.36mm sieve, all Category 1 aggregates

- or their acceptable major mineral components or both listed on the Part B form in LS-616.
- b. For the fraction retained on the 4.75 mm sieve, the following rock types, when classified according to the descriptions given in LS-609, Appendix:
 - i) Rock types 3, 4, 5, 6, 7, 8, 9, 10, 11, 22 AND
 - ii) For mixes with a (G), (M) or (T) primary coarse aggregate, up to 12.5% rock types 25, 27, 29 and 30 (i.e. the actual percentage of these rock types in that fraction may be greater than 12.5%, provided there is a minimum of 77.5% of the rock types shown in i); OR
 - iii) For mixes with a (D) primary coarse aggregate, rock types 1, 2, 20 and 21.
4. Category 2 aggregates shall include the following rock types, when classified according to the descriptions given in LS-609, Appendix:
- a. For mixes where the primary coarse aggregate is from a carbonate or dolomitic sandstone source:
 - i) Rock types 23, 24, 26, 35, 40, 41, 42, 43, 44, 45, 49; AND
 - ii) Rock types 1, 2, 20, 21, where the siliceous component determined by petrographic analysis (i.e. and confirmed by insoluble residue testing using LS-613, when the Petrographic Analyst is unsure) is less than 45%.
 - b. For mixes where the primary coarse aggregate is not from a carbonate or dolomitic sandstone source, rock types 1, 2, 20, 21, 23, 24, 26, 35, 40, 41, 42, 43, 44, 45 and 49.
- In the event of a dispute based on the petrographic testing described above, the extracted coarse aggregates must have at least 60% insoluble residue retained on the 75 µm sieve, in accordance with LS-613.
5. This requirement shall only apply to mixes with primary coarse aggregate types (G), (M) or (T) and where the mix design submission indicates that any RAP in the mix does not contain dolomitic sandstone retained on the 4.75 mm sieve (i.e. the RAP does not contain rock types 3 and/or 22, according to the descriptions given in LS-609, Appendix or, when present, fine powder obtained from scratching those materials does not effervesce, when subjected to 5% HCl by volume) and shall include all:
- a. Category 2 aggregates, as specified in Note 4 b); and
 - b. Category 5 aggregates consisting of the following rock types, according to the descriptions given in of LS-609, Appendix: types 28, 32, 34, 46, 48, 50, 51, 52, 53, 54, 55, 56, 60, 61, 62, 63, 64, 71, 73, 74, 77, 78, 79, 80, 82, 83, 84, 85, 86, 87, 88, and 97 as well as any other rock types that do not fall under Categories 1, 2 or 3.
- In the event of a dispute based on the petrographic testing described above, then the extracted coarse aggregates must have at least 95% insoluble residue retained on the 75 µm sieve, in accordance with LS-613.
6. Category 3 contaminants include but are not limited to clay and soluble minerals, clay lumps, earth, wood, crack sealant as well as all waste materials such as gypsum, plaster, gypsum/plastic wallboard, hydraulic cement concrete, clay brick, tile, coal, fly ash, cardboard, paper, metals, slags, glass, ceramics, soluble minerals, paint, rubber, etc.
7. For mixes with primary coarse aggregate types (G), (M) or (T) and where, in the mix design submission, petrographic testing in accordance with LS 609 Part b), clearly indicates that any RAP in the mix contains dolomitic sandstone (i.e. the material contains rock types 3 and/or 22, according to the descriptions given in LS-609, Appendix and fine powder obtained from scratching those materials at least slightly effervesces when subjected to 5% HCl by volume) retained on the 4.75 mm sieve.
8. For mixes with a (D) primary coarse aggregate, the % insoluble residue retained on the 75 µm sieve, determined from the average of TWO blended samples of aggregates [i.e. see Table 2, Note 5, part i)] MINUS the % insoluble residue retained on the 75 µm sieve for the coarse portion of the aggregate extracted from the HMA sample, shall not exceed:
- i) 15% by mass for mixes containing RAP that has at least 10% its aggregates retained on the 4.75 mm sieve;
 - ii) 12% by mass for mixes containing RAP that has less than 10% of its aggregates retained on the 4.75 mm sieve; and
 - iii) 10% by mass for mixes that does not contain RAP.

Table 5
Consensus Property Requirements for HMA Coarse and Fine Aggregates
Including RAP or RST or Both (Note 1)

Traffic Category	Combined Aggregates Passing the 4.75 mm Sieve			Combined Aggregates Retained on the 4.75 mm Sieve		
	AASHTO T 176 Sand Equivalent Method 1, % minimum (Note 2)	LS-629 Uncompacted Void Content, % minimum		ASTM D 4791 Flat and Elongated Particles, % maximum at 5:1	ASTM D 5821 Fractured Particles in Coarse Aggregate, % minimum (Note 4)	
		≤ 100mm (Note 3)	> 100mm (Note 3)		≤ 100 mm (Note 3)	> 100 mm (Note 3)
A	40	-	-	-	55/-	-/-
B	40	40	40	10	75/-	50/-
C	45	45 (Note 5)	40		85/80	60/-
D	45	45 (Note 5)	40		95/90	80/75
E	50	45 (Note 5)	45 (Note 5)		100/100	100/100

Notes for Table 5:

1. As specified in LS-600, the aggregate used for the following tests shall be prepared by first splitting off sufficient quantities of each of the aggregate components including, with the exception of AASHTO T 176 (i.e. see Note 2.), any aggregates derived from RAP and RST, based on the individual percentages of each aggregate component stated in the mix design and the overall blended quantity required for the test(s). The split portions of each of the aggregate components shall be placed in a vessel of appropriate size and blended together by mixing. The blended aggregate shall then be split on the 4.75 mm sieve and the portions passing and retained on the 4.75 mm sieve set aside for testing.
2. When the total combined fine aggregate includes aggregate derived from RAP or RST or both, this requirement shall be met prior to blending with RAP or RST or both.
3. Denotes the depth of the top of lift below the final pavement surface. If less than 25% of a layer is within 100 mm of the surface, then the layer may be considered to be below 100 mm.
4. 85/80 denotes that 85% of the coarse aggregate has one fractured face and 80% has two or more fractured faces.
5. An uncompacted void content of 43% is acceptable, provided that the selected mix satisfies the mix volumetrics specified in the Contract Documents.

Table 6
Field Sample Size

Material	Minimum Mass, kg (Note 1)
Fine aggregate	15
Coarse aggregate	25
RAP	10
RST	5
Filler / Baghouse Fines	2
Hot Mix Asphalt	25

Note for Table 6:

1. Individual sample containers shall hold no more than 30 kg of aggregate. When more than 30 kg is required, additional sample containers shall be used.



MATERIAL SPECIFICATION FOR AGGREGATES - MISCELLANEOUS

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APPENDICES

1004-A	Commentary

1004.01 SCOPE

This specification covers material requirements for aggregates for use as clear stone, granular sheeting, gabion stone, mortar sand, rip-rap, rock protection, truck arrester bed aggregate and winter sand.

1004.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1004.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1004.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1001 Aggregates - General
OPSS 1010 Aggregates - Base, Subbase, Select Subgrade and Backfill Material

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-601 Materials Finer than 75 µm Sieve in Mineral Aggregates by Washing
LS-602 Sieve Analysis of Aggregates
LS-604 Relative Density and Absorption of Coarse Aggregate
LS-607 Determination of Percent Crushed Particles in Processed Coarse Aggregate
LS-608 Determination of Percent Flat and Elongated Particles in Coarse Aggregate
LS-610 Organic Impurities in Sands for Concrete
LS-614 Freezing and Thawing of Coarse Aggregate
LS-616 Petrographic Analysis of Fine Aggregate
LS-618 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-619 Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-625 Guidelines for Sampling of Aggregate Materials
LS-631 Determination of Presence of Plastic Fines in Aggregates

MTO Forms:

PH-D-10 Aggregate Sample Data Sheet

ASTM International

C 87/87M-10 Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
D 6473-10 Standard Test Method for Specific Gravity and Absorption of Rock for Erosion Control

1004.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Clear Stone means a graded aggregate intended for use in drainage, backfill, bedding, and other applications.

Duplicate Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Gabion Stone means a graded fractured rock aggregate intended for use in gabion baskets and gabion mats.

Granular Sheetting means a graded granular aggregate material intended for use as a protective surface layer on erodible soil slopes.

Mortar Sand means a fine aggregate intended for application in Portland cement based mortars.

Nominal Maximum Size means the largest sieve in the applicable specification upon which material is permitted to be retained.

Physical Property means an inherent attribute or feature of an aggregate material. Tests are carried out to determine a material's resistance to weathering or degradation or both.

Pit-Run Material means material excavated directly from an existing bank in a pit and delivered to the job site without further processing, i.e., crushing, screening, washing, and classifying.

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that materials received from the Contractor meet the specified requirements.

Referee Testing means testing of a material property or attribute for the purpose of resolving acceptance.

Rip-Rap means a well graded, fractured rock or crushed reclaimed concrete intended for use as slope protection in hydraulic channels.

Rock Protection means a well graded, fractured rock or crushed reclaimed concrete intended for use as general slope protection.

Spheroidal Particle means when the ratio of the greatest dimension in the longitudinal axis compared to the least dimension in a plane perpendicular to the longitudinal axis is less than 2:1.

Truck Arrester Bed Aggregate means a single-sized aggregate used in runaway truck lanes to slow and stop the progress of vehicles.

Winter Sand means a fine aggregate intended for application to roadways during winter conditions to improve frictional properties of the pavement surface.

1004.05 MATERIALS

1004.05.01 General

The requirements of OPSS 1001 shall apply to this specification.

All aggregate source materials shall be clean, hard, durable particles free of earth, humus, clay or other coatings, clay lumps, shale or shaley partings and other deleterious materials. Aggregates may be sands, gravels, cobbles, boulders, or quarried rock. Reclaimed asphalt pavement, reclaimed hydraulic cement concrete, glass, other reclaimed materials, and slag materials shall not be used. When reclaimed materials are permitted by this specification or specified in the Contract Documents, they shall be homogeneously blended. When reclaimed hydraulic cement concrete is permitted, it shall not contain loose reinforcing material and shall be free of protruding metal.

When any change in the character of the aggregate occurs or when the performance of aggregate meeting the requirements of this specification is found to be unsatisfactory, use of the aggregate shall be discontinued until a reappraisal by the Contractor, with the approval of the Contract Administrator, proves the source to be satisfactory.

Irrespective of compliance or non-compliance with the gradation and physical property requirements of this specification, aggregates may be accepted or rejected on the basis of field performance, as determined by the Owner.

1004.05.02 Clear Stone

Clear stone may be 53.0 mm, 19.0 mm Type I, 19.0 mm Type II, 16.0 mm, 13.2 mm, or 9.5 mm and shall meet the physical property requirements shown in Table 1 and the gradation requirements shown in Table 2.

1004.05.03 Granular Sheetting

Granular sheetting shall meet the physical property requirements shown in Table 3 and the gradation requirements shown in Table 4.

1004.05.04 Mortar Sand

Mortar sand shall consist of natural sand, or with the approval of the Contract Administrator, other inert materials with similar characteristics, or combinations thereof, having hard, strong, durable particles.

Mortar sand shall meet the physical property requirements shown in Table 5 and the gradation requirements shown in Table 6.

1004.05.05 Gabion Stone, Rip-Rap and Rock Protection

Gabion stone, rip-rap and rock protection shall be produced from crushed or fractured bedrock fragments with 100% fractured faces or crushed from cobbles or boulders greater than 300 mm diameter and shall not deteriorate when exposed to air and water and shall be resistant to deterioration by cycles of wetting, drying, freezing, and thawing.

Reclaimed hydraulic cement concrete may be used in non-watercourse applications.

Gabion stone, rip-rap and rock protection shall meet the physical property requirements shown in Table 7 and the gradation requirements shown in Table 8.

1004.05.06 Truck Arrester Bed Aggregate

Truck arrester bed aggregate shall be pit-run material meeting the physical property requirements shown in Table 9 and the gradation requirements shown in Table 10. In addition, truck arrester bed aggregate shall meet the following shape requirements:

- a) Rounded particles shall be a minimum of 30% by mass. Rounded particles shall be determined by the procedure given in LS-607, reporting the percentage of rounded particles instead of crushed particles. The test specimen size shall be a minimum of 3,000 g passing the 26.5 mm sieve and retained on the 19 mm sieve.
- b) Spheroidal particles shall be a minimum of 50% by mass. Spheroidal particles shall be determined by the procedure given in LS-608, using a figure-eight calliper in which the ratio of the opening at one end to that at the other end is 2:1 instead of 4:1. The test specimen size shall be a minimum of 3,000 g passing the 26.5 mm sieve and retained on the 19 mm sieve.

1004.05.07 Winter Sand

Winter sand shall meet the physical property requirements shown in Table 11 and the gradation requirements shown in Table 12.

1004.07 PRODUCTION

1004.07.01 Aggregate Processing, Handling, and Stockpiling

Aggregates separated during processing shall be placed in individual stockpiles. Processed aggregates secured from different sources and aggregates from the same source but of different gradations shall be placed in individual stockpiles.

Aggregates that have become mixed with foreign matter of any description or aggregates from different stockpiles that have become mixed with each other shall not be used and shall be removed from the stockpile immediately.

1004.08 QUALITY ASSURANCE

1004.08.01 General

Each aggregate, with the exception of mortar sand, shall be randomly sampled in lots according to Table 13.

When the quantity of aggregate material is insufficient for a complete lot and the quantity is:

- a) Less than one-half the quantity of a complete lot, then that quantity shall be added to the previous lot.
- b) Greater than or equal to one-half the quantity of a complete lot, then that quantity shall form its own lot.

Mortar sand shall be sampled and tested at the discretion of the Contract Administrator.

The Contract Administrator shall be allowed access to all sampling locations.

The laboratory designated by the Owner shall carry out testing for purposes of ensuring that aggregates used in the Work are according to the physical property and grading requirements of this specification. The Owner shall be responsible for all costs associated with testing for QA purposes, unless otherwise indicated in this specification. Individual test results shall be forwarded to the Contractor, as they become available.

Test data for each aggregate type shall be managed independently. When more than one source is used for supplying material, test data from each source and product shall be managed independently.

1004.08.02 Sampling

Sampling shall be according to LS-625 and taken at the time and location determined by the Contract Administrator. Samples shall be of sufficient mass to conduct the necessary gradation and physical property tests of the material. Minimum sample sizes for most aggregate types shall be according to Table 14.

Unless otherwise indicated, all QA samples shall be taken from individual stockpiles at the source. Each QA sample shall be treated as a discrete sample and not combined or blended with any other sample. When material contains blended or reclaimed aggregates or both, QA sampling shall be performed on the final blended product.

All samples shall be duplicate samples.

The Contractor shall provide new or clean sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. Metal or cardboard containers are unacceptable. QA samples shall be identified both inside and outside of the sample container. Data to be included with QA samples shall be according to the requirements of MTO Form PH-D-10.

At least one set of QA samples shall be obtained for each aggregate used in the Work. The Contract Administrator shall seal each QA sample container at the time and place of sampling.

The Contractor shall deliver all samples to the appropriate laboratory in a condition that is suitable for testing.

1004.08.03 Testing and Retention of Samples

When the Contract Administrator has elected to carry out QA testing, one of the duplicate samples shall be randomly selected for testing by the QA laboratory. The QA laboratory shall retain the remaining sealed sample for possible referee testing, if required.

1004.08.03.01 Winter Sand

Following delivery, winter sand shall be subject to a visual inspection of the stockpile to determine the presence of oversize material. Oversize particles may be confirmed with a 9.5 mm sieve.

1004.08.04 Acceptance

QA test results shall be used for acceptance purposes, except when referee testing of any aggregate or a visual examination of winter sand has been carried out.

When QA test results show that the material meets the applicable gradation and physical property requirements of this specification, the material shall be accepted.

When QA test results show that the material does not meet the applicable requirements of this specification, then all the aggregates in that lot shall be considered rejectable and removed from the Work at no cost to the Owner.

The Contract Administrator shall notify the Contractor that material represented by the test result shall not be accepted. This notification shall take place in writing within 3 Business Days of receipt of the non-conforming data.

1004.08.05 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator, within 5 Business Days following notification that the aggregate does not meet the requirements of this specification.

Referee testing shall be carried out, as specified herein and elsewhere in the Contract Documents.

The retained duplicate QA sample shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, then the Contractor shall be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates specified elsewhere in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

TABLE 1
Physical Property Requirements for Clear Stone

MTO Laboratory Test	MTO Test Number	Nominal Maximum Size			
		53 mm	19 mm		16 mm, 13.2 mm, and 9.5 mm
			Type I	Type II	
Wash Pass 75 µm Sieve, Guideline B, % maximum	LS-601	2.0	2.0	2.0	2.0
Percent Crushed Particles, % minimum	LS-607	-	50	60	60
Micro-Deval Abrasion, Coarse Aggregate, % maximum loss	LS-618	25	25	25	25

TABLE 2
Gradation Requirements for Clear Stone

Sieve Size	Gradation (LS-602), Percent Passing					
	Nominal Maximum Size					
	53 mm	19 mm		16 mm	13.2 mm	9.5 mm
		Type I	Type II			
63 mm	100	-	-	-	-	-
53 mm	90 - 100	-	-	-	-	-
26.5 mm	-	100	100	-	-	-
19.0 mm	0 - 15	90 - 100	90 - 100	100	-	-
16.0 mm	-	-	65 - 90	96 - 100	100	-
13.2 mm	-	-	-	67 - 86	96 - 100	100
9.5 mm	-	0 - 55	20 - 55	29 - 52	50 - 73	95 - 100
6.7 mm	-	-	-	-	-	20 - 45
4.75 mm	-	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10
75 µm	0 - 2.0	0 - 2.0	0 - 2.0	0 - 2.0	0 - 2.0	0 - 2.0

TABLE 3
Physical Property Requirements for Granular Sheeting

MTO Laboratory Test	MTO Test Number	Requirement
Petrographic Requirement, Fine Aggregate, Part A	LS-616	(Note 1)
Micro-Deval Abrasion, Coarse Aggregate, % maximum loss (Note 2)	LS-618	30
Micro-Deval Abrasion, Fine Aggregate, % maximum loss	LS-619	35
Plastic Fines	LS-631	NP

Notes:

1. For materials north of the French/Mattawa Rivers only: For materials with > 4.0% passing the 75 µm sieve, the amount of mica passing the 150 µm sieve and retained on the 75 µm sieve shall not exceed 10% of the material on that sieve. Prior data demonstrating compliance with this requirement shall be acceptable provided that such testing has been done within the past 5 years and the Contractor can show to the satisfaction of the Owner that field performance has continued to be acceptable.
2. The requirement for the coarse aggregate Micro-Deval abrasion loss test shall be waived if the material has more than 80% passing the 4.75 mm sieve.

TABLE 4
Gradation Requirements for Granular Sheeting

Sieve Size	Gradation (LS-602), Percent Passing
150 mm	100
26.5 mm	50 - 100
13.2 mm	35 - 100
9.5 mm	-
4.75 mm	20 - 80
1.18 mm	10 - 50
300 µm	5 - 25
150 µm	0 - 15
75 µm	0 - 8.0

TABLE 5
Physical Property Requirements for Mortar Sand

MTO Laboratory Test	Test Number	Requirement
Organic Impurities, Organic Plate Number	LS-610	3 (Note 1)
Mortar Strength Test	ASTM C 87/C87M	(Note 2)
Notes: 1. When the fine aggregate for use as mortar sand is subjected to this test, it shall not produce a darker colour than the standard solution or Organic Plate Number 3. However, a fine aggregate failing this test may be approved by the Owner, if it meets the requirements of the Mortar Strength Test according to ASTM C 87. 2. Mortar specimens comprised of fine aggregate for use as Mortar Sand and hydraulic cement shall develop a compressive strength at the age of 7 Days, of not less than 90% of the strength developed by a mortar prepared in the same manner, with the same cement and with graded Ottawa sand having a fineness modulus of 2.40 ± 0.10.		

TABLE 6
Gradation Requirements for Mortar Sand

Sieve Size	Gradation (LS-602), Percent Passing
4.75 mm	100.0
2.36 mm	95 - 100
1.18 mm	60 - 100
600 µm	35 - 80
300 µm	15 - 50
150 µm	2 - 15
75 µm	0 - 5.0

TABLE 7
Physical Property Requirements for Gabion Stone, Rip-Rap and Rock Protection

MTO Laboratory Test	Test Number	Gabion Stone and Rip-Rap	Rock Protection
Specific Gravity, minimum	ASTM D 6473 (Note 1)	2.50	2.50
Absorption, % maximum		2.0	2.0
Flat and Elongated Particles, % maximum	LS-608 (Note 2)	15	15
Micro-Deval Abrasion Coarse Aggregate, Grading A % maximum loss	LS-618 (Note 3)	25	25

Notes:

1. These requirements shall be based on the average test results for at least 5 pieces of rock when the source is macroscopically uniform or at least 8 pieces of rock when the source is macroscopically non-uniform. In addition, no individual piece of tested rock shall have a specific gravity less than 2.30 or an absorption greater than 3.5%.
2. These requirements shall be based on measurements taken of at least 20 randomly-chosen pieces of rock either in stockpile at the source or after being delivered to the site.
3. Testing using LS-618 may be carried out on another aggregate product that is being simultaneously produced from the same crushing stage as Rip-Rap, Gabion Stone or Rock Protection, as long as the other aggregate product being produced is sufficient for sampling and testing, according to the requirements of the procedure. As an example, if the Contractor can show that both Rip-Rap and Granular A which meets the requirements of OPSS 1010, are being simultaneously produced from a primary crusher, a sample of the Granular A may be used for acceptance testing, in-lieu of testing a sample of Rip-Rap.

TABLE 8
Gradation Requirements for Gabion Stone, Rip-Rap and Rock Protection

Mass kg	Approximate Dimension of an Equivalent Cube in cm (Note 1)	Gradation, percent less than mass specified (Note 2)				
		Gabion Stone		Rip-Rap		Rock Protection
		G-3	G-10	R-10	R-50	
330	50.0	-	-	-	-	100
75	30.5	-	-	-	100	↑ Well-Graded ↓
50	26.5	-	-	-	70 - 90	
25	21.0	-	-	-	40 - 55	
15	18.0	-	100	100	-	
10	15.5	-	90 - 100	70 - 90	-	
5	12.5	100	-	40 - 55	-	0 - 10
3	10.5	90 - 100	-	-	-	
2.5	10.0	-	0 - 5	-	0 - 15	
0.5	6.0	0 - 5	-	0 - 15	-	-

Notes:

1. These dimensions are for estimating purposes only and are based on material having a specific gravity of 2.65.
2. The gradation shall be determined by individually weighing a minimum of 20 randomly-chosen stone particles from a sample taken from the stockpile representing a lot then comparing the total mass of the stone particles within each fraction with the total mass of all of the stone particles measured in the sample. For pieces of rock with masses that are larger than 25 kg, the approximate dimension of the equivalent cube determined using an average of the three rectilinear measurements of the piece shall be allowed, in lieu of weighing.

TABLE 9
Physical Property Requirements for Truck Arrester Bed Aggregate

MTO Laboratory Test	MTO Test Number	Requirement
Wash Pass 75 µm Sieve, Guideline B, % maximum	LS-601	1.0
Absorption, % maximum	LS-604	2.0
Unconfined Freeze-Thaw, % maximum loss	LS-614	6
Micro-Deval Abrasion, Coarse Aggregate, % maximum loss	LS-618	21

TABLE 10
Gradation Requirements for Truck Arrester Bed Aggregate

Sieve Size Mm	Gradation (LS-602), Percent Passing
37.5	100
26.5	90 - 100
19.0	0 - 10

TABLE 11
Physical Property Requirements for Winter Sand

Laboratory Test	MTO Test Number	Requirement
Micro-Deval Abrasion, fine aggregate, % maximum loss	LS-619	25 (Note 1)
Notes: 1. When obtained from sources on St. Joseph Island, Manitoulin Island, or areas of Ontario south and west of a boundary delineated by the Severn River, Provincial Highway 12, and Provincial Highway 7 east of Highway 12.		

TABLE 12
Gradation Requirements for Winter Sand

Sieve Size	Gradation (LS-602), Percent Passing
9.5 mm	100.0 (Note 1)
6.7 mm	97 - 100
4.75 mm	90 - 100
2.36 mm	50 - 95
1.18 mm	20 - 90
600 µm	0 - 70
300 µm	0 - 35
150 µm	0 - 15
75 µm	0 - 5.0

Notes:

1. In addition to LS-602, this shall be confirmed by visual inspection of the stockpile.
2. The minimum size of the test sample shall be 5 kg. Following oven drying, the sample shall be sieved on the 9.5 mm, 6.7 mm, and 4.75 mm sieves. Material passing the 4.75 mm sieve shall be split to an appropriate size according to LS-602 for subsequent washing and fine sieving. The final grading shall be calculated according to LS-602 as the percentage of material passing each sieve based on the total mass of the oven dried sample.

TABLE 13
Lot Sizes

Aggregate Type	Units of Measurement	Physical Properties and Gradation (Based on Tender Quantities)		
Clear Stone	tonnes (t)	< 200 t: at CA's discretion	200 – 5000 t: One lot	> 5000 t: 5000 t lots
Gabion Stone	m ³ of gabion baskets	< 100 m ³ : at CA's discretion	100 – 1000 m ³ : One lot	> 1000 m ³ : 1000 m ³ lots
Granular Sheeting	m ²	< 200 m ² : at CA's discretion	200 – 5000 m ² : One lot	> 5000 m ² : 5000 m ² lots
Rip-Rap	m ²	< 200 m ² : at CA's discretion	200 – 5000 m ² : One lot	> 5000 m ² : 5000 m ² lots
Rock Protection	m ³	< 200 m ³ : at CA's discretion	200 – 5000 m ³ : One lot	> 5000 m ³ : 5000 m ³ lots
Truck Arrestor Bed	tonnes (t)	< 5000 t: One lot	> 5000 t: 5000 t lots	
Winter Sand	tonnes (t)	< 500 t: at CA's discretion	500-10000 t: One Lot	> 10000 t: 10000 t lots

TABLE 14
Sample Size Requirements

Aggregate	Nominal Maximum Size mm	Minimum Sample Size kg
Clear Stone	53	80
	19.0	20
	16.0	15
	13.2	15
	9.5	10
Granular Sheeting		25
Mortar Sand		10
RipRap / Gabion Stone / Rock Protection (for physical properties only)		25 (consisting of stone particles from 2 to 5 kg each)
Truck Arrestor Bed Aggregate		75
Winter Sand		10

Appendix 1004-A, November 2012
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



MATERIAL SPECIFICATION FOR AGGREGATES - WATERBODY

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This specification covers the requirements for aggregate materials placed in waterbodies.

1005.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Materials

OPSS 1001 Aggregates - General

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-602	Sieve Analysis of Aggregates
LS-618	Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-619	Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-625	Guidelines for Sampling of Aggregate Materials
LS-630	Determination of the Amount of Contamination of Coarse Aggregate

MTO Forms:
PH-CC-112 Waterbody Materials Worksheet
PH-D-10 Aggregate Sample Data Sheet

Designated Sources for Materials (DSM)
DSM #3.05.25 Aggregates: Surface Friction Courses

MTO Aggregate Sources Lists (ASL):
Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates
Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates

ASTM International

D 6473-10 Standard Test Method for Specific Gravity and Absorption of Rock for Erosion Control

1005.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 182 and the following definitions apply:

Deleterious Material means as defined in OPSS 1001.

Unacceptable Material means earth, humus, clay or other coatings, clay lumps, shale or shaley partings, deleterious materials, or deleterious substances, reclaimed asphalt pavement, reclaimed hydraulic cement concrete, glass, ceramics, or any other reclaimed or slag materials.

1005.05 MATERIALS

1005.05.01 General

The requirements of OPSS 1001 shall apply to this specification.

All waterbody materials shall consist of clean, hard, durable, natural particles that are free of unacceptable materials.

Waterbody materials for the WB-100 and smaller gradation bands, shall consist of naturally-formed, rounded or sub-rounded materials obtained from pit sources. Waterbody materials with top sizes larger than the gradation band for WB-100 may come from pit sources, quarry sources or both, unless otherwise specified in the Contract Documents.

When any change in the character of the aggregate occurs or when the performance of an aggregate meeting the requirements of this specification is found to be unsatisfactory, use of that aggregate shall be discontinued until a reappraisal with the approval of the Contract Administrator proves the source to be satisfactory.

1005.05.02 Physical Properties

All waterbody materials shall meet the requirements of Table 1.

In addition, all waterbody materials shall meet the requirements shown in Table 2 unless one of the following applies:

- a) Material is from a source on:
 - i. the ministry's DSM list; or

- ii. Ontario Ministry of Transportation Structural Concrete Aggregate Sources List; or
- iii. Concrete Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates.

Or;

b) Acceptance by the Owner based on a written request for consideration containing all the following:

- i. Prior testing results demonstrating the physical requirements are as specified in Table 2.
- ii. The testing has been done within 12 months of the material being used in the Work.
- iii. Field performance has continually been satisfactory.

1005.05.03 Gradation or Size and Mass

All waterbody materials shall be according to Tables 3, 4, and 5, for gradation or size and mass requirements.

For each waterbody material of WB-400 and larger:

- a) The largest rectilinear dimension of every boulder shall be no more than 1.5 times the average of its 2 smallest rectilinear dimensions (i.e. for an equivalent rectangular prism); and
- b) At least 80% of the boulders, by mass, shall have an average of their two smallest rectilinear dimensions (i.e. for an equivalent rectangular prism), no larger than the designated size and no smaller than 60% of the designated size.

1005.07 PRODUCTION

1005.07.01 Aggregate Processing, Handling, and Stockpiling

Aggregates separated during processing shall be placed in individual stockpiles. Processed aggregates secured from different sources and aggregates from the same source, but of different gradations shall be placed in individual stockpiles.

Aggregates that have become mixed with foreign matter of any description or aggregates from different stockpiles that have become mixed with each other shall not be used and shall be removed from the stockpile immediately.

1005.08 QUALITY ASSURANCE

1005.08.01 General

The total quantity of each different waterbody material type from each source location shall represent an individual lot.

The Contract Administrator shall be permitted access to all sampling locations.

Unless specified in the Contract Documents, testing shall be carried out for the purpose of ensuring that the waterbody materials used in the Work are according to the physical property and gradation requirements.

Test data for each waterbody material type shall be managed independently according to an individual lot.

1005.08.02 Sampling

Sampling shall be according to LS-625 and taken at the time and location determined by the Contract Administrator. Samples shall be of sufficient mass to conduct the necessary gradation and physical property tests of the material. Minimum sample sizes for each waterbody material type, up to the WB-350 gradation, shall be as shown in Table 6.

Unless specified in the Contract Documents, all samples shall be randomly taken from sampling pads constructed from individual stockpiles that is intended for use in the Work. Suitable stockpile locations include the Working Area and the source. Each sample shall be treated as a discrete sample and not combined or blended with any other sample.

All samples, representing an individual lot of waterbody material, shall be duplicate samples. At least one set of duplicate samples shall be obtained for each waterbody material item used in the Work.

The Contractor shall provide new or clean containers for sampling. Sample containers shall be constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. Metal or cardboard containers are unacceptable. Samples shall be identified both inside and outside of the sample container. Data to be included with samples shall be according to the requirements of MTO Form PH-D-10, Aggregate Sample Data Sheet.

Medium to large boulders, as specified in Table 5 shall be randomly chosen for sampling, at the discretion of and at the location determined by the Contract Administrator.

Unless specified in the Contract Documents, testing for physical properties shall be completed. For WB-350 and larger waterbody materials, duplicate sawed portions of individual boulders may be required as specified in Table 2.

1005.08.03 Testing and Retention of Samples

1005.08.03.01 General

One of the duplicate samples of waterbody materials shall be randomly selected for testing.

1005.08.03.02 Designated Laboratory

Unless specified in the Contract Documents, the laboratory designated by the Owner shall carry out the following testing:

- a) Testing of physical properties and gradation for WB-53 and smaller, as specified in Tables 1, 2 and 3.
- b) Testing of physical properties for WB-100 and larger as specified in Table 2.

The laboratory shall retain the remaining sealed samples for referee testing if it is invoked.

1005.08.03.03 Contract Administrator

1005.08.03.03.01 General

The Contract Administrator shall carry out the testing within the Working Area or the source.

The remaining sealed samples shall be retained for referee testing if it is invoked.

1005.08.03.03.02 Examination of stockpiles

Examination of stockpiles of waterbody materials for unacceptable materials and contamination as specified in Table 1.

1005.08.03.03.03 Mass Gradation

Mass gradation for WB-100, WB-200 and WB-350 shall be according to Table 4.

The mass gradation shall be determined by individually weighing a minimum of 20 randomly-chosen cobbles and boulders from a sampling pad, constructed according to LS-625, from the stockpiled material that's intended for use and then comparing the mass of the stone particles within each specified fraction of the mass gradation with the total mass of all of the stone particles that were measured for that sample. That information shall be recorded on Form PH-CC-112.

For a boulder with a mass larger than 25 kg, its approximate mass may be determined by multiplying the average of its three rectilinear dimensions (i.e. for an equivalent rectangular prism) by the average specific gravity for the same waterbody material, determined according to Notes 1 and 2 of Table 2.

1005.08.03.03.04 Measurements

Measurements for WB-400 and larger shall be according to Table 5.

For each waterbody material type in Table 5, the dimensions for a minimum of 20 randomly-chosen boulders, that are intended for use, shall be recorded on Form PH-CC-112.

1005.08.04 Acceptance

QA test results shall be used for acceptance purposes, except when referee testing has been carried out.

When QA test results for the sample representing an individual lot shows that the material meets the applicable physical property, gradation, size and mass requirements of this specification, the lot shall be accepted.

When QA test results show that the material does not meet the applicable requirements of this specification, then all the aggregates in that lot shall be considered rejected and shall be removed from the Work at no additional cost to the Owner.

The Contract Administrator shall notify the Contractor that material represented by the test result is not acceptable. This notification shall take place in writing within 3 Business Days of receipt of the non-conforming data.

1005.08.05 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator within 5 Business Days following notification that the aggregate does not meet the requirements of this specification.

Referee testing shall be carried out, as specified herein and elsewhere in the Contract Documents.

The retained duplicate QA sample shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted based on the referee test results, then the Contractor shall be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates specified in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

1005.08.05.01 Referee Testing Directly After QA Testing

Upon receiving the Contractor's written request, the Contract Administrator may elect to carry out the referee testing for mass gradation or measurements directly after the QA testing.

1005.08.05.01.01 Referee Testing for Mass Gradation

The Contract Administrator shall carry out the referee testing for mass gradation according to the Mass Gradation clause.

1005.08.05.01.02 Referee Testing for Measurements

The Contract Administrator shall carry out the referee testing according to the Measurements clause.

TABLE 1
Mandatory Physical Property Requirements for Waterbody Materials

Description of Test	Test Number	WB-6.7	WB-13.2	WB-19	WB-37.5	WB-53	WB-100	WB-200	WB-350	WB-400	WB-500	WB-750	WB-1000	WB-1250	WB-1500
Loss by Washing, Pass 75 µm Sieve, Guideline A, % Maximum	LS-601	5.0	2.0	2.0	-	2.0	-								
Amount of Contamination, % Maximum	LS-630	0.5	0.5	0.5	0.5	0.5	-								
Notes: A. Stockpiles of any waterbody materials intended for use in the Work shall not contain any visible unacceptable materials and contamination.															

TABLE 2
Physical Property Requirements for Waterbody Materials

Description of Test	Test Number	WB-6.7	WB-13.2	WB-19	WB-37.5	WB-53	WB-100	WB-200	WB-350	WB-400	WB-500	WB-750	WB-1000	WB-1250	WB-1500
Specific Gravity, Minimum	ASTM D6473 or LS-604 (Notes 1 & 2)	-	-	-	-	-	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Absorption, % Maximum		-	-	-	-	-	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Absorption, % Maximum	LS-604	2.0	2.0	2.0	2.0	2.0	-	-	-	-	-	-	-	-	-
Micro-Deval Abrasion Coarse Aggregate Loss, Grading A % Maximum	LS-618	-	30	30	30 (Note 3)	30	30 (Note 4)	-	-	-	-	-	-	-	-
Micro-Deval Abrasion Fine Aggregate Loss, % Maximum	LS-619	35	-	-	35	-	-	-	-	-	-	-	-	-	-

Notes:

1. These requirements shall be based on the average test results for at least five cobbles, boulders or sawed portions of individual boulder of WB-350 and larger, where the source appears lithologically uniform or at least eight cobbles or boulders or sawed portions of individual boulder of WB-350 and larger, where the source appears lithologically non-uniform. The cobbles or boulders, to be tested, shall be randomly sampled, as specified in Notes 1, 2, and 3 of Table 6. Each sawed portion shall be a minimum of 2kg. In addition, no individual piece of tested rock shall have a specific gravity less than 2.30 or an absorption greater than 3.5%.
2. ASTM D6473 shall be used for acceptance for WB-100 and larger, unless written notification to the Contract Administrator to replace it with LS-604 for acceptance is received prior to sampling of the applicable materials for QA purposes. Provided the Contract Administrator has received such a request, LS-604 shall be performed on another aggregate product or on a WB-53 or smaller, if it is being simultaneously produced from the same formation and location within a pit or a quarry as the WB-100 and larger. Otherwise, conformance to ASTM D6473 shall be required.
3. This requirement shall be waived if the material has more than 80% passing the 4.75 mm sieve.
4. Testing may be carried out on another aggregate product or on a WB-53 or smaller, if it is being simultaneously produced from the same formation and location within a pit or a quarry as the WB-100, as long as the quantity of the other aggregate product being produced is sufficient for sampling and testing using LS-618. For example, if it can be demonstrated that the cobbles used to produce WB-100 are the oversize for the simultaneous production of a coarse granular material or a WB-37.5 which has a LS-618 Micro-Deval Abrasion Loss of no more than 30%, then the WB-100 cobbles being simultaneously produced with that granular material or the WB-37.5 shall also be considered to meet the requirements of LS-618.

TABLE 3
Gradation Requirements for Sand and Gravel Used for Waterbody Materials,
Percent Passing

Sieve Size mm	Gradation (LS-602) of Waterbody Materials % Less Than Sieve Size Specified				
	WB-6.7	WB-13.2	WB-19	WB-37.5	WB-53
63.00	-	-	-	-	100
53.00	-	-	-	100	90-100
37.50	-	-	-	90-100	-
26.50	-	-	100	50-100	-
19.00	-	-	90-100	-	0-15
16.00	-	100	-	-	-
13.20	-	96-100	-	-	-
9.50	100	50-73	0-55	30-100	-
6.70	97-100	-	-	-	-
4.75	90-100	0-10	0-10	20-100	-
2.36	50-95	-	-	-	-
1.18	20-90	-	-	10-100	-
0.60	0-70	-	-	-	-
0.30	0-35	-	-	2 - 65	-
0.15	0-15	-	-	-	-
0.07	0-5	0-2	0-2	0-8	0-2

TABLE 4
Mass Gradation Requirements for Cobbles and Small Boulders
Used as Waterbody Materials

Gradation %, By Mass, Less Than Mass Specified				
Maximum 2 nd Smallest Dimension of an Equivalent Rectangular Prism (mm)	Mass of Gravel/Cobble /Boulder (kg)	WB-100	WB-200	WB-300
350	97	-		100
300	60	-		75-100
200	18	-	100	20-40
150	7.7	-	40-60	0-15
100	2.3	100	0-10	-
63	0.55	40-60	-	-
53	0.35	0-10	-	-

TABLE 5
Medium to Large Boulders Used For Waterbody Materials

Size	WB-400	WB-500	WB-750	WB-1000	WB-1250	WB-1500
Designated Size (i.e. the Average of the Two Smallest Dimensions of an Equivalent Rectangular Prism) (mm)	400	500	750	1000	1250	1500
Average Approximate Mass of Boulders (kg) (Note 1)	145	285	955	2265	4425	7645
Note: 1. The mass of any individual boulder, will vary significantly from the stated values, depending on its shape (e.g. cubical, prism, sphere, oblate spheroid etc.) and actual dimensions.						

TABLE 6
Sample Size Requirements

Waterbody Material Designation	Minimum Sample Size for Physical Properties Testing kg (Note 1)
WB-6.7	10
WB-13.2	20
WB-19	20
WB-37.5	40
WB-53	80
WB-100	25 (Note 2)
WB-200	75 (Note 3)
WB-350	150 (Note 3)
WB-400, WB-500, WB-750, WB-1000, WB-1250 and WB-1500	(Note 3)
Notes: 1. Individual sample bags shall not exceed 25 kg. For a boulder with a mass larger than 25 kg, the boulder shall be cut using a portable diamond saw by the contractor to produce duplicate sample portions for testing. 2. Each duplicate sample shall consist of at least five cobbles from lithologically uniform sources or at least eight cobbles from lithologically non-uniform sources and no cobble shall have a mass less than 0.4 kg. 3. Each duplicate sample shall consist of at least five cobbles, boulders or sawed portions of individual boulder of WB-350 and larger from lithologically uniform sources or at least eight cobbles, boulders or sawed portions of individual boulder of WB-350 and larger from lithologically non-uniform sources.	



MATERIAL SPECIFICATION FOR AGGREGATES - SURFACE TREATMENT

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1006.01 SCOPE

This specification covers the requirements for aggregates for use in surface treatment.

1006.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1006.01.02

Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1006.02

REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Materials

OPSS 1001 Aggregates - General

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

- LS-601 Material Finer than 75 μm Sieve in Mineral Aggregates by Washing
- LS-602 Sieve Analysis of Aggregates
- LS-604 Relative Density and Absorption of Coarse Aggregate
- LS-606 Soundness of Aggregate by Use of Magnesium Sulphate
- LS-607 Percent Crushed Particles in Processed Coarse Aggregate
- LS-608 Percent Flat and Elongated Particles in Coarse Aggregate
- LS-609 Petrographic Analysis of Coarse Aggregate
- LS-613 Determination of Insoluble Residue of Carbonate Aggregates
- LS-614 Freezing and Thawing of Coarse Aggregate
- LS-618 The Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- LS-619 Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- LS-625 Guidelines for Sampling of Granular Materials
- LS-631 Qualitative Determination of Presence of Plastic Fines in Aggregates

MTO Forms:

PH-D-10 Aggregate Sample Data Sheet

1006.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Duplicate Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Lot means a specific quantity of material from a single source.

Physical Property means an inherent attribute or feature of an aggregate material. Tests are carried out to determine an aggregate's resistance to weathering or degradation or both. Aggregate production processes generally do not affect physical properties.

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that Materials received from the Contractor meet the requirements specified in the Contract Documents.

Slag means for the purposes of this specification, fused silicate material from the processing of ores and includes air-cooled blast furnace slag, blast furnace slag, copper slag, nickel slag, and steel slag.

1006.05

MATERIALS

1006.05.01

Aggregates

Aggregates shall be according to OPSS 1001, unless otherwise specified in this specification.

Aggregates shall be clean, hard durable particles produced from sands, gravels, or quarried rock and shall be free of earth, humus, clay coatings, and clay lumps or fragments of any size or shape.

Aggregates containing slag or composed of slag shall not be acceptable for use as surface treatment aggregates.

At the discretion of the Owner, aggregate may be accepted or rejected for physical properties on the basis of past field performance, according to Note 1 shown in Table 1.

When any change in the character of the aggregate occurs or when the performance of aggregate meeting the requirements of this specification is found to be unsatisfactory, use of that aggregate shall be discontinued until a reappraisal by the Contractor, with the approval of the Contract Administrator, proves the source to be satisfactory.

1006.07

PRODUCTION

1006.07.01

Aggregate Processing, Handling, and Stockpiling

Aggregates separated during processing, aggregates secured from different sources, and aggregates from the same source but of different gradations shall be stockpiled separately. When screenings from primary and secondary crushers are produced separately, they shall be stockpiled separately.

Aggregates that have become mixed with foreign matter of any description or aggregates from different stockpiles that have become mixed with each other shall not be used and shall be removed from the stockpile immediately.

1006.08 QUALITY ASSURANCE

1006.08.01 General

The laboratory designated by the Owner shall carry out QA testing for purposes of ensuring that the aggregates used in the Work are according to the physical property and grading requirements of this specification. The Owner shall be responsible for all costs associated with testing for QA purposes, unless otherwise specified in the Contract Documents. Individual test results shall be forwarded to the Contractor, as they become available.

When a hydrated lime anti-stripping agent is used, test samples for the physical property requirements shall be taken prior to the addition of the hydrated lime. If this is not practical, samples coated in hydrated lime may be taken and the lime removed by washing prior to testing. In this case, the requirements for LS-601 shall be waived.

QA acceptance of aggregates for surface treatment shall be based on lots that are sampled and tested for both physical properties and gradation.

1006.08.02 Alternative to LS-614

LS-614 shall be used for acceptance, unless written notification to the Contract Administrator to replace it with LS-606 for acceptance is received prior to sampling of the applicable materials for QA purposes. Provided the Contract Administrator has received such a request, LS-606 shall be used. Otherwise, conformance to LS-614 shall be required.

When notification is provided after QA testing using LS-614 has been initiated, the Contractor shall then be charged \$600.00 for each test initiated, which includes the cost of the testing using LS-614, administrative charges, and additional sampling, if required.

1006.08.03 Sampling

Aggregates to be used in the Work shall be made available for sampling a minimum of 3 weeks prior to the time of intended use. The Contract Administrator shall have access to all sampling locations at any time with notice to the Contractor. The stockpiles from which the samples are to be taken shall contain at least 10% of the total quantity of aggregate needed or a minimum quantity of 500 tonnes or 250 m³, whichever is greater, unless otherwise directed by the Contract Administrator.

All samples shall be duplicate samples obtained from stockpiles according to LS-625 and all other requirements stated elsewhere in the Contract Documents.

For physical properties, at least one set of QA samples of each aggregate and from each individual source shall be randomly sampled from lots according to the schedule shown in Table 1.

For production properties, lots according to the schedule shown in Table 1 shall be divided into four sublots of approximately equal tonnage. One duplicate QA sample shall be randomly obtained from each subplot.

Duplicate QA samples with a minimum mass of 25 kg shall be taken from the stockpiles. Each bag or container shall hold no more than 30 kg of material.

The Contractor shall provide new or clean sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. Metal or cardboard containers are unacceptable. The Contract Administrator shall seal each QA sample container at the time and place of sampling.

QA samples shall be identified both inside and outside of the sample container. Data to be included with QA samples shall be according to MTO form PH-D-10.

In the event that the Contractor is unavailable to take the samples, no further materials shall be placed in the Work until they have been taken.

One of the duplicate QA samples shall be randomly selected for testing by the QA laboratory. The QA laboratory shall retain the remaining sample for referee testing, if required.

1006.08.04 Acceptance

The acceptability of a lot of aggregates for surface treatment may result in payment at full price, payment at a reduced price, or rejection.

Irrespective of the negotiation of a reduced price payment, the warranty provisions of the Contract Documents shall apply.

1006.08.04.01 Acceptance of Physical Properties

A lot of aggregates shall be deemed to be acceptable for physical properties if all of the test results for the samples representing that lot meet all of the requirements shown in Table 2.

If a tested sample of aggregates representing a lot does not meet all of the requirements of this specification, then a reduced price payment of 20% shall be given for that lot, as long as the applicable test results for that sample do not:

- a) Exceed the requirement for LS-614, or LS-606 if it has been accepted by the Owner as an alternative to LS-614, by more than 25% of the specified value.
- b) Exceed the requirement for LS-618 by more than 10% of the specified value.
- c) Exceed the requirement for LS-619 by more than 15% of the specified value.
- d) Identify plastic fines within the material, when determined according to LS-631 and meet the requirements for LS-602 on the 75 µm sieve.
- e) Exceed 10% of the specified value for any other requirement stated in this specification.

Should the test results for the sample not meet all of the requirements listed above, then all of the aggregates within that lot shall be considered rejectable and any surface treatment that includes those aggregates shall be removed from the Work at no cost to the Owner.

1006.08.04.02 Acceptance of Production Properties Based on LS-602 and LS-607

Test results from each subplot within a lot shall be combined to determine the mean and the range of the lot for each test.

All lot means and ranges for test results carried out according to LS-602 and LS-607 shall be computed to one decimal place and reported on the MTO Form PH-D-ST by the Contract Administrator.

The acceptability of a lot based on LS-602 and LS-607 may result in payment at full price, payment at a reduced price or rejection.

A complete or incomplete lot shall be deemed to meet the applicable requirements for LS-602 and LS-607, if the mean of the test results for that lot is within the limits specified in Table 3 and the range of the test results for that lot is within the limits specified in Table 5.

Lots that are subject to a total payment adjustment factor of more than 25 percent in respect of lot mean and range are deemed to be rejected and shall be removed from the Work at no cost to the Owner.

When the Contractor chooses to use a lot or incomplete lot that does not meet the requirements of LS-602 and LS-607 and is not subject to removal then, at the request of the Contractor, a payment adjustment calculated according to the following formula shall be allowed:

$\text{PAYMENT REDUCTION} = \text{lot quantity in tonnes (or m}^3\text{)} \times \text{item price in \$/tonne (or \$/m}^3\text{)} \times \text{payment adjustment factor (\%)}$,

where:

The lot quantity shall be expressed in tonnes (or m³) and the item price shall be the contract price for the tender quantity in tonnes (or m³).

The payment adjustment factor, in percent for production properties, shall be equal to the sum of the adjustment points determined as follows:

- a) adjustment points shall be applied for each 0.1 percent that the mean gradation falls outside the gradation specification limits for each sieve, according to Table 4,
- b) 0.1 adjustment points shall be applied for each 0.1 percent that the range exceeds the maximum acceptable range for each sieve, according to Table 5; and
- c) 0.2 adjustment points shall be applied for each 0.1 percent that the lot mean falls below the applicable limits for percent crushed.

The reduced price payment for the lot given above shall be in addition to any payment reduction determined according to the Acceptance of Physical Properties clause.

1006.08.05 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator within 5 Business Days following notification that the aggregate does not meet the requirements of this specification.

Referee testing shall be carried out as specified herein and elsewhere in the Contract Documents.

The retained QA samples shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, the Contractor shall then be responsible for the cost of referee testing of that lot, including the cost of transporting the samples to the referee laboratory at the rates specified elsewhere in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

TABLE 1
Lot Schedule for Sampling and Testing

Quantity from Each Source In tonnes (or m ³)	Class 1, 2, 3, 4, 5, and 6
< 500 t (or <250 m ³)	Sampling and testing may be waived at the discretion of the Owner.
500 t to 5,000 t (or 250 to 2,500 m ³)	One lot for both physical properties and gradation.
> 5,000 t (or > 2,500 m ³) (Note 1)	Gradation: 5,000 tonne lots up to 20,000 tonnes and 10,000 tonne lots thereafter (or 2,500 m ³ lots up to 10,000 m ³ and 5,000 m ³ lots thereafter) Physical Properties: 20,000 tonne lots (or 10,000 m ³ lots)
Notes: 1. When the quantity of granular material is insufficient for a complete lot and is: a) less than one-half the quantity of a complete lot, that quantity shall then be added to the previous lot; or b) greater than or equal to one-half the quantity of a complete lot, then that quantity shall form its own lot.	

TABLE 2
Physical Property Requirements

MTO Laboratory Test	MTO Test No.	Class 1 (Note 1)	Class 2 (Note 1)	Class 3 (Note 1)	Class 4	Class 5 (Note 1)	Class 6 (Note 1)
Wash Pass 75 µm sieve, Guideline B, % maximum	LS-601	1.3 (Note 2)	--	1.3 (Note 2)	--	1.3 (Note 2)	1.3 (Note 2)
Absorption, % maximum	LS-604	1.75	--	2.0	--	1.75	1.75
Flat and Elongated Particles, % maximum	LS-608	20	20	20	--	20	20
Petrographic Examination, % non-carbonate of retained 4.75 mm, minimum	LS-609	60 (Note 3)	60 (Note 3)	60 (Note 3)	--	60 (Note 3)	60 (Note 3)
Unconfined Freeze-Thaw, % maximum loss (Note 4)	LS-614	6	15	6	--	6	6
Micro-Deval Abrasion (Coarse Aggregate), % maximum loss	LS-618	17	25	17	--	17	17
Micro-Deval Abrasion (Fine Aggregate), % maximum loss	LS-619	--	30	--	25	--	--
Plastic Fines	LS-631	--	NP	--	NP	--	--
Alternative Requirement to Unconfined Freeze-Thaw Loss, LS-614							
Magnesium Sulphate Soundness (coarse aggregate), % max loss	LS-606	12	15	12	--	12	12
Notes: 1. With the exception of LS-619 and LS-631, the physical property requirements for Class 1, 2, 3, 5, and 6 aggregates noted above shall be conducted on the material retained on the 4.75 mm sieve. 2. When quarried rock is used as a source of coarse aggregate, a maximum of 2.0% passing the 75 µm sieve shall be permitted. 3. The requirements listed below are only applicable to the area to the north and west of a boundary defined by the north shore of Lake Superior, the north shore of the St. Mary's River, the south shore of St. Joseph's Island, the north shore of Lake Huron easterly to the north and east shore of Georgian Bay, excluding Manitoulin Island, along the Severn River to Washago and a line easterly passing through Norland, Burnt River, Burleigh Falls, Madoc, and hence easterly along Highway 7 to Perth and northerly to Calabogie and easterly to Arnprior and the Ottawa River: a) When the coarse aggregate for use in surface treatment is obtained from a gravel pit or quarry containing more than 40% carbonate rock type (e.g., limestone and dolostone) then blending with aggregate from non-carbonate rock types shall be required to increase the minimum non-carbonate rock type content of the coarse aggregate to 60%, as determined by petrographic examination, LS-609. In cases of dispute, LS-613 shall be used with a minimum acid insoluble residue of 60%. b) When the coarse aggregate for use in surface treatment is obtained from a non-carbonate source, blending with aggregate from carbonate rock types is not permitted. 4. The Owner shall waive the requirements for LS-614, unconfined freeze-thaw, provided the Contractor has submitted a written request that the coarse aggregates meet the alternative requirements for LS-606, magnesium sulphate soundness.							

TABLE 3
Production Requirements

Lab Test Description	MTO Test Number	Class 1 (Note 1)	Class 2	Class 3	Class 4	Class 5 (Note 1)	Class 6
Sieve Analysis	LS-602	% Passing By Mass					
	Sieve Size						
	19.0 mm	--	100	100	--	--	--
	16.0 mm	--	98-100	96-100	--	--	100
	13.2 mm	100	75-95	67-86	--	--	96-100
	9.5 mm	75-100	50-80	29-52	100	100	50-73
	6.7 mm	0-40	--	--	--	40-85	--
	4.75 mm	0-10	25-50	0-10	70-100	5-25	0-10
	2.36 mm	--	--	--	10-100	0-10	--
	1.18 mm	--	10-40	--	5-90	0-5	--
	600 µm	--	--	--	3-70	--	--
	300 µm	--	2-20	--	2-40	--	--
	150 µm	--	2-13	--	0-15	--	--
	75 µm	(Note 2)	2-7	(Note 2)	0-7	(Note 2)	(Note 2)
	Percent Crushed Particles	LS-607	% Minimum				
60			60	60	-	60	60
Notes: 1. Class 1 and Class 5 aggregates shall be washed according to OPSS 1001. 2. The requirements for percent passing the 75 µm for Class 1, 3, 5, and 6 aggregates are shown in Table 2.							

TABLE 4
Mean Requirements For Gradation (LS-602)

MTO Sieve Designation	Adjustment Points Per 0.1% Deviation from Specified Limit					
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
19.0 mm	--	0.1	0.1	--	--	--
16.0 mm	--	0.1	0.1	--	--	0.1
13.2 mm	0.1	0.1	0.1	--	--	0.1
9.5 mm	0.1	0.1	0.1	0.1	0.1	0.1
6.7 mm	0.1	--	--	--	0.1	--
4.75 mm	Excess Passing 0.5 / Insufficient Passing 0.2					
2.36 mm	--	--	--	--	0.1	--
1.18 mm	--	0.1	--	--	0.1	--
600 µm		--	--	0.1	--	--
300 µm	--	0.1	--	0.1	--	--
150 µm	--	0.1	--	0.1	--	--
75 µm	--	1.0	--	1.0	--	--

TABLE 5
Range Requirements For Gradation (LS-602)

MTO Sieve Designation	Maximum Acceptable Range					
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
19.0 mm	--	1	1	--	--	--
16.0 mm	--	2	4	--	--	1
13.2 mm	1	12	14	--	--	4
9.5 mm	20	14	16	1	1	14
6.7 mm	24	--	--	--	24	--
4.75 mm	8	14	5	18	14	6
2.36 mm	--	--	--	34	8	--
1.18 mm	--	14	--	34	4	--
600 µm	--	--	--	--	--	--
300 µm	--	12	--	22	--	--
150 µm	--	8	--	12	--	--
75 µm	--	4	--	6	--	--



**MATERIAL SPECIFICATION FOR
AGGREGATES - BASE, SUBBASE,
SELECT SUBGRADE, AND BACKFILL MATERIAL**

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APPENDICES

1010-A	Commentary

1010.01	SCOPE

This specification covers the requirements for granular aggregate materials for use in subgrade, subbase, base, gravel surface course, shouldering and bedding and backfill to sewers, culverts, and other structures.

1010.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1010.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1010.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications Material

OPSS 1001 Aggregates - General

Ontario Ministry of Transportation Publications

Laboratory Testing Manual:

LS-601	Material Finer than 75 µm Sieve in Mineral Aggregates by Washing
LS-602	Sieve Analysis of Aggregates
LS-607	Percent Crushed Particles in Processed Coarse Aggregate
LS-614	Freezing and Thawing of Coarse Aggregate
LS-617	Percent Particles with Two or More Crushed Faces and Uncrushed Particles in Processed Coarse Aggregate
LS-618	Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-619	Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-621	Determination of Amount of Asphalt Coated Particles in Coarse Aggregate
LS-625	Guidelines for Sampling of Granular Materials
LS-630	Determination of Amount of Contamination of Coarse Aggregates
LS-631	Qualitative Determination of Presence of Plastic Fines in Aggregates
LS-709	Determination of Permeability of Granular Soils

MTO Forms:

PH-D-1A	Granular A Gradation Computation Acceptance & Payment Adjustment Sheet
PH-D-1B	Granular B Types I, II & III Gradation Computation Acceptance & Payment Adjustment Sheet
PH-D-1M	Granular M Gradation Computation Acceptance & Payment Adjustment Sheet
PH-D-1O	Granular O Gradation Computation Acceptance & Payment Adjustment Sheet
PH-D-1SSM	SSM Gradation Computation Acceptance & Payment Adjustment Sheet
PH-D-10	Aggregate Sample Data Sheet

1010.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Bench means a ledge parallel to the stratigraphic bedding that, in quarries, forms a single level of operation above which rock is excavated from a contiguous face.

Delivery Sample means a random sample taken at the point of loading or discharge from delivery vehicles.

Duplicate Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Fines means material passing the 75 µm sieve when tested according to LS-601 or LS-602.

Gradation Test means a test used to determine the particle size distribution of an aggregate or soil material by sieving.

Lot means a specific quantity of material from a single source or a specified amount of construction assumed to be produced by the same process.

Mean means the arithmetic average of a set of data.

Physical Property means an inherent attribute or feature of an aggregate or soil material. Tests are carried out to determine a materials resistance to weathering or degradation or both. Physical properties are generally not affected by production.

Production Property means an attribute or feature of an aggregate or soil material, including gradation, that is introduced through the manufacturing process (i.e., crushing, screening, blending etc.). Tests are carried out to measure the affects of the process on the material.

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that Materials received from the Contractor meet the requirements specified in the Contract Documents.

Random Numbers means numbers generated by chance, and recorded in random number tables.

Random Sample means a sample based on random numbers so that any portion of a lot or subplot has an equal opportunity of being selected.

Range means the difference between the largest and the smallest measurements in a set of data.

Road Sample means a random sample taken from road construction after placement and spreading of the material in the work, but prior to compaction.

Steel Slag means the non-metallic product resulting from the production of steel in a basic oxygen furnace or an electric arc furnace.

1010.05 MATERIALS

1010.05.01 General

Aggregates for Granular A, O, B, M and SSM shall be according to OPSS 1001, unless otherwise specified in this specification, and shall conform to the requirements of Table 2 and Table 3 when tested according to the test methods identified herein.

Aggregates shall be clean, hard, durable particles and shall be produced from material free of earth, humus, clay coatings, and clay lumps or fragments of any size or shape. When tested according to LS-630, the total amount of wood shall not exceed 0.1% by mass, and the total amount of clay brick, gypsum, gypsum plaster wallboard and other contaminants shall not exceed a combined total of 1.0% by mass.

When reclaimed asphalt pavement (RAP), post-consumer glass or ceramic material is used, it shall be homogeneously blended in a manner acceptable to the Contract Administrator.

Steel slag shall not be used.

1010.05.02 Granular O

Aggregates for Granular O shall be produced from a quarry or from boulders, cobbles or gravel retained on the 50 mm sieve. Recycled or reclaimed materials, including hydraulic cement concrete, RAP, slag, glass, and ceramic are not permitted.

1010.05.03 Granular A and M

Aggregates for Granular A and M shall be produced from one or a blend of the following:

- a) Boulders, cobbles, gravel, sand, and fines from naturally formed deposits.
- b) A quarry or talus.
- c) Reclaimed hydraulic cement concrete.
- d) Iron blast furnace slag or nickel slag.

Granular A and M aggregates may include up to 30% by mass of asphalt coated particles derived from RAP, and not more than a combined total of 15% by mass of glass or ceramic material or both, unless specified elsewhere in the Contract Documents.

Granular A or M produced with RAP containing steel slag aggregates is acceptable for unpaved shouldering purposes only. Such materials shall be stockpiled separately.

1010.05.04 Granular B

Granular B may be of Type I, Type II, or Type III.

Aggregates for Granular B shall be aggregates produced from one or a blend of the following, subject to the following restrictions:

- a) Boulders, cobbles, gravel, sand, and fines from naturally formed deposits.
- b) A quarry or talus.
- c) Reclaimed hydraulic cement concrete.
- d) Iron blast furnace slag or nickel slag.

Aggregates for Granular B Type I and Type III may include up to 30% by mass of asphalt coated particles derived from RAP, and not more than a combined total of 15% by mass of glass or ceramic material or both. RAP containing steel slag aggregates shall not be permitted.

Aggregates for Granular B Type II shall only be produced from a quarry or from talus, iron blast furnace slag, or nickel slag. Recycled materials shall not be permitted.

1010.05.05 Select Subgrade Material (SSM)

Aggregates for select subgrade material shall be produced only from natural deposits of non-plastic silt, sand, and gravel material. Recycled or reclaimed materials of any type shall not be permitted.

1010.08 QUALITY ASSURANCE

1010.08.01 General

The laboratory designated by the Owner shall carry out QA testing for purposes of ensuring that aggregates used in the Work conform to the physical and production requirements of this specification. Individual test results shall be forwarded to the Contractor, as they become available.

The Owner shall be responsible for all costs associated with testing for QA purposes, unless otherwise specified in this specification.

QA testing for physical properties may be waived by the Contract Administrator when the delivered quantity of Granular A, O, B, M, or SSM is less than 5,000 tonnes.

1010.08.01.01 Sampling

QA samples shall be taken according to the Contract Documents and LS-625 and shall be road samples or delivery samples obtained from the Work at a location determined by the Contract Administrator. When required, the Contractor shall provide a front-end loader to obtain material for QA samples.

When it is not possible to take road or delivery samples, samples of compacted material taken with the permission of the Owner shall be used for QA acceptance purposes.

In the event that the Contractor is unavailable to take a sample, no further materials shall be placed in the Work until the required QA samples have been taken.

QA sampling and testing shall be based on lots that are established for each aggregate type; Granular A, O, B, M, and SSM. When more than one aggregate source is used, separate lots shall also be established for each source. When aggregates are produced from materials that are extracted from within the right-of way, each area within a 1,000 m segment of the right-of-way or within a radius of 500 m of the extraction operation located within the right-of-way shall be considered equivalent to a single aggregate source for QA acceptance purposes. When aggregates are produced with blended or reclaimed materials or both, QA testing shall be performed on the final product.

The Contractor shall provide new or clean sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. Metal or cardboard containers are unacceptable. QA samples shall be identified both inside and outside of the sample container. Data to be included with QA samples shall be according to MTO form PH-D-10.

The Contractor shall deliver all samples to the appropriate laboratory in a condition that is suitable for testing.

All QA samples shall be duplicate samples. One of the samples shall be randomly selected for testing by the QA laboratory and the remaining sample shall be retained by the QA laboratory for possible referee testing.

1010.08.01.02 Sample Size

The mass of the each QA sample shall meet the requirements shown in Table 4. When more than 30 kg of material is required, the total sample shall be recombined prior to testing.

1010.08.02 Physical Properties

At least one set of duplicate QA samples of each aggregate to be used in the Work shall be randomly sampled from lots of 25,000 tonnes or part thereof for physical properties. All materials delivered to the Work shall be included within a lot.

1010.08.02.01 Testing of Physical Properties

The QA laboratory shall carry out testing for each physical property requirement shown in Table 2, as applicable for each QA sample.

1010.08.02.02 Acceptance of Physical Properties

The acceptability of a lot for physical properties may result in payment at full price, payment at a reduced price, or rejection.

A lot shall be deemed to be acceptable for physical properties if all of the test results for the samples of aggregates representing that lot meet the requirements shown in Table 2.

If a tested sample of aggregates representing a lot does not meet all of the requirements shown in Table 2, then a reduced price payment of 20% of the tender price shall be given for that lot for physical properties, as long as the lot is not rejectable and the applicable test results for that sample:

- a) do not exceed the requirement for LS-614 by more than 25% of the specified value.
- b) do not exceed the requirement for LS-618 by more than 10% of the specified value.
- c) do not identify plastic fines within the material, when determined according to LS-631 and acceptance test results for LS-602 are not subject to a payment adjustment on the 75µm sieve.
- d) meet all other physical property requirements of this specification.

Should the test results for any sample of aggregates representing a lot not meet the requirements listed above, then all of the aggregates within that lot shall be considered rejectable and any of those aggregates used in the Work shall be removed at no cost to the Owner.

The reduced price payment for the lot given above shall be in addition to any payment reduction determined according to the Acceptance Based on LS-602 and LS-607 clause for production properties.

Irrespective of the negotiation of a reduced price payment, the warranty provisions of the Contract Documents shall apply.

1010.08.03 Production Properties

All lots for production properties shall be divided into four sublots of approximately equal tonnage and one duplicate QA sample shall be randomly obtained from each subplot.

For each tender item, the Contract Administrator shall estimate the quantities of granular materials obtained from each different source or process. Then, for each of those individual sources or processes, the Contract Administrator shall identify the number and size of each lot to be sampled and tested using the lot schedule shown in Table 1.

In addition, if circumstances such as the closure of the construction season or changes in production or delivery result in a lot not being completed, then the Contractor shall notify the Contract Administrator prior to the first sample is taken within that lot, in order for the Contract Administrator to adjust the subplot sizes equally to accommodate the reduced tonnage. If such notification is not given in time, then acceptance shall be based on the number of sampled sublots that are available for the incomplete lot. All lots shall be deemed to be complete at the end of each calendar year.

1010.08.03.01 Testing of Production Properties

The QA laboratory shall conduct sieve analysis according to LS-602 and determine test results for each sieve designation shown in Table 3. The QA laboratory shall also carry out testing for percent crushed particles according to LS-607, particles with two or more crushed faces according to LS-617, and amount of asphalt coated particles according to LS-621, as applicable.

1010.08.03.02 Acceptance of Production Properties

Test results from each subplot within a lot shall be combined to determine the mean and the range of the lot for each test.

1010.08.03.02.01 Acceptance Based on LS-602 and LS-607

All lot means and ranges for test results carried out according to LS-602 and LS-607, as applicable, shall be computed to one decimal place and reported on the appropriate MTO form by the Contract Administrator, as indicated below:

Granular A	PH-D-1A
Granular O	PH-D-1O
Granular B, Types I, II or III	PH-D-1B
Granular M	PH-D-1M
SSM	PH-D-1SSM

The acceptability of a lot based on LS-602 and LS-607 may result in payment at full price, payment at a reduced price, or rejection.

A complete or incomplete lot shall be deemed to meet the applicable requirements for LS-602 and LS-607, if the mean of the test results for that lot is within the limits shown in Table 3 and the range of the test results for that lot is within the limits shown in Table 5.

Lots that are subject to a total payment adjustment factor of more than 25% in respect of lot mean and range are deemed to be rejected and shall be removed from the Work at no cost to the Owner.

When a complete or incomplete lot does not meet the requirements of LS-602 and LS-607, is not subject to removal, but the Contractor chooses to use the lot or for some reason it cannot be totally excluded from the Work, then at the request of the Contractor, an adjusted payment calculated according to the following formula shall be allowed in lieu of removal:

PAYMENT REDUCTION = lot quantity (tonnes) x item price (\$/tonne) x payment adjustment factor (%)

Where:

The lot quantity shall be expressed in tonnes as determined according to Table 6, and the item price shall be according to one of the following:

- a) The contract price for the items having the tender quantity in tonnes.
- b) \$21.50 per tonne for Granular A, O, and M; \$15.50 per tonne for Granular B Type II; \$15.00 per tonne for Granular B Type I and Type III; and \$8.50 per tonne for SSM where bidding is not by tender quantity such as lump sum Contracts.

In addition, the payment adjustment factor, in percent, shall be equal to the sum of the adjustment points determined as follows:

- a) Adjustment points shall be applied for each 0.1% that the mean gradation falls outside the gradation specification limits for each sieve, according to Table 7.
- b) 0.1 adjustment points shall be applied for each 0.1% that the range exceeds the maximum acceptable range for each sieve.
- c) 0.2 adjustment points shall be applied for Granular A or M for each 0.1% that the lot mean falls below the applicable limits for percent crushed.

The reduced price payment for the lot given above shall be in addition to any payment reduction determined according to the Acceptance of Physical Properties clause.

1010.08.03.02.02 Acceptance Based on LS-617 or LS-621

A lot shall be deemed to meet the applicable requirements of this specification for LS-617 or LS-621, if the mean value of the test results for that lot is within the limits shown in Table 3. When the mean value of the test results for that lot does not meet these requirements, the material shall be considered deficient and managed according to the requirements specified elsewhere in the Contract Documents.

1010.08.04 Referee Testing

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator within 5 Business Days following notification that the lot does not meet the requirements of this specification.

Referee testing shall be carried out as specified herein and elsewhere in the Contract Documents.

The retained duplicate QA samples for all sublots shall be used for referee testing of the lot.

All referee test results shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, then the Contractor shall be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory at the rates specified elsewhere in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing of that lot.

Table 1
Lot Schedule for Sampling and Testing

Quantity for Each Source or Process (tonnes)	Gran A, O, and M	Granular B Type I, B Type II, B Type III, and SSM
< 1,000	Sampling and testing may be waived at the discretion of the Contract Administrator	
1,000 - 5,000	One lot	One lot
> 5,000 (Note 1)	5,000 tonne lots up to 20,000 tonnes, and 10,000 tonne lots thereafter	10,000 tonne lots up to 20,000 tonnes, and 20,000 tonne lots thereafter
Note: 1. When the quantity of granular material is insufficient for a complete lot and is: a) less than one-half the quantity of a complete lot, that quantity shall then be added to the previous lot; or b) greater than or equal to one-half the quantity of a complete lot, then that quantity shall form its own lot.		

Table 2
Physical Property Requirements

Laboratory Test	MTO Test Number	Granular					Select Subgrade Material
		A	B		M	O	
			Type I / Type III	Type II			
Unconfined Freeze-Thaw, % maximum loss	LS-614	-	-	-	-	15	-
Micro-Deval Abrasion (Coarse Aggregate), % maximum loss	LS-618	25	30 (Note 1)	30	25	21	30 (Note 1)
Micro-Deval Abrasion (Fine Aggregate), % maximum loss	LS-619	30	35	35	30	25	-
Amount of Contamination	LS-630	(Note 2)					
Plastic Fines	LS-631	NP (Non-Plastic)					
Determination of Permeability, k	LS-709	(Note 3)					
Notes:							
1. The coarse aggregate micro-Deval abrasion loss test requirement shall be waived if the material has more than 80% passing the 4.75 mm sieve. 2. Granular A, B Type I, B Type III, or M may contain up to 15% by mass crushed glass or ceramic material or both. Granular A, O, B Type I, B Type III, and M shall not contain more than 1.0% by mass of any combination of wood, clay brick, gypsum, gypsum wall board, or plaster. Granular B Type II and SSM shall not contain more than 0.1% by mass of wood. 3. For materials north of the French/Mattawa Rivers only, the coefficient of permeability, k shall be greater than 1.0×10^{-4} cm/s or alternatively, when past field experience has demonstrated satisfactory performance. Prior data demonstrating compliance with this requirement for k shall be acceptable provided that such testing has been done within 5 years of the material being used and field performance has continually been shown to be satisfactory.							

**Table 3
Production Requirements**

Lab Test	MTO Test Number	Granular						SSM
		A	B			M	O	
Sieve Analysis, % passing	LS-602 (sieve)		Type I (Note 2)	Type II	Type III (Note 2)			
	150 mm	-	100	-	100	-	-	100
	106 mm	-	-	100	-	-	-	-
	37.5 mm	-	-	-	-	-	100	-
	26.5 mm	100	50.0-100	50.0-100	50.0-100	-	95.0-100	50.0-100
	19.0 mm	85.0-100 (87.0-100) Note 3	-	-	-	100	80.0-95.0	-
	13.2 mm	65.0-90.0 (75.0-95.0) Note 3	-	-	-	75.0-95.0	60.0-80.0	-
	9.5 mm	50.0-73.0 (60.0-83.0) Note 3	-	-	32.0-100	55.0-80.0	50.0-70.0	-
	4.75 mm	35.0-55.0 (40.0-60.0) Note 3	20.0-100	20.0-55.0	20.0-90.0	35.0-55.0	20.0-45.0	20.0-100
	1.18 mm	15.0-40.0	10.0-100	10.0-40.0	10.0-60.0	15.0-40.0	0-15.0	10.0-100
	300 µm	5.0-22.0	2.0-65.0	5.0-22.0	2.0-35.0	5.0-22.0	-	5.0-95.0
	150 µm	-	-	-	-	-	-	2.0-65.0
	75 µm	2.0-8.0 (2.0-10.0) Note 4	0-8.0 (0-10.0) Note 4	0-10.0	0-8.0 (0-10.0) Note 4	2.0-8.0 (2.0-10.0) Note 4	0-5.0	0-25.0
Percent Crushed Particles, % minimum	LS-607	60	-	100	-	60	100	-
2 or more Crushed Faces, % minimum	LS-617	-	-	-	-	-	85 Note 5	-
Asphalt Coated Particles, Coarse Aggregates,% maximum	LS-621	30	30	0	30	30	0	0

Notes:

1. When Granular B is used for granular backfill for pipe subdrains, 100% of the material shall pass the 37.5 mm sieve.
2. When RAP is blended with Granular B Type I or Type III, 100% of the RAP shall pass the 75 mm sieve. Conditions in Note 1 supersede this requirement.
3. When the aggregate is obtained from an iron blast furnace slag source.
4. When the aggregate is obtained from a quarry or blast furnace slag or nickel slag source.
5. When Granular O is produced from boulders, cobbles, or gravel retained on the 50 mm sieve.

**Table 4
Sample Size**

Material	Minimum Mass of Field Samples, kg (Note 1)
Granular O, A, M; Granular B, SSM (100% passing 26.5 mm sieve)	25
Granular B, SSM	50
Notes: 1. Individual sample containers shall hold no more than 30 kg of aggregate. When more than 30 kg is required, additional sample containers shall be used.	

**Table 5
Range Requirements For Gradation (LS-602)**

MTO Sieve	Maximum Acceptable Range						
	Granular						SSM
	A	B Type I	B Type II	B Type III	M	O	
150 mm	-	1	-	1	-	-	1
106 mm	-	-	1	-	-	-	-
37.5 mm	-	-	-	-	-	1	-
26.5 mm	1	-	30.0	-	-	5.0	-
19.0 mm	8.0	-	-	-	1	8.0	-
13.2 mm	20.0	-	-	-	16.0	17.0	-
9.5 mm	20.0	-	-	-	18.0	17.0	-
4.75 mm	18.0	-	22.0	-	18.0	18.0	-
1.18 mm	18.0	-	18.0	-	18.0	12.0	-
300 µm	12.0	50.0	12.0	25.0	12.0	-	-
75 µm	5.0	7.0	5.0	7.0	5.0	4.0	15.0

**Table 6
Lot Quantity Determinations for Adjusted Payments**

Item	Road or Delivery Samples
Items having the tender quantity in tonnes.	The quantity measured for payment by weighing.
All other items.	The weighed quantity when available; otherwise the theoretical quantity calculated by the Contract Administrator using a conversion factor of 2.0 tonnes per cubic metre.

**Table 7
Adjustment Points**

MTO Sieve Designation	Adjustment Points Per 0.1% Deviation from Specified Limit				
	Granular A	Granular B	Granular M	Granular O	Select Subgrade Material
150 mm	-	0.1 (Note 1)	-	-	0.1
106.5 mm	-	0.1 (Note 2)	-	-	
37.5 mm	-	-	-	0.1	-
26.5 mm	0.1	0.1	-	0.1	0.1
19.0 mm	0.1	-	0.1	0.1	-
13.2 mm	0.1	-	0.1	0.1	-
9.5 mm	0.1	-	0.1	0.1	-
4.75 mm	Excess Passing 0.5 / Insufficient Passing 0.2				0.1
1.18 mm	0.1	0.1	0.1	0.1	0.1
300 µm	0.1	0.1	0.1	-	0.1
150 µm	-	-	-	-	0.1
75 µm	1.0	1.0	1.0	1.0	0.5
Notes: 1. Granular B Type I and Type III only. 2. Granular B Type II only.					

Appendix 1010-A, April 2013
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



**MATERIAL SPECIFICATION FOR
PERFORMANCE GRADED ASPHALT CEMENT**

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1101.01	SCOPE

This specification covers the requirements for the properties, use, and payment of performance graded asphalt cements.

1101.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt - End Result

Ontario Provincial Standard Specifications, Material

OPSS 1151 Superpave and Stone Mastic Asphalt Mixtures

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-100 Rounding-Off of Test Data and Other Numbers

LS-228 Accelerated Aging of Asphalt Cement Using Modified Pressure Aging Vessel Protocols

LS-299	Determination of Asphalt Cement's Resistance to Ductile Failure Using Double Edge Notched Tension Test (DENT)
LS-308	Determination of Performance Grade of Physically Aged Asphalt Cement Using Extended Bending Beam Rheometer (BBR) Method
LS-319	Determining the Cross-Over Temperature of Asphalt Cement
LS-320	Determining the Low Temperature Critical Spread of Asphalt Cement

American Association of State Highway and Transportation Officials (AASHTO)

M 320-17	Standard Specification for Performance Graded Asphalt Binder
R 29-15 (2019)	Grading or Verifying the Performance Grade of an Asphalt Binder
R 66-16	Sampling Asphalt Materials
T 350-19	Standard Method of Test for Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

ASTM International

D7643 - 16	Standard Practice for Determining the Continuous Grading Temperatures and Continuous Grades for PG Graded Asphalt Binders
D8078 - 18	Standard Test Method for Ash Content of Asphalt and Emulsified Asphalt Residues

1101.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Asphalt Binder means modified or unmodified asphalt cement.

Asphalt Cement Anti-Stripping Treatment (AST-AC) means as defined in OPSS 1151.

High Temperature Performance Grade (XX) means the high temperature performance grade specified in the Contract Documents and also referred to as the XX specified for the PGAC where the PGAC grade specified is PG XX-YY, and the maximum design pavement temperature.

Hot Mix Asphalt (HMA) means as defined in OPSS 313.

Lot means as defined in OPSS 313.

Low Temperature Limiting Grade (LTLG) means the warmest of the Limiting Grades, T_L obtained for 1 hour, 24 hours, 72 hours and the two conditioning temperatures according to LS-308, and Form B of LS-308.

Low Temperature Performance Grade (-YY) means the low temperature performance grade specified in the Contract Documents and also referred to as the -YY specified for the PGAC where the PGAC grade specified is PG XX-YY, and the minimum design pavement temperature.

Performance Graded Asphalt Cement (PGAC) means an asphalt binder that is produced from petroleum residue, either with or without the addition of non-particulate modifiers, according to AASHTO M 320.

Quality Assurance (QA) means as defined in OPSS 313.

Recompaction Temperature means the temperature to which plant produced mix shall be reheated for testing purposes and shall be the same as the laboratory mix design compaction temperature.

1101.04 DESIGN AND SUBMISSION REQUIREMENTS

1101.04.01 Submission Requirements

1101.04.01.01 PGAC Product Documentation

For each grade of PGAC specified in the Contract Documents, the following items shall be supplied to the Contract Administrator at least 14 Days prior to the first use of each product:

- a) The PGAC supplier, the facility type, and location that the product shall be supplied from.
- b) Applicable mixing and compaction temperatures for the product.
- c) The minimum temperature of the HMA immediately after spreading, recommended by the PGAC supplier. This information is required when paving on bridge decks only.
- d) Documentation of construction, storage, and handling requirements, including the material safety data sheet, recompaction temperature, mix discharge temperature, and recommended extraction procedure.
- e) When the PGAC contains any polyphosphoric acid (PPA) and a liquid AST-AC is incorporated into the PGAC at the PGAC supplier's depot:
 - i. Information on how much AST-AC was added to the PGAC.
 - ii. Documentation from the PGAC supplier stating that the PPA modified PGAC with the liquid AST-AC added at the PGAC supplier's depot shall meet all PGAC material requirements specified in the Contract Documents, including AASHTO M 320 for the PGAC grade specified.

1101.04.01.02 PGAC Supply Documentation

For each grade of PGAC specified in the Contract Documents, the following items shall be supplied to the Contract Administrator prior to the commencement of HMA production:

- a) All PGAC documentation from the PGAC supplier in the form of bill of lading and certificate of analysis, confirming the grade of PGAC. The bill of lading and certificate of analysis shall also be supplied for each subsequent delivery of PGAC that will be used for the HMA production.
- b) Documentation identifying the PGAC storage tank at the HMA plant that will be supplying the PGAC during production of HMA for this Contract. The Contract Administrator shall be notified and provided updated documentation prior to changing the storage tank that is being used to supply PGAC for the HMA production at the HMA plant.

1101.05 MATERIALS

All PGAC shall be according to AASHTO M 320 for the performance grades specified in the Contract Documents when tested using the methods designated in AASHTO R 29, section Test Procedure for Grading an Unknown Asphalt Binder and continuous grading temperatures according to ASTM D7643 and reported continuous grading temperatures rounded to the nearest 0.1 °C.

When silicone oil is added to the PGAC, it shall be less than five parts per million of the PGAC.

The PGAC shall be homogeneous; free of water and any contamination; and shall not foam when heated to the temperatures specified by the manufacturer for the safe handling and use of the product. It shall be shipped, used, and always handled in accordance with the manufacturer's specifications.

All PGAC 70-28, 70-34, and 64-34 shall not contain more than 0.5% PPA and shall only be used as a catalyst for the purpose of modification with polymers. Other grades of PGAC shall contain no more than 1.0% PPA. All grades of PGAC shall not contain any orthophosphoric acid.

The PGAC shall meet the performance grading requirements shown in Table 1 and the additional testing requirements shown in Table 2.

1101.07 PRODUCTION

1101.07.01 Sampling and Testing

Sampling shall be as specified in the Quality Assurance section.

1101.08 QUALITY ASSURANCE

1101.08.01 Sampling

1101.08.01.01 General

The QA, referee, and other required samples for possible Owner testing shall be taken at the same time.

1101.08.01.02 Performance Graded Asphalt Cement

All PGAC test samples shall be obtained during the production of the HMA at the HMA plant from the storage tank which is directly feeding the production of the HMA according to AASHTO R 66 and the asphalt plant's Health and Safety Plan. The asphalt plant's Health and Safety Plan and procedure for sampling shall be discussed at the pre-pave meeting.

Notification from the Contract Administrator shall be provided when the PGAC is required to be sampled.

Sampling frequency, minimum quantities, and additional labelling shall be as shown in Table 3.

1101.08.02 Lot Size

The Contract Administrator shall determine the size and location of the lots for each grade of PGAC, after discussion with the Contractor and before HMA production for the HMA tender item starts.

For tonnage tender items, the quantity of PGAC incorporated into a maximum of 10,000 tonnes of HMA is considered one lot or as determined by the Contract Administrator.

For square metre tender items, the quantity of PGAC incorporated into a maximum of 80,000 m² of HMA for lift thicknesses in the order of 40 to 55 mm is considered one lot or as determined by the Contract Administrator. For lift thicknesses in the order of 60 to 100 mm, the lot size is adjusted to a maximum of 50,000 m² or as determined by the Contract Administrator.

All PGAC lot sizes shall be based on the HMA tender quantity for each grade of PGAC.

A lot shall be terminated when the source of PGAC is changed. A lot may be terminated at the Contract Administrator's option when HMA production for the Contract ceases for a period of 20 Days or more.

1101.08.02.01 Switching Performance Grades

When switching from the use of one performance grade to a different performance grade, a request may be made that the quantity of PGAC in the first tanker load be considered as a separate lot. This request shall be submitted in writing to the Contract Administrator. The Contract Administrator shall consider only one request for the duration of the Contract.

1101.08.03 Acceptance Testing

Material acceptance of PGAC for performance grading and for the additional testing specified in Tables 1 and 2, respectively, shall be based on QA test results conducted by the Owner's designated laboratory unless superseded by referee test results, subject to the conditions specified in the Contract Documents.

Test results from the tests completed to determine if the material complies with the requirements of the Contract Documents shall be provided by the Owner.

1101.08.04 Basis of Acceptance

Lots of PGAC are categorized for acceptance according to Tables 1 and 2.

When a PGAC lot is categorized with more than one category in Tables 1 and 2, acceptance of the HMA shall be dealt with using the category selected by the Owner.

1101.08.04.01 Asphalt Cement Anti-Stripping Treatment

At the discretion of the Owner, an allowance may be made for the impact of the asphalt cement anti-stripping treatment on a PGAC grade for QA or referee purposes provided that when production begins a request is submitted to the Owner with complete AASHTO M 320 test results for the following:

- a) Asphalt cement with anti-stripping treatment at the percentage identified in the mix design.
- b) Asphalt cement without the anti-stripping treatment.

1101.08.05 Referee Testing

Referee testing may be invoked for any lot of PGAC within five Business Days of receiving all the QA test results for the lot.

Referee testing costs as specified in the Contract Documents shall be borne by the Contractor, unless the referee testing confirms total conformance of the PGAC sample to the Contract Documents when the QA testing did not, in which case the costs shall be borne by the Owner.

Referee testing may only be invoked for a PGAC lot that is categorized as major borderline or rejectable.

The referee testing shall include all testing specified in Tables 1 and 2. Test results generated by the referee laboratory shall be used to re-evaluate the lot to determine whether the PGAC conforms to the Contract Documents and the disposition of the HMA. The referee test results are binding on both the Owner and the Contractor.

1101.08.06 Disposition of HMA Produced with Borderline and Rejectable Lots

The Owner shall review the test results and determine the disposition of the HMA produced using any PGAC that does not conform to all requirements of the Contract Documents. HMA for which PGAC test results indicate that the PGAC did not conform to the Contract Documents shall be dealt with as follows and a non-conformance report shall be issued:

Minor Borderline: HMA shall be accepted into the Work at full payment.

Major Borderline: HMA shall be accepted into the Work, provided that a payment reduction is accepted, calculated as follows:

$$\text{PGAC Payment Reduction} = 5\% \text{ of HMA contract price} \times \text{quantity of HMA in the PGAC lot.}$$

The quantity of HMA shall be in tonnes or square metres as specified for the applicable HMA tender item.

This payment reduction is assessed independently of other payment adjustment provisions specified in the Contract Documents.

If the PGAC in a particular lot has been used for the production of more than one HMA type, the payment reduction shall be calculated using the actual quantities of the HMA types produced with the PGAC for the HMA type, within the PGAC lot.

Rejectable: HMA for which PGAC test results are rejectable shall be subject to repair or payment adjustment. The Contract Administrator shall determine if a rejectable lot may remain in the Work without repairs, with a payment adjustment accepted by the Owner.

When there are changes from one performance grade to a different performance grade and the request for the establishment of a separate lot has been accepted according to the Switching Performance Grades clause, HMA produced with this separate PGAC lot shall be administered as follows:

- a) The HMA payment shall not be assessed a PGAC payment reduction for a major borderline disposition due to performance grading.
- b) All HMA with PGAC that is rejectable shall be removed or its payment shall be adjusted at the discretion of the Contract Administrator.

TABLE 1
Performance Grading Requirements and Categories for PGAC

Category	Performance Grading Test Result Requirements (Notes 1 & 2)
Acceptable	Equal to or above XX and equal to or below -YY
Minor Borderline	≤ 0.5 °C below XX and ≤ 0.5 °C above -YY
Major Borderline	≤ 1.0 °C below XX and ≤ 1.0 °C above -YY
Rejectable	> 1.0 °C below XX or > 1.0 °C above -YY
Notes: 1. XX is the specified high temperature performance grade and design maximum pavement temperature. -YY is the specified low temperature performance grade and design minimum pavement temperature. 2. Performance grading test results shall be reported rounded to the nearest 0.1 °C.	

TABLE 2
Additional Testing Requirements and Categories for PGAC

PGAC Grade (Note 1)	Property and Attributes (Unit)	Test Method	Results Reported Rounded to Nearest (Note 2)	Category			
				Acceptable	Minor Borderline	Major Borderline	Rejectable
All PGAC Grades except PG58-28	Ash Content, % by mass of residue (%)	ASTM D8078	0.01	≤ 0.60	N/A	> 0.60 and ≤ 0.80	> 0.80
PG58-28				≤ 0.40	N/A	> 0.40 and ≤ 0.60	> 0.60
All PGAC Grades except PG58-28 and PG52-34	Non-recoverable creep compliance at 3.2 kPa, $J_{nr-3.2}$ (kPa^{-1})	AASHTO T 350 (Note 3)	0.01	< 4.50	N/A	N/A	≥ 4.50
	Average percent recovery at 3.2 kPa, $R_{3.2}$ (%)		0.1	$> \text{the lesser of } 55.0 \text{ or } [(29.371) (J_{nr-3.2})^{-0.2633}]$	$\leq \text{the lesser of } 55.0 \text{ or } [(29.371) (J_{nr-3.2})^{-0.2633}]$ and $> \text{the lesser of } 45.0 \text{ or } [(29.371) (J_{nr-3.2})^{-0.2633-10}]$	N/A	$\leq \text{the lesser of } 45.0 \text{ or } [(29.371) (J_{nr-3.2})^{-0.2633-10}]$
	Percent difference in non-recoverable creep compliance between 0.1 kPa and 3.2 kPa, $J_{nr\text{diff}}$ (%)		0.1	Testing carried out for information purposes only.			
PG70-28, PG64-28	CTOD, δ_t (mm)	LS-299 (Note 4)	0.1	≥ 10.0	< 10.0 and ≥ 6.0	< 6.0 and ≥ 4.0	< 4.0
	LTLG (°C)	LS-308 (Note 4)	0.1	≤ -28.0	> -28.0 and ≤ -25.0	> -25.0 and ≤ -22.0	> -22.0
	Grade Loss (°C)	LS-308 (Note 4)	0.1	≤ 6.0	N/A	> 6.0 and ≤ 8.0	> 8.0

PGAC Grade (Note 1)	Property and Attributes (Unit)	Test Method	Results Reported Rounded to Nearest (Note 2)	Category			
				Acceptable	Minor Borderline	Major Borderline	Rejectable
PG58-28	CTOD, δ_t (mm)	LS-299 (Note 4)	0.1	≥ 6.0	< 6.0 and ≥ 4.0	N/A	< 4.0
	LTLG ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ -24.0	N/A	> -24.0 and ≤ -22.0	> -22.0
	Grade Loss ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ 6.0	N/A	N/A	> 6.0
PG70-34, PG64-34, PG58-34, PG52-34	CTOD, δ_t (mm)	LS-299 (Note 4)	0.1	≥ 14.0	< 14.0 and ≥ 10.0	< 10.0 and ≥ 8.0	< 8.0
	LTLG ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ -34.0	> -34.0 and ≤ -31.0	> -31.0 and ≤ -28.0	> -28.0
	Grade Loss ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ 6.0	N/A	> 6.0 and ≤ 8.0	> 8.0
PG58-40, PG52-40	CTOD, δ_t (mm)	LS-299 (Note 4)	0.1	≥ 18.0	< 18.0 and ≥ 14.0	< 14.0 and ≥ 12.0	< 12.0
	LTLG ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ -37.0	N/A	> -37.0 and ≤ -34.0	> -34.0
	Grade Loss ($^{\circ}\text{C}$)	LS-308 (Note 4)	0.1	≤ 6.0	N/A	> 6.0 and ≤ 8.0	> 8.0
ALL PGAC grades	CTOD, δ_t (mm)	LS-299 (Note 5)	0.1	Testing carried out for information purposes only.			
	Cross-Over Temperature, $T_{\delta 45}$ ($^{\circ}\text{C}$)	LS-319 (Note 4)	0.1	Testing carried out for information purposes only.			
	Cross-Over Temperature, $T_{\delta 45}$ ($^{\circ}\text{C}$)	LS-319 (Note 5)	0.1	Testing carried out for information purposes only.			
	Low Temperature Critical Spread, ΔT_c ($^{\circ}\text{C}$)	LS-320 (Note 4)	0.1	Testing carried out for information purposes only.			
	Low Temperature Critical Spread, ΔT_c ($^{\circ}\text{C}$)	LS-320 (Note 5)	0.1	Testing carried out for information purposes only.			

Notes:

1. PGAC grades are as specified in the Contract Documents.
2. The rounding-off procedure, for all values, shall be according to LS-100.
3. Conducted at 52 $^{\circ}\text{C}$ for Contracts located north of the boundary formed by the French River, Lake Nipissing, and the Mattawa River, excluding Manitoulin Island (also referred to as PGAC Zone 1). Conducted at 58 $^{\circ}\text{C}$ for locations South of PGAC Zone 1 in Ontario, including Manitoulin Island (also referred to as PGAC Zones 2 and 3).
4. Conducted on PAV residue LS-228 Method A.
5. Conducted on PAV residue LS-228 Method C.

TABLE 3
PGAC Sampling Requirements

Samples	Frequency	Minimum Sample Quantity	Labelling
Owner Samples (includes QA and Referee)	Each Lot	6 litres (Note 1)	Label shall include: - Grade - Supplier
Notes: 1. Six litres shall be provided in 6 suitable one litre containers or 3 containers able to hold a minimum of 2 litres each.			



MATERIAL SPECIFICATION FOR EMULSIFIED ASPHALT

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1103.01	SCOPE

This specification covers the requirements for different types and grades of emulsified asphalt suitable for both roadway construction and as a straw mulch adhesive.

1103.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-220	Demulsibility of Emulsified Asphalts
LS-224	Coating for Emulsified Asphalts
LS-226	Test for High Float Emulsified Asphalt

ASTM International

D5/D5M-20	Standard Test Method for Penetration of Bituminous Materials
D36/D36M-14(2020)	Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D113-17	Standard Test Method for Ductility of Asphalt Materials
D139-16	Standard Test Method for Float Test for Bituminous Materials
D244-09(2017)	Standard Test Methods and Practices for Emulsified Asphalts

D1310-14(2021)	Standard Test Method for Flash Point and Fire Point of Liquids by Tag Open-Cup Apparatus
D6084/D6084M-21	Standard Test Method for Elastic Recovery of Asphalt Materials by Ductilometer
D6930-19	Standard Test Method for Settlement and Storage Stability of Emulsified Asphalts
D6933-18	Standard Test Method for Oversized Particles in Emulsified Asphalts (Sieve Test)
D6935-17	Standard Test Method for Determining Cement Mixing of Emulsified Asphalt
D6997-12(2020)	Standard Test Method for Distillation of Emulsified Asphalt
D7402-09(2017)	Standard Practice for Identifying Cationic Emulsified Asphalts
D7496-18	Standard Test Method for Viscosity of Emulsified Asphalt by Saybolt Furoi Viscometer
D8078-18e1	Standard Test Method for Ash Content of Asphalt and Emulsified Asphalt Residues

American Association of State Highway and Transportation Officials (AASHTO)

R 66-16 (2020)	Standard Practice for Sampling Asphalt Materials
T 59-16 (2021)	Standard Method of Test for Emulsified Asphalts
T 300-11 (2020)	Standard Method of Test for Force Ductility Test of Asphalt Materials

Others

Environment and Climate Change Canada - Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt - Feb, 2017
Ozone Annex (2000) of the Canada-United States Air Quality Agreement (1991)
Canadian Environmental Protection Act, 1999 (CEPA 1999)

1103.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Emulsified Asphalt means asphalt cement milled into microscopic particles and dispersed in water using a chemical emulsifier and other additives. Based on the electrical charges surrounding the asphalt particles, it can be anionic, cationic and non-ionic. It can be classified based on setting time of the asphalt droplets (RS, MS, QS, SS), viscosity of the emulsions (1,2), hardness of the base asphalt cement (H, HH), polymer content (P), and float & flow properties (HF).

Ozone Season means the period of May 1st through September 30th (warm-season months, when the days are warmer and longer), as defined in the Ozone Annex (2000) of the Canada-United States Air Quality Agreement (1991).

Tack Coat means an emulsified asphalt applied to the surface of a new or existing asphalt layer to enhance the bond between the asphalt layers, prior to placing an overlaying layer.

Volatile Organic Compounds (VOC) means the Item 65 components on the List of Toxic Substances in Schedule 1 of the Canadian Environmental Protection Act, 1999 (CEPA 1999).

1103.05 MATERIALS

1103.05.01 Emulsified Asphalt

Emulsified asphalt shall be of the type and grade as specified in the Contract Documents and shall be supplied from a source named on the ministry's DSM. Under no circumstances shall the source of supply or the product be changed, or partial or total supply allocated to another supplier without prior written approval of the Owner.

1103.05.02 Physical Requirements

Emulsified asphalts shall consist of suitable paving asphalts dispersed in water and shall meet the requirements specified in Tables 1, 2, 3, 4, 5, and 6. The addition of polymers or other additives after the manufacture of an emulsified asphalt shall not be permitted.

Emulsified asphalts shall be homogeneous after mixing and show no signs of separation within 14 Days of delivery.

1103.05.03 Straw Mulch Adhesive

Emulsified asphalt used as a straw mulch adhesive shall be:

- a) A specially refined petroleum asphalt emulsified in water;
- b) Designed to have a fluid consistency for cold spray applications;
- c) Designed with no petroleum solvents nor other components toxic to plant life; and
- d) According to Table 1.

1103.07 PRODUCTION

1103.07.01 Shipping

The material shall be shipped in clean containers. Containers that are being reused shall be inspected and cleaned, if required, prior to loading to ensure there is no contamination.

When shipping is by tank truck or railway tank car, the material shall arrive at the destination at a temperature at least 5 °C higher than the minimum spraying temperature specified in Table 7 and not more than the maximum spraying temperature specified in Table 7.

When no spraying temperatures are specified in Table 7, the material shall arrive at a temperature meeting the manufacturer's requirements.

1103.08 QUALITY ASSURANCE

1103.08.01 Compliance

Emulsified asphalts shall be according to Tables 1, 2, 3, 4, 5, and 6 for the particular type and grade when tested according to the test methods designated in the tables.

1103.08.02 Inspection

The Owner may inspect shipping containers for cleanliness at any time.

1103.08.03 Sampling

Representative samples of material being supplied may be taken from either the supplier's plants, maintenance yards, construction sites, or any shipment using the sampling methods according to AASHTO R 66 in the presence of the Contract Administrator. Sample material taken prior to delivery shall be at no additional cost to the Owner.

The samples shall remain in a condition that maintain their original physical and engineering properties of the samples for quality acceptance testing and referee testing, if invoked by the Contractor. The samples shall be protected from freezing, heat, pressure and agitation during the storage period and transportation process.

Duplicate sample shall be taken. The sample size for each sample shall be 3.8 L, or quantity as required by the specific testing. The containers for samples shall be new clean plastic wide-mouth jars or bottles with tight screw caps. The caps and the containers shall fit together tightly. The containers shall be free from contamination, and shall not be submerged in solvent, nor wiped with a solvent saturated cloth. Transferring samples from one container to another shall be avoided if possible.

If the sample appears to be inhomogeneous after reconditioning and mixing, or the sample was subjected to freeze-thaw cycling prior to receipt, the sample shall be discarded and resample for testing shall be required.

1103.08.04 Testing

Samples may be tested by the Owner according to the tests listed in Tables 1, 2, 3, 4, 5, and 6.

Before performing the tests, the samples shall be conditioned and stirred thoroughly to a homogeneous mixture according to AASHTO T 59 to ensure that the emulsified asphalt is in its optimal state for determining its true properties.

1103.08.05 Acceptance

Failure of any sample to conform to any of the material requirements shall be cause for rejection of the material, unless payment adjustments are as specified in the Contract Documents.

TABLE 1
Anionic Emulsified Asphalts

Requirements	Type	Rapid Setting						Medium Setting				Slow Setting								Test Method
	Grade	RS-1		RS-2		RS-1HH		MS-1		MS-2		SS-1		SS-1H		SS-1HH		Straw Mulch Adhesive		
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Tests on Emulsion																				
Viscosity, Saybolt Furol Seconds: at 25 °C at 50 °C	20 --	100 --	-- 75	-- 300	20 --	60 --	20 --	60 --	-- 35	-- 400	20 --	60 --	20 --	60 --	20 --	60 --	17 --	40 --	ASTM D7496	
Residue by Distillation, % by Mass	55	--	60	--	55	--	55	--	65	--	55	--	55	--	55	--	55	--	ASTM D6997	
Settlement, %, 5 Days 7 Days	-- --	3 --	-- --	3 --	-- --	5 --	-- --	3 --	-- --	3 --	-- --	5 --	-- --	5 --	-- --	5 --	-- --	-- 5	ASTM D6930	
Demulsibility, % 35 ml, 0.02 N CaCl ₂ 50 ml, 0.1 N CaCl ₂	60 --	-- --	60 --	-- --	60 --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- 2.0	LS-220	
Oil Portion of Distillate, % by Volume/Mass	--	--	--	--	--	1	--	--	--	10	--	--	--	--	--	--	1	--	ASTM D6997	
VOC Content as determined by Oil Portion of Distillate, % by Volume (Note 1)	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	ASTM D6997	
Sieve Test, % by Mass	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	ASTM D6933	
Cement Mixing Test, % by Mass	--	--	--	--	--	--	--	--	--	--	--	2.0	--	2.0	--	--	--	--	ASTM D6935	
Particle Charge	NEGATIVE OR NEUTRAL																		ASTM D7402	
Coating Ability and Water Resistance, %, (Note 2)	--	--	--	--	--	--	80	--	80	--	--	--	--	--	--	--	--	--	LS-224	
Fire Resistance	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	PASS		(Note 3)	
Tests on Residue																				
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm	100	200	100	200	20	55	100	200	100	250	100	200	40	100	20	55	100	200	ASTM D5M	
Ductility (at 25 °C, 5 cm/min), cm	60	--	60	--	40	--	40	--	40	--	40	--	40	--	40	--	40	--	ASTM D113	
Ash Content, % by Mass of Residue	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	ASTM D8078	
Notes:																				
1. Apply to emulsified asphalt used in paving material or in paving, construction and maintenance operations during the ozone season in accordance with 'Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt' with distillation temperature to 260°C.																				
2. This requirement does not apply for tack coat or joint painting emulsified asphalts.																				
3. There shall be no flash or flare-up when the flame of a Bunsen burner is held in contact with the surface of the material, as received, for a period of 10 seconds.																				

TABLE 2
Cationic Emulsified Asphalts

Requirements	Type	Rapid Setting						Medium Setting				Slow Setting						Slurry Seal		Test Method
	Grade	CRS-1		CRS-2		CRS-1HH		CMS-2		CMS-2H		CSS-1		CSS-1H		CSS-1HH		CSS-H		
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Tests on Emulsion																				
Viscosity, Saybolt Furol Seconds : at 25 °C at 50 °C		-- 50	-- 150	-- 100	-- 400	20 --	60 --	-- 50	-- 400	-- 50	-- 400	20 --	100 --	20 --	100 --	20 --	60 --	20 --	100 --	ASTM D7496
Residue by Distillation, % by Mass		62	--	67	--	55	--	65	--	65	--	57	--	57	--	55	--	57	--	ASTM D6997
Settlement, %, 5 Days		--	5	--	5	--	5	--	5	--	5	--	5	--	5	--	5	--	5	ASTM D6930
Demulsibility, % 35 ml 0.8% Dioctyl Sodium Sulfosuccinate Solution		40	--	40	--	40	--	--	--	--	--	--	--	--	--	--	--	--	--	LS-220
Oil Portion of Distillate, % by Volume/Mass		--	3	--	3	--	1	--	10	--	10	--	5	--	5	--	1	--	--	ASTM D6997
VOC Content as determined by Oil Portion of Distillate, % by Volume (Note 1)		--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	ASTM D6997
Sieve Test, % by Mass		--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	ASTM D6933
Cement Mixing Test, % by Mass		--	--	--	--	--	--	--	--	--	--	--	2.0	--	2.0	--	--	--	--	ASTM D6935
Particle Charge		POSITIVE																		ASTM D7402
Coating Ability and Water Resistance, % (Note 2)		--	--	--	--	--	--	80	--	80	--	--	--	--	--	--	--	--	--	LS-224
Test on Residue																				
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm		100	250	100	250	20	55	100	250	40	125	100	250	40	125	20	55	40	125	ASTM D5M
Ductility (at 25 °C, 5 cm/min), cm		60	--	60	--	40	--	60	--	40	--	60	--	40	--	40	--	40	--	ASTM D113
Ash Content, % by Mass of Residue		--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	ASTM D8078
Notes:																				
1. Apply to emulsified asphalt used in paving material or in paving, construction and maintenance operations during the ozone season in accordance with 'Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt' with distillation temperature to 260°C.																				
2. This requirement does not apply for tack coat or joint painting emulsified asphalts.																				

TABLE 3
High Float Emulsified Asphalts

Require- ments	Type	High Float														Test Method
	Grade	HFRS-2		HFMS-2(ON)		HF-100S		HF-150S		HF-250S		HF-150M		HF-1000M		
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Tests on Emulsion																
Viscosity, Saybolt Furol Seconds at 50 °C	75	400	50	300	35	150	35	150	35	150	50	--	50	--	ASTM D7496	
Residue by Distillation, % by Mass	63	--	62	--	62	--	62	--	62	--	62	--	65	--	LS-226	
Demulsibility, % 35 ml 0.02 N CaCl ₂ 50 ml 0.10 N CaCl ₂ 50 ml 0.02 N CaCl ₂	60 -- --	-- -- --	-- -- 40	-- -- --	-- 75 --	-- -- --	-- 75 --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	LS-220	
Oil Portion of Distillate, % by Volume/Mass	--	--	0.5	3	0.5	4	0.5	4	1	6	1	6	1	7	ASTM D6997	
VOC Content as determined by Oil Portion of Distillate, % by Volume (Note 1)	--	3	--	3	--	3	--	3	--	3	--	3	--	3	ASTM D6997	
Sieve Test, % by Mass	--	0.10	--	0.10	--	0.10	--	0.10	--	0.10	--	0.10	--	0.10	ASTM D6933	
Particle Charge	--		Negative		--		--		--		--		--		ASTM D7402	
Coating Ability and Water Resistance, %	--		(Note 2)		(Note 2)		(Note 2)		(Note 2)		(Note 3)		(Note 3)		ASTM D244	
Storage Stability 24 h, % by Mass	--	1.0	--	1.5	--	1.5	--	1.5	--	1.5	--	1.5	--	1.5	ASTM D6930	
Test on Residue																
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm	100	200	90	200	100	175	150	250	250	500	150	--	--	--	LS-226	
Ductility (at 25 °C, 5 cm/min), cm	40	--	--	--	--	--	--	--	--	--	--	--	--	--	ASTM D113	
Ash Content, % by Mass of Residue	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	ASTM D8078	
Float Test at 60 °C, s	1200	--	1200	--	1200	--	1200	--	1200	--	1200	--	1200	--	LS-226	
Apparent Viscosity (at 60 °C), Pa·s	--	--	--	--	250	--	90	--	20	--	10	80	2	8	LS-226	

Notes:

1. Apply to emulsified asphalt used in paving material or in paving, construction and maintenance operations during the ozone season in accordance with 'Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt' with distillation temperature to 260°C.
2. Follow ASTM D244, except that the mixture of aggregate and emulsified asphalt shall be mixed vigorously for 5 min. at the end of which period the aggregates shall be thoroughly and uniformly coated. The mixture shall then be completely immersed in tap water and the water poured off. The aggregate shall then be at least 90% coated.
3. Follow ASTM D244, except that the mixture of aggregate and emulsified asphalt shall be mixed vigorously for 5 min. then allowed to stand for 3 hours after which the mixture shall be capable of being mixed an additional 1 min. The mixture shall then be rinsed twice with approximately its own volume of tap water, without showing appreciable loss of bituminous film. After the second washing the aggregate shall be at least 90% coated.

TABLE 4
Polymer-Modified Emulsified Asphalts

Requirements	Type	Anionic				Cationic								High Float								Test Method
	Grade	RS-1P		RS-2P		CRS-1P		CRS-2P		CQS-1HP		CSS-1P		HFMS-2P(ON)		HF-100SP		HF-150SP		HF-150MP		
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Tests on Emulsion																						
Viscosity, Saybolt Furol Seconds: at 25 °C at 50 °C	20 --	100 --	-- 75	-- 300	-- 25	-- 150	-- 75	-- 400	20 --	100 --	20 --	100 --	-- 50	-- 300	-- 35	-- 150	-- 35	-- 150	-- 50	-- --	ASTM D7496	
Residue by Distillation to 204°C, % by Mass	55	--	60	--	62	--	65	--	62	--	62	--	62	--	62	--	62	--	62	--	ASTM D6997 LS-226	
Storage Stability, 24 h, % by Mass	--	1	--	1	--	1	--	1	--	1	--	1	--	1.5	--	1.5	--	1.5	--	1.5	ASTM D6930	
Demulsibility, % 35 ml, 0.02 N CaCl ₂ 50 ml 0.10 N CaCl ₂ 50 ml 0.02 N CaCl ₂	60 -- --	-- -- --	60 -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- 40	-- -- --	-- 75 --	-- -- --	-- 75 --	-- -- --	-- -- --	-- -- --	LS-220	
35 ml, 0.8% Dioctyl Sodium Sulfo-Succinate Solution	--	--	--	--	40	--	40	--	--	--	--	--	--	--	--	--	--	--	--	--		
Oil Portion of Distillate, % by Volume/Mass	--	--	--	--	--	--	--	--	--	--	--	5	0.5	3	0.5	4	0.5	4	1	6	ASTM D6997	
VOC Content as determined by Oil Portion of Distillate, % by Volume (Note 1)	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	--	3	ASTM D6997	
Sieve Test, % by Mass	--	0.2	--	0.2	--	0.2	--	0.2	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	--	0.1	ASTM D6933	
Particle Charge	Negative or Neutral				Positive								Negative		--		--		--		ASTM D7402	
Coating Ability and Water Resistance, %	--		--		--		--		--		--		(Note 2)		(Note 2)		(Note 2)		(Note 3)		ASTM D244	
Test on Residue																						
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm	100	200	100	200	100	250	100	250	40	90	100	250	90	200	90	150	150	250	150	250	ASTM D5M LS-226	
Float Test at 60 °C, s	--	--	--	--	--	--	--	--	--	--	--	--	1200	--	1200	--	1200	--	1200	--	LS-226 ASTM D139	
Ash Content, % by Mass of Residue	--	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--	10	--	1.0	--	1.0	--	1.0	--	1.0	ASTM D8078	
Elastic Recovery (at 10 °C), % (Note 4)	55	--	55	--	55	--	55	--	50	--	55	--	55	--	55	--	50	--	50	--	ASTM D6084M	
Force Ductility at 800% Elongation, 5 cm/min. Pull Rate at 4 °C, kg	0.5	--	0.5	--	0.5	--	0.5	--	--	--	--	--	0.5	--	0.5	--	--	--	--	--	AASHTO T 300	
Softening Point, R&B, °C	--	--	--	--	--	--	--	--	57	--	--	--	--	--	--	--	--	--	--	--	ASTM D36M	

Notes for Table 4:

1. Apply to emulsified asphalt used in paving material or in paving, construction and maintenance operations during the ozone season in accordance with 'Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt' with distillation temperature to 204°C for polymer-modified emulsified asphalts.
2. Follow ASTM D244, except that the mixture of aggregate and emulsified asphalt shall be mixed vigorously for 5 min. at the end of which period the aggregates shall be thoroughly and uniformly coated. The mixture shall then be completely immersed in tap water and the water poured off. The aggregate shall then be at least 90% coated.
3. Follow ASTM D244, except that the mixture of aggregate and emulsified asphalt shall be mixed vigorously for 5 min. then allowed to stand for 3 hours after which the mixture shall be capable of being mixed an additional 1 min. The mixture shall then be rinsed twice with approximately its own volume of tap water, without showing appreciable loss of bituminous film. After the second washing the aggregate shall be at least 90% coated.
4. Testing Procedure B of ASTM D6084M to be used for elongation of 20 ± 0.25 cm.

TABLE 5
Emulsified Asphalt Primer (EAP)

Requirements	Min.	Max.	Test Method
Viscosity, Saybolt Furol Seconds at 50 °C	35	150	ASTM D7496
Residue by Distillation to 260 °C, % by Mass	40	--	ASTM D6997
Oil Portion of Distillate, % by Volume/Mass	10	30	ASTM D6997 (Note 1)
VOC Content as determined by Oil Portion of Distillate, % by Volume (Note 2)	--	3	ASTM D6997
Particle Charge	Neutral		ASTM D7402 (Note 3)
Flash Point, Tag Open Cup, °C	45	--	ASTM D1310
Storage Stability, 24 h	No visible separation		ASTM D6930 (Note 4)
Tests on Residue			
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm	100	300	ASTM D5M
Ductility (at 25 °C, 5 cm/min), cm	100	--	ASTM D113
Ash Content, % by Mass of Residue	--	1.0	ASTM D8078
Notes:			
1. Since the total distillate exceeds 100 ml, follow ASTM D6997 with the following modification: Prior to reaching 100 ml of distillate, carefully replace the first 100 ml graduated cylinder with a second one. After the distillation is complete, determine the volume of oil distillate in both cylinders and record the sum. Calculate the oil portion of the distillate as a percentage of the original weight of primer: % Oil = (Total Volume of oil distillate, ml X 100) / (200 g primer)			
2. Apply to emulsified asphalt used in paving material or in paving, construction and maintenance operations during the ozone season in accordance with 'Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt' with distillation temperature to 260°C.			
3. Follow ASTM D7402 with the modification that the asphalt does not deposit due to an electrical charge on either the anode (positive electrode) or the cathode (negative electrode). Equal adherence to both electrodes due to the viscous nature of the material is not considered deposition.			
4. Follow ASTM D6930 to obtain the percentage of residue from the top samples and bottom samples, and the testing results will be for information purposes only. The compliance of storage stability shall be based on any visual separation of 500 ml representative sample in the glass cylinder after 24 hours.			

TABLE 6
Solvent-Free Emulsified Asphalt

Requirements	Min.	Max.	Test Method
Viscosity, Saybolt Furol Seconds at 25 °C	5	50	ASTM D7496
Residue by Distillation to 260 °C, % by Mass	40	-	ASTM D6997
Sieve Test, % by Mass	-	0.1	ASTM D6933
Oil Portion of Distillate, % by Volume/Mass	-	0.5	ASTM D6997 (Note 1)
Storage Stability, 24 h, %	No visible separation		ASTM D6930 (Note 2)
Particle Charge	Negative or Neutral		ASTM D7402
Tests on Residue			
Penetration (at 25 °C, 100 g, 5 s), 0.1 mm	40	150	ASTM D5M
Ductility (at 25 °C, 5 cm/min), cm	40	--	ASTM D113
Ash Content, % by Mass of Residue	--	1.0	ASTM D8078
Notes:			
1. Since the total distillate will exceed 100 ml, follow ASTM D6997 with the following modification: Prior to reaching 100 ml of distillate, carefully replace the first 100 ml graduated cylinder with a second one. After the distillation is complete, determine the volume of oil distillate in both cylinders and record the sum. Calculate the oil portion of the distillate as a percentage of the original weight of solvent-free emulsified asphalt: $\% \text{ Oil} = (\text{Total Volume of oil distillate, ml} \times 100) / (200 \text{ g solvent-free emulsified asphalt})$			
2. Follow ASTM D6930 to obtain the percentage of residue from the top samples and bottom samples, and the testing results will be for information purposes only. The compliance of storage stability shall be based on any visual separation of 500 ml representative sample in the glass cylinder after 24 hours.			

TABLE 7
Temperature for Spraying and Mixing Emulsified Asphalts, °C

Grade	Spraying		Mixing	
	Minimum	Maximum	Minimum	Maximum
RS-1, RS-1P, RS-1HH	30 (Note 1) 20 (Note 2)	70 70	-- --	-- --
RS-2, RS-2P	60 (Note 1)	80	--	--
MS-1	--	--	30	70
MS-2	--	--	30	70
SS-1	20	70	20	70
SS-1H, SS-1HH	20	70	20	70
HFRS-2	60	80	--	--
HFMS-2(ON), HFMS-2P(ON)	60	80	--	--
HF-100S, HF-100SP	60	80	--	--
HF-150S, HF-150SP	60	80	--	--
HF-250S	60	80	--	--
HF-150M, HF-150MP	--	--	40	80
HF-1000M	--	--	40	75
CRS-1, CRS-1P, CRS-1HH	60	80	--	--
CRS-2, CRS-2P	60	80	--	--
CMS-2	--	--	30	70
CMS-2H	--	--	30	70
CSS-1	--	--	30	70
CSS-1H	--	--	30	70
CSS-1P	--	--	20	60
CSS-1HH	20	70	--	--
CSS-H (Slurry)	--	--	20	35
CQS-1HP	--	--	Manufacturer's Requirements	
Emulsified Asphalt Primer (EAP)	Manufacturer's Requirements		--	--
Solvent-Free Emulsified Asphalt	Manufacturer's Requirements		--	--
Notes:				
1. For surface treatment.				
2. For other uses.				



MATERIAL SPECIFICATION FOR SUPERPAVE AND STONE MASTIC ASPHALT MIXTURES

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1151.01	SCOPE

This specification covers the requirements for the materials, equipment, and processes for proportioning and mixing hot mix asphalt (HMA) including warm mix asphalt (WMA), recycled mixes, and mixes for miscellaneous work according to the Superpave and stone mastic asphalt (SMA) mix design methodology.

1151.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt - End Result

Ontario Provincial Standard Specifications, Material

OPSS 1001 Aggregates - General
OPSS 1003 Aggregates - Hot Mix Asphalt
OPSS 1101 Performance Graded Asphalt Cement

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM) Manual

MTO Laboratory Testing Manual:

LS-282	Quantitative Extraction of Asphalt Cement and Analysis of Extracted Aggregate from Bituminous Paving Mixtures
LS-284	Recovery of Asphalt from Solution by Rotary Evaporator
LS-292	Quantitative Determination of Asphalt Cement Content by Ignition and Analysis of Remaining Aggregate from Bituminous Paving Mixtures
LS-309	Superpave Mix Design
LS-311	Stone Mastic Asphalt Mix Design
LS-316	Practice for Mix Check
LS-318	Practice for Warm Mix Asphalt (WMA) Mix Design
LS-321	Method for Calculation of Asphalt Film Thickness
LS-602	Sieve Analysis of Aggregates
LS-603	Resistance to Degradation of Coarse Aggregate by Abrasion and Impact in the Los Angeles Abrasion Machine

MTO Forms:

PH-CC-251	Method to Calculate Asphalt Film Thickness

American Association of State Highway and Transportation Officials (AASHTO)

M 325-08	Standard Specification for Designing Stone Matrix Asphalt (SMA)
T 305-14	Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

National Asphalt Pavement Association (NAPA)

QIS 122	Designing and Constructing SMA Mixtures — State-of-the-Practice

1151.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 313, OPSS 1101, and the following definitions apply:

AMRL means the AASHTO Materials Reference Laboratory.

Anti-Stripping Treatment (AST) means a treatment used to minimize stripping of asphalt cement from HMA aggregates, and can be either AST-AGG or AST-AC.

Aggregate Anti-Stripping Treatment (AST-AGG) means an AST applied directly to the HMA aggregates prior to incorporating them into the mix or dryer at the HMA plant.

Asphalt Cement Anti-Stripping Treatment (AST-AC) means an AST added directly to the asphalt cement to be used in the mix, prior to incorporating it into the mixer at the HMA plant.

Binder Replacement means the asphalt cement from the RAP contributing to the total asphalt cement content in the mix, expressed as a percentage.

CCIL means the Canadian Council of Independent Laboratories.

Coarse Aggregate means that portion of aggregate material retained on the 4.75 mm sieve, when tested according to LS-602.

Deleterious Material means materials other than reclaimed asphalt pavement, and that includes but is not limited to the following: ceramic, clay brick, clay tile, glass, gypsum, gypsum plaster, plastic, reclaimed concrete material, wallboard, and wood.

Fine Aggregate means that portion of aggregate material passing the 4.75 mm sieve when tested according to LS-602.

Maximum Aggregate Size means one sieve size larger than the nominal maximum aggregate size.

Mix Design means the design of the proportions of aggregates, asphalt cement, and additives, when uniformly mixed, results in an acceptable HMA in accordance with the specified method.

Nominal Maximum Aggregate Size means one sieve size larger than the first sieve to retain more than 10% by mass.

Primary Control Sieve means the sieve defining the break point between fine and coarse-graded mixtures for each nominal maximum aggregate size.

Roof Shingle Tabs (RST) means ground roof shingle scrap generated when new shingles are trimmed during production

1151.04 DESIGN AND SUBMISSION REQUIREMENTS

1151.04.01 Design Requirements

1151.04.01.01 General

A laboratory that has current CCIL Type A certification, AMRL, or AMRL equivalent certification shall be used to conduct all mix designs and mix checks.

Superpave mixes shall be designed using the procedures specified in LS-309, with the exception of WMA mixes. WMA mixes shall be designed using the procedures specified in LS-318 at the anticipated WMA production temperature. In the mix design procedure, all references to reclaimed asphalt pavement (RAP) content shall be deleted and replaced with % binder replacement.

Superpave materials, mix designs, and the JMF shall be according to the requirements specified in Tables 1, 2, and 3 for the HMA mix type specified in the Contract Documents.

The use of roof shingle tabs (RST) is not permitted in the HMA.

SMA mixes shall be designed using the procedures specified in LS-311. The SMA materials, mix designs, and the JMF shall be according to the requirements specified in Tables 1, 4, and 5 for the SMA mix type specified in the Contract Documents. Cellulose or mineral fibres shall be used as a stabilizing additive in dosage rates of 0.3% or 0.4%, respectively, by mass of the total mixture. Regardless of the type of fibre used, the manufacturer's recommendations for any product used shall be followed.

The composition of the HMA may be modified as permitted in Table 6.

The amount of RAP allowable by mass in a mix will be calculated by the asphalt binder replacement method according to the following formula:

$$\% \text{ binder replacement} = \frac{[(\% \text{ asphalt cement content of RAP} \times \% \text{ RAP by mass of mix}) / (\% \text{ total asphalt cement content of mix})]}{1}$$

RAP as processed and ready for use in a HMA shall be tested using LS-282 or LS-292 to determine the average percentage asphalt cement and the average gradation for the extracted RAP aggregates.

Density testing of aggregates and RAP shall be conducted for the purpose of developing the mix design for each mix type in the Contract. Such testing shall be performed during production of each aggregate, RAP, or during stockpiling of the materials at the HMA plant.

In addition, if the composition of the mix is modified by including RAP, the high and low grade of performance graded asphalt cement (PGAC) required shall be lowered by 6 °C when:

% Binder Replacement > 20 %

The JMF selected for use shall produce HMA that meets all the requirements as specified in the Contract Documents.

1151.04.01.02 Changes to the Job-Mix Formula and the Mix Design

Changes to the JMF shall be permitted subject to the conditions as specified in the Contract Documents.

A new mix design shall be completed according to the Mix Design clause, when:

- a) A material is eliminated.
- b) A new material is added.
- c) A material source is changed.
- d) The net impact of all adjustments to the original JMF exceeds any of the maximum field adjustments as specified in the Contract Documents.
- e) The allowable time period has been exceeded and the use of the mix design has not been extended.

1151.04.01.03 Anti-Stripping Treatments

1151.04.01.03.01 General

The AST shall treat the mix components at the greater of the dosages specified in the Aggregate Anti-Stripping Treatment clause, the Asphalt Cement Anti-Stripping Treatment clause, or as specified in the Contract Documents.

1151.04.01.03.02 Moisture Sensitivity

Moisture sensitivity shall meet the tensile strength ratio requirements specified in Tables 3 and 4.

1151.04.01.03.03 Aggregate Anti-Stripping Treatment

1151.04.01.03.03.01 General

Irrespective of any moisture sensitivity testing that shows that AST-AGG is not required, hydrated lime or an approved AST-AGG from the ministry's DSM shall be used in all mixes consisting of more than 75% quartzite and dolomitic sandstone aggregates, or combinations thereof.

Irrespective of any moisture sensitivity testing that shows that AST-AGG is not required, the AST-AGG dosage and type shown in the ministry's DSM shall be the minimum used for all aggregates to be incorporated into SMA and Superpave 12.5FC 2.

1151.04.01.03.03.02 Hydrated Lime

When hydrated lime is used as the AST-AGG, the dosage shall be the greater of:

- a) The amount determined to meet the moisture sensitivity requirements, or
- b) one percent by mass of total dry aggregate, or
- c) the listed dosage from the ministry's DSM.

1151.04.01.03.03.03 Alternate Aggregate Anti-Stripping Treatment

When an alternate is used as the AST-AGG in place of hydrated lime, the dosage shall be the greater of:

- a) The amount determined to meet the moisture sensitivity requirements; or
- b) the listed dosage from the ministry's DSM.

1151.04.01.03.04 Asphalt Cement Anti-Stripping Treatment

When AST-AGG is not required in the mix, AST shall be used in the mix if:

- a) Mix moisture sensitivity testing indicates an AST is required; or
- b) the Contract Documents note that an AST is required.

The amount of AST to be used in the mix shall be the greater of:

- a) The amount required to meet the moisture sensitivity requirements; or
- b) the listed minimum dosage from the ministry's DSM.

1151.04.02 Submission Requirements

1151.04.02.01 Mix Design

A copy of all mix design and JMF documents, signed, dated, and certified correct by the person accountable for the engineering and management responsibility for the laboratory that conducted the work, shall be submitted to the Contract Administrator. The mix design shall include a statement that the mix exceeds 75% if the percentage of the mix comprising quartzite and dolomitic sandstone aggregates, or combinations thereof, is more than 75%. The Hamburg test results shall be submitted with the mix design, or up to 30 Days after submission of the original WMA mix design.

The % Binder Replacement shall be calculated and submitted with the mix design.

For SMA mix, the technical data sheet for the supplied fibres shall be submitted with the mix design.

The asphalt film thickness (T_F) shall be calculated according to LS-321 and submitted on form PH-CC-251 along with the mix design. The calculated asphalt film thickness shall be shown on the mix design summary sheet.

The mix design shall be valid for a maximum of 14 months from when the mix design was prepared. To extend use of the mix design for each calendar year past the initial 14 months, a one point mix check for the properties listed in Table 7, using the methodology in LS-316 as applicable, shall be submitted to the Contract Administrator. The mix must meet the requirement and tolerances given in Table 7.

The mix shall not be placed until the Contract Administrator gives written confirmation that the submitted mix design documents and JMF meet the Contract requirements. Within four Business Days following the delivery of all required documentation, the Contract Administrator shall provide written confirmation that the mix design and all samples meet the Contract requirements or advise of any requirements that have not been met.

Confirmation of conformance to Contract requirements of the submitted mix design does not constitute any guarantee that the mix can be produced or constructed or both to Contract requirements and does not relieve the Contractor of the responsibility for ensuring the specified quality of Materials and workmanship.

1151.04.02.02 Material Samples

At the written request of the Contract Administrator, one set of material samples representative of those used for mix design shall be submitted to the laboratory as specified in the Contract Documents. The materials shall be delivered within two Days of the request made by the Contract Administrator or within two Days of submission of the mix design to the Contract Administrator, whichever is later.

For the one point mix check, new samples for aggregate density determination shall be submitted within two Days of submission of the mix check to the Contract Administrator.

Each material sample shall be packaged separately, and each filled sample container shall not exceed a mass of 30 kg.

The sample quantities are specified in Table 8.

1151.04.02.03 Warm Mix Asphalt

For WMA, the following information shall be submitted to the Contract Administrator in writing with the mix design:

- a) The WMA technology to be used.
- b) Complete name and address of the WMA supplier.
- c) The type and dosage of WMA additives, if applicable, and how the additives are incorporated.
- d) The WMA technology supplier's established recommendations for usage.

1151.05 MATERIALS

1151.05.01 Asphalt Cement

Asphalt cement shall be performance graded asphalt cement according to OPSS 1101.

1151.05.02 Aggregates

Aggregates shall be according to OPSS 1003.

1151.05.02.01 Reclaimed Asphalt Pavement

The aggregate contained in the RAP, where permitted in an HMA, shall be according to the aggregate requirements of OPSS 1003 for the mix type as specified in the Contract Documents.

Any RAP that is contaminated with deleterious material shall not be used and shall be removed from the work. The RAP shall be stockpiled conforming to the stockpiling requirements for coarse aggregates according to OPSS 1001, except that when the material is stockpiled on a compacted granular pad, the top 75 mm of the pad shall be the coarse aggregate that is required for a new (virgin) mixture of the tendered hot mix item.

The use of RAP that is obtained from existing stockpiles that do not have a foundation conforming to the above paragraph shall be permitted provided that the bottom 0.3 m of the stockpile is not incorporated into the work.

Process control sampling and testing of the RAP shall be as specified in the Contract Documents.

1151.05.03 Silicone

Silicone oil, when added to the asphalt cement, shall be less than five parts per million of asphalt cement.

1151.05.04 Filler

Filler shall be according to OPSS 1003.

1151.05.05 Fibres

Fibres shall be either cellulose or mineral fibres, and appropriate for use in the SMA mix design, such as those detailed in QIS 122. The use of rock wool, asbestos, fiberglass, and fibres contained in RST, is prohibited.

1151.07 PRODUCTION

1151.07.01 Anti-Stripping Treatments

1151.07.01.01 Asphalt Cement Anti-Stripping Treatments

If the AST-AC is added by the asphalt cement supplier at the refinery depot, the Contract Administrator shall be provided with the AST-AC and PGAC documentation from the asphalt cement supplier in the form of a weigh bill or bill of lading, confirming the type and concentration of the AST-AC for each tanker of asphalt cement.

If the AST-AC is added at the HMA plant, the Contract Administrator shall be provided with documentation from the HMA plant confirming the type and concentration of the AST-AC, accompanied by an approved statement of calibration for the metering device and a continuous record of the process prior to placement of mix containing AST-AC for each batch of asphalt cement with AST-AC added.

1151.07.01.02 Aggregate Anti-Stripping Treatments

Aggregate treated and stored from a previous construction season may be used only after the Contract Administrator agrees to a written proposal that verifies the effectiveness of the stored aggregate. The proposal shall include the sampling protocol used and test results from those samples that show that the aggregates meet the moisture sensitivity requirements of this specification.

When hydrated lime or an alternative AST-AGG is used, it shall be added to all aggregates requiring AST by one of the following processes:

- a) Blending During Aggregate Production

Hydrated lime or an alternative AST-AGG can be mixed with aggregate at the pit or quarry prior to delivery of the aggregate to the HMA plant. The mixing shall ensure uniform and complete adhesion of the AST-AGG to the aggregate.

b) Blending at the HMA Plant

The AST-AGG may be homogeneously mixed with aggregate prior to entering the dryer at the HMA plant. The HMA plant shall be equipped with suitable pumps, mixers and spray bars for introducing the required quantity of AST-AGG to the aggregates. Mixing shall be accomplished with a pugmill or a drum-type mixer.

Regardless of the process or mixing equipment used, the process shall result in the production of aggregates that are uniformly and homogeneously coated with the quantity of the AST-AGG as specified in the Contract Documents, and that are free of clumps and balls prior to entering the dryer at the HMA plant.

1151.07.02 Preparation of the Mixture

Proportioning and mixing of materials shall produce a uniform homogeneous mixture in which all particles of the aggregate are thoroughly and uniformly coated.

The maximum temperature of the mixture after it is discharged from the mixing chamber shall not exceed the maximum specified mixing temperature from the mix design by more than 20 °C, to a maximum of 170°C.

TABLE 1
Aggregate Gradation

HMA Type	Percentage Passing by Dry Mass of Aggregates									
	Sieve Size mm									
	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.075
Superpave 4.75	-	-	-	-	100	95-100	90-100	-	30-60	6-12
Superpave 9.5	-	-	-	-	100	90-100	32-90	32-67	-	2-10
Superpave 12.5, 12.5FC 1 and 12.5FC 2	-	-	-	100	90-100	45-90	50-65 (Note 1)	39-58 (Note 1)	-	2-10
Superpave 19.0	-	-	100	90-100	23-90	-	-	23-49	-	2-8
Superpave 25.0	-	100	90-100	19-90	-	-	-	19-45	-	1-7
Superpave 37.5	100	90-100	15-90	-	-	-	-	15-41	-	0-6
SMA 9.5	-	-	-	-	100	70-95	30-50	20-30	(Note 2)	8-12
SMA 12.5	-	-	-	100	90-100	50-80	20-35	16-24		8-11
SMA 19.0	-	-	100	90-100	50-88	25-60	20-28	16-24		8-11
Notes: 1. For mixes that have been specified in the Contract Documents as coarse graded, the allowable range of percentage by mass passing the 4.75 mm sieve shall be 45-55, and for the 2.36 mm sieve the allowable range will be 28-58. 2. For the SMA 9.5 mm, the maximum percentage passing the 1.18 mm, 0.600 mm, and 0.300 mm sieves is 21, 18, and 15 respectively.										

TABLE 2
Superpave Gradation Primary Control Sieve Points

HMA Type	Primary Control Sieve mm	PCS Control Point at % Passing
Superpave 4.75	-	-
Superpave 9.5	2.36	47
Superpave 12.5, 12.5FC 1, and 12.5FC 2	2.36	39
Superpave 19.0	4.75	47
Superpave 25.0	4.75	40
Superpave 37.5	9.5	47

TABLE 3
Superpave HMA Properties

Traffic Category (Note 1)	% of Theoretical Maximum Specific Gravity			VMA % minimum						VFA (Note 2) %	Dust to Binder Ratio (Note 3)	Minimum Tensile Strength Ratio %
				Nominal Maximum Aggregate Size mm								
	N _{initial}	N _{design}	N _{max}	37.5	25.0	19.0	12.5	9.5	4.75			
A	≤ 91.5	96.0	≤ 98.0	11.0	12.0	13.0	14.0	15.0	16.0	70-80 (Note 4)	0.6-1.2	80
B	≤ 90.5									65-78		
C	≤ 89.0 (Note 5)									65-75 (Note 6)		
D												
E												

Notes:

1. Traffic category as specified in the Contract Documents.
2. For Traffic categories C, D, and E Superpave 9.5 mixes shall have a VFA range of 73 to 76%, while Superpave 4.75 mixes shall have a VFA range of 75 to 78%.
3. For Superpave 4.75 mixes, the dust-to-binder ratio shall be 0.9 to 2.0. Superpave mixes with gradations that pass beneath the PCS Control Point in Table 2, the dust-to-binder ratio shall be 0.8 to 1.6.
4. For Traffic category A, Superpave 25.0 mixes shall have a VFA range of 67 to 80%.
5. The percent of Theoretical Maximum Specific Gravity at N_{initial} of ≤ 89.5 shall be permitted at the Contractor's option with the understanding that the contractor may be exposed to quality issues related to constructability including, but not limited to, mix tenderness and stability for paving equipment.
6. Superpave 37.5 mixes shall have a VFA range of 64 to 75%.

TABLE 4
Properties for all SMA Mix Types

% Air Voids (Note 1)	Minimum VMA %	VCA of the Compacted Mixture %	Maximum Draindown at Production Temperature (Note 2) %	Minimum Tensile Strength Ratio %
4.0	17	Less than the VCA in the dry rodded condition.	0.3	70

Notes:

1. SMA mixes shall be designed with 100 gyrations, unless the mix aggregates have an L.A. Abrasion value according to LS-603 of greater than 30%, then the SMA mix shall be designed with 75 gyrations.
2. Tested according to AASHTO T 305.

TABLE 5
SMA Minimum Asphalt Content for
Aggregates with Varying Bulk Specific Gravities

Combined Aggregate Bulk Relative Density	Minimum Asphalt Content Based on Mass, %
2.40	6.8
2.45	6.7
2.50	6.6
2.55	6.5
2.60	6.3
2.65	6.2
2.70	6.1
2.75	6.0
2.80	5.9
2.85	5.8
2.90	5.7
2.95	5.6
3.00	5.5

TABLE 6
Maximum % Binder Replacement

Traffic Category (Note 1)	Binder Course 150 mm or More Below Pavement Surface	Binder Course Within 150 mm of Pavement Surface	Surface Course
A, B	40%	40%	0%
C, D	40%	20%	0%
E	40%	20%	0%

Notes:

1. Traffic category as specified in the Contract Documents.

TABLE 7
One Point Mix Check Requirements

Mix and Aggregate Property	Requirements
Gradation of component aggregates	For information only
Bulk Relative Density (BRD) of (blended) coarse aggregate and (blended) fine aggregate, and the resulting BRD of the combined aggregate	For information only
Bulk Relative Density and Maximum Relative Density of Mix	For information only
Air voids at N_{design}	$\pm 0.5\%$ from submitted mix design
VMA	$\pm 1.0\%$ from submitted mix design and not less than contract design minimum
VFA	Within specified mix design range
%G _{mm} at $N_{initial}$	Not more than contract design maximum
%G _{mm} at N_{max}	Not more than contract design maximum
Dust Proportion	Within specified mix design range
Tensile Strength Ratio	Not less than 0.8

TABLE 8
Sample Quantities for Mix Design Monitoring

Material	Quantity (Note 1)
Asphalt Cement	4 litres evenly split between 2 containers
Aggregate	75 to 100 kg of each type
RAP	75 to 100 kg required when RAP contained in the mix
Fines material passing 75 μ m sieve	5 to 10 kg when the mix is to be produced with a plant that returns fines to the mix
Mineral Filler	5 to 10 kg sample for SMA mixes
Any other material samples including anti-stripping agents and fibres to be used in HMA	Quantity large enough to allow for a complete mix design
Notes:	
1. Each material sample receptacle shall have a maximum mass of 30 kg.	



**MATERIAL SPECIFICATION FOR
EMULSIFIED ASPHALT PATCHING MATERIAL AND
PROPRIETARY COLD PATCHING MATERIAL**

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1153.01 SCOPE

This specification covers the requirements for the manufacturing of emulsified asphalt patching material and proprietary cold patching material (PCPM).

1153.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1003 Aggregates - Hot Mix Asphalt
OPSS 1151 Superpave and Stone Mastic Asphalt Mixtures

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-282 Method of Test for Quantitative Extraction of Asphalt Cement and Analysis of Extracted Aggregate from Bituminous Paving Mixtures
LS-289 Workability of Cold Patching Materials by Blade Resistance Method

LS-290 Cohesion of Cold Bituminous Patching Materials by Rolling Sieve Method
LS-323 Stripping Resistance of Asphaltic Mixtures by Using Boiling Water

Others

Environment and Climate Change Canada - Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from Cutback and Emulsified Asphalt, February 2017

1153.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 307 apply.

1153.04 DESIGN AND SUBMISSION REQUIREMENTS

1153.04.01 Design Requirements

The emulsified asphalt patching material or PCPM shall meet all of the requirements of this specification and shall maintain its effective properties in stockpile for a minimum period of eight months from the date of supply.

1153.04.02 Submission Requirements

1153.04.02.01 Emulsified Asphalt Patching Material

The emulsified asphalt patching material mixture composition shall be submitted to the Contract Administrator 7 Days before the start of the production. The following items shall also be included in the submission:

- a) Type and grade of asphalt emulsion, supplier and facility type, and location from which the asphalt emulsion is being supplied.
- b) A statement that the Volatile Organic Compound (VOC) content of the emulsified asphalt used in the mix is not more than the limit specified in the Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from Cutback and Emulsified Asphalt.
- c) Test results for the asphalt emulsion that demonstrate compliance to the requirements of the Asphalt Emulsion clause.
- d) The aggregate supplier and location from which the aggregates are being supplied.
- e) Type of aggregate and test results for the aggregate that demonstrate compliance to the requirements of the Aggregates clause.
- f) Test results for percent of residual asphalt content and percent by mass of patching mixture, when tested according to LS-282, that demonstrate compliance according to the Composition clause.
- g) Testing results for the mixture property tests including stripping resistance, workability and cohesion.

1153.04.02.02 Proprietary Cold Patching Material

The following shall be submitted to the Contract Administrator at least 7 Days prior to the delivery of the PCPM:

- a) A copy of the manufacturer's product specification.
- b) A statement that the binder used has a Volatile Organic Compound (VOC) content not more than the limit specified in the Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from Cutback Asphalt and Emulsified Asphalt.
- c) The aggregate supplier and location from which the aggregates are being supplied.
- d) The type of aggregate and test results for the aggregate that demonstrate compliance to the requirements of General clause of Proprietary Cold Patching Material.
- e) Test results for percent of residual asphalt content and percent by mass of patching mixture, when tested according to LS-282, that demonstrate compliance to the requirements of manufacturer's product specification.
- f) Testing results for the mixture property tests including stripping resistance, workability and cohesion.

1153.05 MATERIALS

1153.05.01 Emulsified Asphalt Patching Material

1153.05.01.01 Asphalt Emulsion

The asphalt emulsion type shall be selected to ensure compatibility with the aggregates to be used.

1153.05.01.02 Aggregates

The aggregates shall consist of a blend of coarse and fine aggregate such that not less than 85% of the portion passing a 4.75 mm sieve is natural sand.

The aggregates shall consist of clean, hard, durable particles according to the physical requirements for Superpave 12.5 according to OPSS 1003.

Gradation of aggregates used in the patching mixture shall be according to Table 1.

1153.05.01.03 Composition

The patching mixture shall contain between 3.7 to 5.5% residual asphalt content by mass. The percent residual asphalt shall be expressed as a percentage of the total mix.

The patching mixture shall meet the mixture property testing requirements according to Table 2.

1153.05.02 Proprietary Cold Patching Material

1153.05.02.01 General

The PCPM shall be according to the manufacturer's product specification and the mix property testing requirement specified in Table 2, including the ingredients that were submitted to obtain Owner approval of the PCPM. The PCPM shall be either a summer or winter mix category as specified in the Contract Documents. The PCPM shall be supplied directly from the manufacturer's terminal without further blending or modification.

The aggregates used in the PCPM shall consist of clean, hard, durable particles meeting the physical requirements for Superpave 12.5 according to OPSS 1003.

All PCPM supplied shall be uniformly coated.

1153.07 PRODUCTION

1153.07.01 Emulsified Asphalt Patching Material

The mineral aggregates and asphalt emulsion shall be combined and mixed to provide a uniformly coated and homogeneous product according to Table 1.

Temperature of the emulsion and mixing temperature shall be as specified by the emulsion supplier.

1153.07.02 Proprietary Cold Patching Material

The composition of the mixture, temperature of the emulsion and mixing temperature shall be according to the manufacturer's product specification.

TABLE 1
Gradation of the Emulsified Asphalt Patching Mixture

MTO Sieve Designation	Percentage Passing by Mass
16.0 mm	100
12.5 mm	98 - 100
9.5 mm	85 - 100
4.75 mm	50 - 85
2.36 mm	35 - 65
1.18 mm	25 - 50
0.600 mm	15 - 40
0.300 mm	7 - 25
0.150 mm	2 - 13
0.075 mm	0 - 7

TABLE 2
Mixture Property Testing Requirements

Mixture Property	Testing Method	Acceptance Parameter	Acceptable Limit	Rejectable Limit
Stripping Resistance	LS-323	Percent Coating	$\geq 75\%$	$< 75\%$
Workability	LS-289	Workability Index	$\leq 2,000 \text{ N}$	$> 2,000 \text{ N}$
Cohesion	LS-290	Cohesion Index	$\geq 60\%$	$< 60\%$



**MATERIAL SPECIFICATION FOR
BEARINGS - ELASTOMERIC PLAIN AND STEEL LAMINATED**

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1202.01 SCOPE

This specification covers the requirements for Materials, design, and fabrication of plain and steel-laminated elastomeric bearings for bridges and for approach slab bearings and ballast wall bearings.

1202.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Laboratory Testing Manual:

- LS-427 Method of Test for Compressive Deformation of Plain Bearings
- LS-428 Method of Test for Compressive Deformation of Laminated Bearings
- LS-429 Method of Test for Measurement of Tolerances for Steel Laminated Bearings

Structural Manual:

Division 1 - Exceptions to the Canadian Highway Bridge Design Code CSA S6 for Ontario

CSA Standards

- S6-19 Canadian Highway Bridge Design Code

ASTM International

D395-18	Standard Test Methods for Rubber Property - Compression Set
D412-16	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
D429-14	Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
D573-04 (2019)	Standard Test Method for Rubber - Deterioration in an Air Oven
D1149-18	Standard Test Method for Rubber Deterioration - Cracking in an Ozone Controlled Environment
D2240-15e1	Standard Test Method for Rubber Property - Durometer Hardness
D4014-03 (2018)	Standard Specification for Plain and Steel-Laminated Elastomeric Bearings for Bridges

American Association of State Highway and Transportation Officials (AASHTO)

M251-06 (2016) Plain and Laminated Elastomeric Bridge Bearings

1202.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Effective Elastomer Thickness means the sum of the thickness of all layers of elastomer, excluding the outer top and bottom layers of the laminated bearings.

Elastomer means a compound containing virgin natural polyisoprene (natural rubber).

Laminated Bearing means a bearing composed of elastomer laminates separated by and fully bonded to steel plates.

Plain Bearing means a bearing, which consists wholly of elastomer.

Plan Dimension means the dimensions of an object, when viewed perpendicular to the top of the object.

1202.04 DESIGN AND SUBMISSION REQUIREMENTS

1202.04.01 Design Requirements

1202.04.01.01 Design

The bearings, including any fasteners or dowels, shall be designed according to CSA S6 and the Structural Manual, Division 1.

1202.04.01.02 Elastomer Thickness

The effective elastomer thickness for plain bearings shall be greater than or equal to 15 mm and less than or equal to 25 mm.

All internal layers of elastomer in a laminated elastomeric bearing shall have the same thickness.

1202.04.01.03 Steel Thickness

The minimum and maximum nominal thickness of the internal steel plates for laminated bearings shall be 3 mm and 5 mm respectively, except bearings with an area that is 0.25 m² or larger shall have internal steel plates of 5 mm nominal thickness. All internal steel plates in a bearing shall be the same thickness, and each plate's thickness shall be uniform.

1202.04.01.04 Compressive Deformation

Compressive deformation of laminated elastomeric bearings shall not exceed 0.05 of the effective elastomer thickness when tested according to LS-428 and this specification.

Compressive deformation of plain elastomeric bearings shall not exceed 0.06 of the effective elastomer thickness when tested according to LS-427 and this specification.

1202.04.02 Submission Requirements

1202.04.02.01 General

Within 30 Days of the Contract award, the name and address of the supplier and manufacturer of the bearings shall be submitted in writing to the Contract Administrator.

Change Proposal shall bear the seal and signature of the design and checking Engineers.

When another authority is involved, all submissions shall be made a minimum of 35 Days prior to the commencement of work.

1202.04.02.02 Working Drawings

At least seven Days prior to commencement of bearing fabrication, one hardcopy set and one electronic PDF copy of Working Drawings for the bearings shall be submitted to the Contract Administrator for information purposes only. An Engineer shall affix their seal and signature on the Working Drawings verifying that the drawings are consistent with the Contract Documents and sound engineering practices.

A sealed and signed copy of these drawings shall be kept on site prior to and during the installation of the bearings.

These drawings shall clearly indicate the following:

- a) Specified bearing design data (Dead Load and Total Load at SLS and ULS, movement at SLS, rotation at SLS).
- b) The number and thickness of internal steel plates.
- c) Compressive stiffness.
- d) Shear stiffness at 20 °C and -40° C.
- e) Bearing alphanumeric identification.

1202.04.02.03 Manufacturer's Certification

Upon completion of fabrication and prior to installation of the bearings, a certificate of compliance signed by the manufacturer, shall be submitted to the Contract Administrator. The certificate of compliance shall include test results according to Table 1 and shall state that the fabricated bearings are according to the Working Drawings and Contract Documents.

1202.05 MATERIALS

1202.05.01 General

Reclaimed material shall not be incorporated in the finished bearing.

1202.05.02 Materials for Elastomeric Plain and Steel Laminated Bearings

1202.05.02.01 Steel

Internal steel plates for laminated bearings shall be according to CSA S6.

1202.05.02.02 Elastomers

Elastomers shall be according to the following:

- a) Virgin natural polyisoprene elastomer shall be the only raw polymer permitted.
- b) The physical properties of any polyisoprene used shall be according to the requirements of Table 1.

1202.05.03 Approach Slab Bearings and Ballast Wall Bearings

The physical properties of elastomer used for the manufacture of approach slab bearings or ballast wall bearings shall be according to the following:

- a) Hardness, when tested according to ASTM D2240 shall be 55 +10 / -5 Shore A.
- b) Minimum tensile strength shall be 15 MPa, when tested according to ASTM D412, Method A.
- c) Minimum ultimate elongation shall be 400%, when tested according to ASTM D412, Method A.

1202.07 PRODUCTION

1202.07.01 Plain Bearings

Plain bearing pads shall be moulded individually, cut from moulded strips or slabs of the required thickness, or extruded and cut to length.

1202.07.02 Laminated Bearings

Laminated bearings shall be moulded under pressure as a single unit and heated in moulds that have a smooth surface finish.

Steel plates shall be according to the following:

- a) Internal steel plates shall be free from sharp edges.
- b) Steel plates shall be completely bonded on all surfaces to the elastomeric material during molding. The cover on the vertical side surfaces shall be 6 mm. The cover on the top and bottom surfaces shall be 5 mm, except that no cover is required over pintle holes.
- c) When pintles are specified in the Contract Documents, the depth of pintle holes shall be such that the pintle engages only one steel plate through the entire thickness of the plate.

Elastomer laminates shall be of uniform thickness.

1202.07.03 Identification

Each laminated elastomeric bearing shall be marked with the date of manufacture (i.e., yyyy-mm-dd) and an individual alphanumeric identification. The alphanumeric identification shall consist of the designated identification letter of the supplier and source followed by the letter I for polyisoprene and a five-digit number. Bearings shall be sequentially numbered. The characters shall be not less than 10 mm in height, stamped or engraved into two adjacent sides, with the indentations or protrusions not less than 1 mm in width and 1 mm in depth.

Plain, approach slab and ballast wall bearings shall be marked every 1 m with the name of manufacturer, the date of manufacture, and the lot number.

1202.07.04 Tolerances

Tolerances shall be according to Table 2.

1202.08 QUALITY ASSURANCE

1202.08.01 General

Bearings shall be acceptable if they meet the requirements of this specification.

12.02.08.02 Acceptance of Physical Properties of Elastomers for Laminated and Plain Bearings

Bearing physical properties shall be acceptable if they meet the requirements of Table 1 of this specification.

1202.08.02.01 Referee Testing of Physical Properties of Elastomers for Laminated and Plain Bearing

A written request may be submitted for referee testing the physical properties of elastomers for any sample within five Business Days of receiving notification of rejection of the lot. Referee testing shall be done on the remaining piece of sample representing the failed acceptance test result. The results of the referee test shall be used for acceptance determination and shall be binding on both parties. If the referee testing results in rejection of the lot, the Contractor shall bear the cost of the referee testing. If the referee testing results in the material passing all test criteria, the referee testing charge shall be paid by the Owner.

1202.08.03 Acceptance of Compressive Deformation

1202.08.03.01 Compressive Deformation of Laminated Bearings

The method of testing bearings shall be according to LS-428. The increment in compressive deformation of laminated bearings shall not exceed 5% of the effective elastomer thickness, when the bearing load is increased from an initial pressure of 1.5 MPa to a pressure of 7 MPa.

1202.08.03.02 Compressive Deformation of Plain Bearings

The method of testing of plain bearings shall be according to LS-427. The increment in compressive deformation of plain bearings shall not exceed 6% of the thickness of the bearing when the bearing load is increased from an initial pressure of 20% of the average pressure to the average pressure, and not greater than 7 MPa.

1202.08.03.03**Compressive Deformation Referee Testing**

A written request may be submitted for referee testing of compressive deformation within five Business Days of receiving notification of rejection of the lot. Referee testing shall be done on the same sample. The results of the referee test shall be used for acceptance determination and shall be binding on both parties. If the referee testing results in rejection of the lot, the Contractor shall bear the cost of the referee testing. If the referee testing results in the material passing all test criteria, the referee testing charge shall be paid by the Owner.

1202.08.04**Acceptance of Approach Slab Bearings and Ballast Wall Bearings**

Approach slab bearings and ballast wall bearings shall be acceptable if properties meet the requirements of this specification.

TABLE 1
Physical Requirements for Polyisoprene

Property	Test	Polyisoprene Requirements
Shear modulus G_{RT} , MPa @ 20 °C (Note 1)	ASTM D4014, Annex A1, as modified by AASHTO M251	0.80 ± 0.15
Shear modulus G_{LT} , MPa @ - 40 °C (Note 2)	ASTM D4014, Annex A1, as modified by AASHTO M251	Not more than 3 times the value at room temperature $G_{LT} \leq 3 G_{RT}$
Tensile strength, MPa	ASTM D412, Method A	minimum 17.0
Ultimate elongation, %	ASTM D412, Method A	minimum 400
Heat resistance	ASTM D573	70 h at 70 °C
Change in hardness, Shore A	ASTM D2240	maximum + 10
Change in tensile strength, %	ASTM D412, Method A	maximum - 25
Change in ultimate elongation, %	ASTM D412, Method A	maximum - 25
Compression set, % (Note 3)	ASTM D395, Method B	22 h at 70 °C maximum 25
Ozone Resistance	ASTM D1149, Method B, Procedure B1 20% strain, 40 ± 2 °C	25 pphm, 48 h no cracks
Peel bond test, N/mm	ASTM D429, Method B	minimum 7.0
Note: 1. Shear Modulus shall be determined at ambient temperature in accordance with ASTM D4014 Annex A1 modified as follows: the initial cycles shall be taken to a strain of 0.7 and on the last cycle the shear modulus shall be determined at 0.5 strain. 2. Shear Modulus testing shall be performed with the test specimen in an enclosed freezer unit capable of maintaining the specified conditioning temperature. A ± 25 percent strain cycle shall be applied for a period of 100 seconds. The first three-quarter cycle of strain shall be discarded and the shear modulus shall be determined by the slope of the force deflection curve for the next half cycle of loading. 3. All test specimens of steel laminated bearings used for compression set test ASTM D395, Method B, shall be prepared from the representative bearing pads and may consist of a single layer or multiple layers of elastomer.		

TABLE 2
Tolerances

Criteria		Tolerance
Bearing thickness $\leq$ 40 mm		0 to + 3 mm
Bearing thickness > 40 mm		0 to + 6 mm
Bearing plan dimension		0 to + 6 mm
Thickness of individual measurement of each elastomer layer according to LS-429		$\pm$ 20% of design value
Deviation from plane parallel to theoretical surface:	Top and bottom	1 in 200
	Sides	1 in 100
Cover to embedded steel on vertical side surfaces		-1.0 to + 4.0 mm
Cover to embedded steel on top and bottom surfaces		-1.0 to +2.0 mm
Pintle hole diameter		0 to + 2 mm
Position of pintle holes relative to each other		$\pm$ 2 mm



**MATERIAL SPECIFICATION FOR
BEARINGS - ROTATIONAL AND SLIDING SURFACE**

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1203.01 SCOPE

This specification covers the requirements for Materials, design, and fabrication of rotational and sliding surface bearings for bridges.

1203.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 906 Structural Steel for Bridges
OPSS 911 Coating Structural Steel Systems

Ontario Provincial Standard Specifications, Material

OPSS 1202 Bearings - Elastomeric Plain and Steel-Laminated

Ontario Ministry of Transportation Publications

Structural Manual:

Division 1, Exceptions to the Canadian Highway Bridge Design Code CAN/CSA S6 for Ontario

CSA Standards

B95-1962 (R2002)	Surface Texture (Roughness, Waviness and Lay)
G40.20-13/40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel /Structural Quality Steel
S6-19	Canadian Highway Bridge Design Code
S157-17	Strength Design in Aluminium
W48-18	Filler Metals and Allied Materials for Metal Arc Welding
W59-18	Welded Steel Construction (metal Arc Welding)

ASTM International

A240-19	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
B36-18	Standard Specification for Brass Plate, Sheet, Strip, and Roller Bar
B137-95(2014)	Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminium
B487-85(2013)	Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section
D395-18	Standard Test Method for Rubber Property - Compression Set
D412-16	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
D429-14	Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
D638-14	Standard Test Method for Tensile Properties of Plastics
D792-13	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D2240-15e1	Standard Test Method for Rubber Property - Durometer Hardness
D4894-19	Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
F2329-15	Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
F3125-19	Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

American National Standards Institute (ANSI)

B4.1-1967 (R2009)	Preferred Limits and Fits for Cylindrical Parts

U.S. Military Specifications

SAE AS 8660	Silicone Compound Nato Code Number S-736

1203.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Disc Bearing means a bearing consisting of a single moulded disc of unreinforced elastomer confined by upper and lower steel bearing plates and restricted from horizontal movement by limiting rings and a centrally located shear restriction mechanism.

Elastomer means a compound containing virgin natural polyisoprene (natural rubber) for confined elastomeric bearings or polyether urethane polymer for disc bearings.

Plan Dimension means the dimensions of an object, when viewed perpendicular to the top of the object.

Pot Bearing means a bearing consisting of a metal piston supported by a single moulded disc of unreinforced elastomer that is confined within a metal cylinder.

Product Drawings means drawings prepared by the manufacturer that have been approved by the Owner for use with the product.

PTFE means polytetrafluoroethylene polymer.

Spherical Bearing means a bearing consisting of a curved spherical metal surface in contact with and sliding on a matching curved sliding surface.

Substructure means the abutments, piers, columns, and other components of a bridge below the bearings.

Superstructure means all parts of a bridge above the bearings.

1203.04 DESIGN AND SUBMISSION REQUIREMENTS

1203.04.01 Design Requirements

1203.04.01.01 Design

All components of the bearings, including fasteners and sliding materials, shall be designed according to the requirements of CSA S6 and Structural Manual, Division 1.

Bearings subject to uplift shall limit the separation of the bearing components to the value specified in the Contract Documents.

1203.04.01.02 Translations and Rotation

Provision for rotation about any horizontal axis shall be by means of a single disc of confined elastomer for pot bearings, a single disc of polyether urethane polymer compound for disc bearings, and a spherical sliding surface of stainless steel or anodized aluminium alloy against a sliding surface for spherical bearings.

The rotational capacity about any horizontal axis shall be the rotation caused by ultimate limit states loads plus 0.02 radians.

The rotational capacity about the vertical axis through the centre of the bearing shall be a minimum of 0.02 radians, unless specified elsewhere in the Contract Documents.

For bearings that are not restrained in the longitudinal direction, the bearings shall accommodate the design movements at Serviceability Limit States (SLS) plus 25 mm in each direction, but no less than 50 mm in each direction. For bearings that are not restrained in the transverse direction, the bearings shall accommodate the design movements at SLS plus 5 mm in each direction, but not less than 10 mm in each direction.

Brass sealing rings shall have a rectangular cross-section.

The depth of the pot wall shall be such that a minimum vertical distance of 2.5 mm remains between the top of the pot wall and the closest point of contact of the sealing rings with the pot wall upon rotating the piston about any horizontal axis to the maximum rotation at ultimate limit states (ULS) plus 0.02 radians.

The pot and piston surfaces in contact with the confined elastomer shall be lubricated with silicone grease. The bearing shall be sealed by a one-piece continuous preformed closed-cell compressible ring against entry of dirt, dust, and moisture between the elastomer and the pot and piston contact surfaces. Any joint in the ring shall be bonded and the strength shall be at least equal to the strength of the ring.

For disc bearings, the upper and lower plates in contact with the elastomer shall be provided with outer limiting rings to restrict the horizontal movement of the elastomer and a centrally located shear restriction mechanism.

1203.04.01.03 Sliding Surfaces

1203.04.01.03.01 Geometric Requirements

The metal surface shall overlap the sliding material by at least 5 mm at extremes of movement. The metal surface shall be positioned above the sliding material element except for guides for lateral restraint.

1203.04.01.03.02 Polytetrafluoroethylene Polymer Layer

Except when used as mating surfaces for guides for lateral restraint, PTFE resin shall be virgin material and shall be used as unfilled sheets and shall contain spherical reservoirs for lubricant pressed into its surface.

Material used as mating surface for guides for lateral restraint shall not be dimpled or lubricated.

1203.04.01.03.03 Lubrication

All PTFE surfaces except those that act as mating surfaces for guides for lateral restraint or that are subject to a contact pressure of less than 5 MPa shall be permanently lubricated with silicone grease.

1203.04.01.03.04 Contact Pressure

The average contact pressure at serviceability limit state loads for filled PTFE elements used to face mating surfaces for guides for lateral restraint shall not exceed the following:

- a) PTFE filled with up to 15% by mass of glass fibres, 45 MPa.
- b) Lead filled PTFE in a bronze matrix, 140 MPa.

1203.04.01.04 Guides for Lateral Restraint

Unless the guide bars are machined to form an integral part of the top plate, they shall be recessed greater than 5 mm into the plate to which they are attached and fastened with bolts.

The translational elements of guides for lateral restraint shall be faced with stainless steel and shall provide lateral restraint by sliding against mating surfaces faced with either PTFE or another Approved sliding material. Lead filled PTFE shall be at least 2 mm thick and shall be mechanically fastened and bonded to the substrate. Glass filled or virgin PTFE shall be recessed and bonded to the substrate.

1203.04.01.05 Top and Base Plates

The top and base plates that are permanently attached to the structure shall be provided with the bearings.

1203.04.01.06 Fasteners and Anchorage

Fasteners used to attach the bearing to the top and base plates and the anchorage devices shall be capable of resisting lateral loads as specified in the Contract Documents.

The beneficial effect of friction shall be neglected in proportioning the fasteners and anchors.

1203.04.01.07 Bearing Assembly Replacement

The entire bearing assembly, except for the top plate used to attach it to the superstructure and the base plate used to anchor it to the substructure but including both contact surfaces of the sliding interface, shall be replaceable without damage to the structure and without removal of any concrete, welds, or anchorages permanently attached to the structure and without lifting the superstructure more than 5 mm. Bearings shall not be recessed into plates that are permanently attached to the structure.

1203.04.01.08 Durability

Bearings shall be designed to prevent moisture and dirt from entering the internal surfaces.

Contact between dissimilar metals that could have corrosion potential and between the aluminium alloy and concrete shall be prevented by use of suitable insulation.

1203.04.01.09 Concrete Bearing Pressure

For bearings subject to compressive loading, the top plate and the base plate shall be designed to ensure the average concrete bearing pressure does not exceed 24 MPa at the ultimate limit states providing the following:

- a) Concrete on which the plate is supported has a specified nominal 28-Day compressive strength of at least 30 MPa.
- b) Edges of the plates are located a minimum of 100 mm from the edge of the concrete.
- c) The largest dimension of plate does not exceed 1,000 mm.

Alternatively, the top plate and the base plate of the bearing shall be designed to ensure the factored bearing resistance of concrete specified in CSA S6 and the Structural Manual, Division 1, is not exceeded.

1203.04.02 Submission Requirements

1203.04.02.01 General

Within 30 Days of the Contract award, the name and address of the supplier of the bearings shall be submitted in writing to the Contract Administrator.

Proposals shall bear the seal and signature of the design and checking Engineers.

When another authority is involved, all submissions shall be made a minimum of 35 Days prior to the commencement of work.

1203.04.02.02 Working Drawings

At least seven Days prior to commencement of bearing fabrication, one hardcopy and one electronic PDF copy of Working Drawings for the bearings shall be submitted to the Contract Administrator for information purposes only. An Engineer shall affix his or her seal and signature on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

The Working Drawings shall be according to the Contract Documents and Product Drawings.

The Working Drawings shall clearly indicate all material properties, dimensions, connection attachments, fasteners and accessories, the bearing alphanumeric identification, and the load capacity at the serviceability and ultimate limit states as follows:

- a) Maximum vertical permanent and total load.
- b) Maximum lateral load and corresponding vertical load.
- c) Maximum rotational capacity about any horizontal axis and about the vertical axis at the centre of the bearing.

The bearing supplier shall have a copy of the Working Drawings at the manufacturing plant prior to and during the bearing fabrication.

1203.04.02.03 Mill Test Certificates

Mill test certificates shall be submitted and shall be according OPSS 906 Mill Test Certificates clause.

1203.04.02.04 Test Reports for Fasteners

Test reports for fasteners shall be submitted and shall be according OPSS 906 Test Reports for Fasteners clause.

1203.04.02.05 Manufacturer's Certification

Upon completion of fabrication and prior to installation of the bearings, a certificate of compliance signed by the manufacturer shall be submitted to the Contract Administrator. The certificate of compliance shall state that the fabricated bearings are according to the Working Drawings, Product Drawings, and Contract Documents.

1203.05 MATERIALS

1203.05.01 Steel

Steel components shall be according to OPSS 906, Grades 300W or 350W, except for components permanently attached to steel superstructures, which shall be Grade 350A.

Stainless steel for sliding surfaces shall have a minimum corrosion resistance according to ASTM A240, Type 304.

Steel fasteners shall be Grade A325M according to ASTM F3125 and hot-dipped galvanized according to ASTM F2329. For guide bars, alternative steel fasteners and corrosion protection systems shall be as specified in the Contract Documents.

Stud shear connectors shall be according to CSA W59 Annex H, Type B.

1203.05.02 Aluminium Alloy

Aluminium alloy shall be according to CSA S157.

1203.05.03 Brass

Brass sealing rings for confined elastomer bearings shall be according to ASTM B36, half-hard.

1203.05.04 Elastomers

Polyisoprene shall be according to OPSS 1202 Table 1 except the shear modulus shall be between 0.65 and 0.80 MPa.

Polyether urethane polymer shall be according to Table 1.

1203.05.05 Sliding Materials

PTFE used in sliding surfaces shall be virgin, according to ASTM D4894. The PTFE shall be unfilled and according to Table 2.

Material used as the mating surface for guides for lateral restraint may be one of the following:

- a) Unfilled PTFE.
- b) PTFE filled with up to 25% by mass of glass fibres.
- c) Lead filled PTFE in a bronze matrix.

Sliding materials other than PTFE shall be from the same material supplier and shall be the same material composition as specified on the product drawings.

1203.05.06 Lubricant

Lubricant for PTFE shall be silicone grease according to SAE AS8660.

Lubricant for other sliding materials shall be as specified by the manufacturer and shall be the same lubricant used during the testing of the sliding material.

1203.05.07 Adhesives

Adhesives for bonding sliding materials to metal shall produce a bond with a minimum peel strength of 3.6 N/mm. Adhesives shall not degrade in the service environment and shall be compatible with both the substrate and the sliding material.

1203.07 PRODUCTION

1203.07.01 Welding

Welding of structural quality steels shall be according to CSA W59.

All welding shall be done with electrodes certified by the Canadian Welding Bureau to the requirements of CSA W48.

Stainless steel sheets that come in contact with sliding materials shall be one piece continuously welded around the perimeter to its backing plate to prevent ingress of moisture. The weld shall be clean, uniform, and without overlaps and located outside the area in contact with the sliding material.

1203.07.02 Fasteners

The threaded portion of the bolts shall be coated with silicone grease prior to installation.

1203.07.03 Anchors

The top and base plate anchorage to concrete shall be by studs approved by the Owner that are fusion welded to the plates.

1203.07.04 Machining

Metal to metal contact surfaces shall be machined or fine ground. The pots and pistons for confined elastomer bearings and the upper and lower plates with limiting rings for disc bearings shall be machined from solid metal plate or castings. The concave and convex plates for spherical bearings shall be machined from solid metal plate or castings.

There shall be no openings or discontinuities in the metal surfaces in contact with the elastomer or sliding material.

1203.07.05 Roughness of Metal Surfaces

The roughness of sliding stainless steel metallic surfaces in contact with a sliding material, measured according to CSA B95, shall not be greater than 0.25 µm arithmetic average for plane surfaces and 0.50 µm arithmetic average for spherical surfaces. The roughness of anodized aluminium metallic surfaces shall not be greater than 0.40 µm arithmetic average.

The roughness of metal surfaces in contact with elastomer measured according to CSA B95 shall not be greater than 3.0 µm arithmetic average.

1203.07.06 Attachment of Sliding Surfaces

Virgin or glass filled PTFE elements shall be recessed in a rigid backing material and shall be bonded over the entire area with an adhesive. The rigid backing material shall be grit blasted prior to applying the adhesive.

Lead filled PTFE shall be mechanically fastened and bonded to the backing plates.

The PTFE elements used as mating surfaces for guides for lateral restraint shall extend to within 10 mm from the ends of the backing plates.

Other sliding materials shall be recessed in a rigid backing and shall be bonded over the entire area with an adhesive.

1203.07.07 Anodizing

Aluminium alloy surfaces shall be anodized using the sulphuric acid process and shall meet the requirements in Table 3.

1203.07.08 Corrosion Protection

All exposed metal corners that receive corrosion protection shall have a 3 mm rounding. All exposed metal surfaces of the bearings, except stainless steel and components permanently attached to steel superstructures, shall be protected against corrosion by a low volatile organic compound coating system according to OPSS 911. The continuous weld attaching the stainless steel sheet shall be ground smooth and have the same corrosion protection as the bearing. Steel fasteners shall be galvanized or as specified in the Contract Documents.

For corrosion protection purposes, bearing components permanently attached to steel superstructures shall be considered part of the structural steel.

1203.07.09 Identification

Each bearing shall be marked with the date of manufacture (i.e., yyyy-mm-dd) and an individual alphanumeric identification. The alphanumeric identification shall consist of the designated identification letter of the supplier and source followed by a sequential five digit number. The characters shall be stamped or engraved into two adjacent sides and shall be clearly legible after installation. The characters shall not be less than 10 mm in height with the indentations not less than 1 mm in width and 0.5 mm in depth.

1203.07.10 Tolerances

The deviation from flatness of sliding surfaces shall not exceed:

- a) 0.2 mm, when the diameter or diagonal is equal to or less than 800 mm.
- b) 0.00025 of the diameter or diagonal, when the diameter or diagonal is greater than 800 mm.

The deviation from flatness of stainless steel or aluminium alloy surfaces in contact with sliding materials for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:

- a) 0.0003 LH mm for a rectangular sliding element.
- b) 0.0006 RH mm for a circular sliding element

where:

L = the greater plan dimension for a rectangular bearing,
R = the radius of a circular bearing, and,
H = the free height of sliding element

For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be + 0.75 to + 1.25 mm. The inside diameter of the pot cylinder shall be the same as the nominal diameter of the elastomer and shall be machined to a tolerance of:

- a) 0 to + 0.125 mm for diameters up to and including 500 mm.
- b) 0 to + 0.175 mm for diameters over 500 mm.

For disc bearings, the gap between the edge of the polyether urethane polymer disc and the inside face of the limiting ring shall be $1.25\% \pm 0.25\%$ of the diameter of the disc.

The plan dimensions of the recess for the sliding material shall be the same as the nominal plan dimensions of the material and shall be machined to a tolerance of 0 to + 0.2% of the diameter or diagonal.

Overall bearing plan dimension		± 3 mm
Overall bearing height		± 3 mm
Machined surface dimensions		± 0.4 mm
Elastomer:		
Diameter	a) 0.0 to -1.5 mm for diameters ≤ 500 mm b) 0.0 to -2.0 mm for diameters > 500 mm	
Thickness	0.0 to + 1.0 mm	
Brass rings:		
	Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer	0 to + 0.5 mm
	Difference between sum of thicknesses of brass rings and recess depth in the moulded elastomer	0 to + 0.25 mm
Recessed Guide Bars - American Standard Clearance Locational Fit Class LC3 according to ANSI B4.1.		
Guides for Lateral Restraint -	Gap between metal restraints surfaces and mating PTFE elements mm	0.50 mm ± 0.25
Sliding material plan dimension	0 to - 0.2% of diameter or diagonal	
Sliding material thickness	0 to + 10.0% of thickness	
Depth of recess for sliding material	0 to + 0.3 mm	

TABLE 1
Physical Requirements for Polyether Urethane Polymer

Physical Property	ASTM Test Methods	Requirements	
		Minimum	Maximum
Hardness, Scale D	D 2240	60	64
Tensile Stress, MPa @ 100% elongation @ 200% elongation	D 412	14 26	-- --
Tensile Strength, MPa	D 412	35	--
Ultimate Elongation, %	D 412	220	--
Compression Set, % 22 h @ 70 °C	D 395	--	40

TABLE 2
Physical Requirements for Polytetrafluoroethylene Polymer

Physical Property	ASTM Test Method	Requirement
Tensile Strength, MPa	D 638	minimum 20
Elongation, %	D 638	minimum 200
Relative Density	D 792	2.16 ± 0.03

TABLE 3
Requirements for Anodizing of Aluminium Alloy Surfaces

Physical Property of Sealed Anodic Coating	Units	Test Method	Requirements
Thickness, t	µm	ASTM B 487	25 minimum
Mass, w Apparent density, d	mg/ cm ² g/ cm ³	ASTM B 137	5.8 minimum 2.32 minimum
The apparent density shall be determined as: $d = \frac{10 w}{t}$			



MATERIAL SPECIFICATION FOR CLAY SEAL

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1205-A	Commentary

1205.01 SCOPE

This specification covers the requirements of clay seal material for use at the upstream or inlet side of culverts.

1205.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1205.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1205.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1010 Aggregates - Base, Subbase, Select Subgrade, and Backfill Material.

ASTM International

D 4318-10 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D 5084-10 Permeability of Saturated Soils Using a Flexible Wall Permeameter

1205.03 DEFINITIONS

For the purpose of this specification the following definitions apply:

Bentonite means a commercial term applied to clay deposits containing sodium montmorillonite as the essential mineral.

Clay means a fine textured (i.e., grain size smaller than 0.002 mm) sedimentary or residual deposit consisting of hydrated silicates of aluminum mixed with various impurities, but no organics. It is a cohesive soil and plastic within a wide range of water content.

Geosynthetic Clay Liner means sodium bentonite soils sandwiched between two protective geotextiles.

Liquid Limit means the water content between the semi-liquid and the plastic states of the soil.

Plastic Limit means the water content between the plastic and semi-solid states of the soil.

Plasticity Index means the water content range of a soil at which it is plastic, defined numerically as the liquid limit minus the plastic limit.

1205.04 DESIGN AND SUBMISSION REQUIREMENTS

1205.04.01 Submission Requirements

1205.04.01.01 Natural Clay

The results of the Atterberg Limit Tests (Liquid Limit and Plasticity Index) on the natural clay shall be submitted to the Contract Administrator at least one week prior to the commencement of work. The Atterberg Limits shall be determined using ASTM D 4318.

1205.04.01.02 Clay Mixture

The results of the Atterberg Limit Tests (Liquid Limit and Plasticity Index) and permeability tests on the clay mixture shall be submitted to the Contract Administrator at least one week prior to the commencement of work. The Atterberg Limits shall be determined using ASTM D 4318. The permeability shall be according to ASTM D 5084.

1205.04.01.03 Geosynthetic Clay Liner

Material specifications containing the physical, mechanical, and hydraulic properties of the geosynthetic clay liner shall be obtained from the manufacturer and submitted to the Contract Administrator. The specification shall include the manufacturer's certification and warranty.

1205.05 MATERIAL

1205.05.01 General

Material used shall have plasticity index and liquid limit percentages that are within the hatched area shown in Figure 1. It shall be natural clay, clay mixture, or a geosynthetic clay liner and shall meet the physical requirements as specified below.

1205.05.02 Natural Clay

Not all clays are suitable for use as clay seal. Clay material shall be according to the following:

- a) Liquid limit shall be $> 50\%$.
- b) Plasticity index shall be $> 0.75 \times (\text{Liquid Limit} - 20\%)$.

1205.05.03 Clay Mixture

A mixture of clay and other materials can be used, provided that they meet the physical properties for natural clay and the permeability as determined from the falling head permeameter test does not exceed 1×10^{-5} mm/s.

1205.05.04 Geosynthetic Clay Liner

The geosynthetic clay liner shall have a permeability not exceeding 1×10^{-5} mm/s.

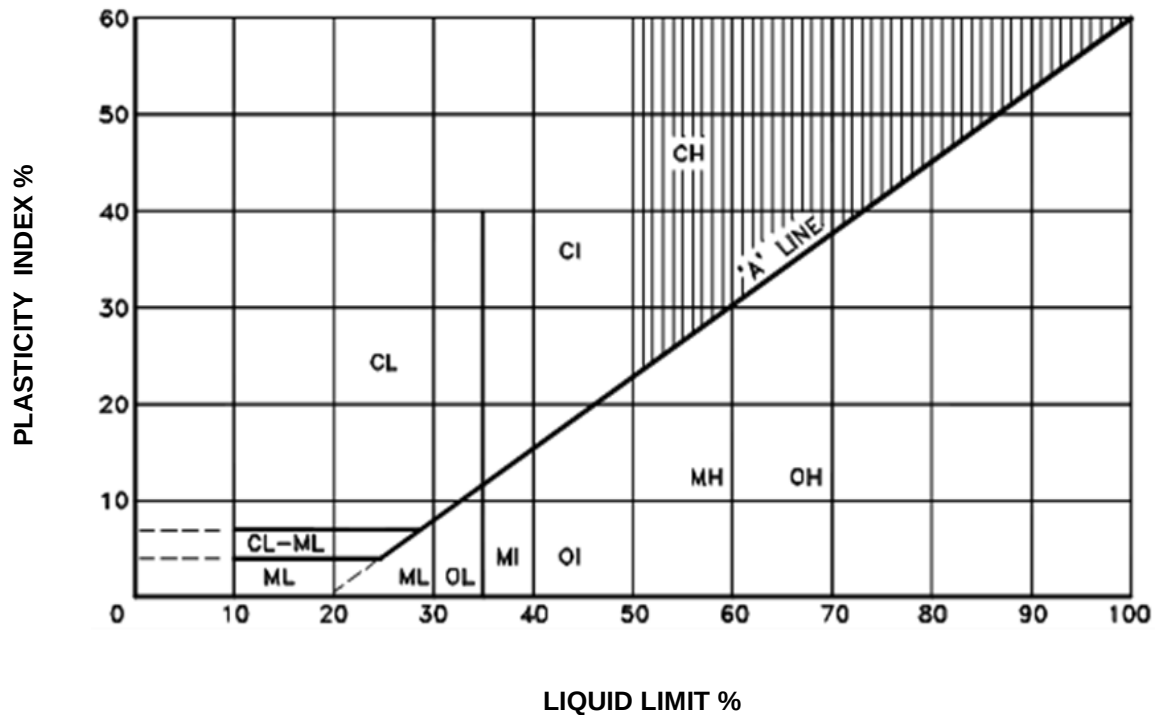


FIGURE 1
Plasticity Chart

LEGEND:

Soil Classifications

- CH - Inorganic Clays of High Plasticity, Fat Clays
- CI - Inorganic Silty Clays of Medium Plasticity
- CL - Inorganic Silty Clays, Gravelly Clays, Sandy Clays, lean Clays
- MH - Inorganic Silts, Highly Compressible Micaceous or Diatomaceous Fine Sandy Silts, Elastic Silts
- MI - Inorganic Compressible Fine Sandy Silt With Clay of Medium Plasticity, Clayey Silts
- ML - Inorganic Silts and Sandy Silts of Slight Plasticity, Rock Flour
- OH - Organic Clays of High Plasticity
- OI - Organic Silty Clays of Medium Plasticity
- OL - Organic Silt of Low Plasticity, Organic Sandy Silts

Appendix 1205-A, April 2015
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



MATERIAL SPECIFICATION FOR DECK JOINT ASSEMBLIES

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1210.09	OWNER PURCHASE OF MATERIAL - Not Used
1210.01	SCOPE

This specification covers the requirements for Materials, design, and fabrication of deck joint assemblies.

1210.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 906	Structural Steel for Bridges
OPSS 920	Deck Joint Assemblies, Preformed Seals, Joint Fillers, Joint Seals, Joint Sealing Compounds, and Waterstops - Structures

Ontario Provincial Standard Specifications, Material

OPSS 1202	Bearings - Elastomeric Plain and Steel Laminated
OPSS 1203	Bearings - Rotational and Sliding Surface

Ontario Ministry of Transportation Publications

Structural Manual:
Division 1, Exceptions to the Canadian Highway Bridge Design Code CAN/CSA S6 for Ontario

CSA Standards

S6-19	Canadian Highway Bridge Design Code
W47.1-09 (R2019)	Certification of Companies for Fusion Welding of Steel
W59-18	Welded Steel Construction (Metal Arc Welding)

ASTM International

A123-17	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A240-18	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Application
D412-16a	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
D471-16a	Standard Test Method for Rubber Property - Effect of Liquids
D573- 04(2015)	Standard Test Method for Rubber Deterioration in an Air Oven
D832-07 (2018)	Standard Practice for Rubber Conditioning for Low Temperature Testing
D1149-18	Standard Test Method for Rubber Deterioration - Cracking in an Ozone Controlled Environment
D2240-15	Standard Test Method for Rubber Property - Durometer Hardness
F835-13	Standard Specification for Alloy Steel Socket Button and Flat Countersunk Head Cap Screws
F2329-15	Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
F3125/F3125M-19	Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

1210.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Armouring means an edging to the deck joint comprising of a steel angle or steel plate permanently attached to the concrete dam corners.

Armouring Angle means the expansion joint angle at the gap.

Bearing means a structural device that transmits load while permitting translation or rotation or both.

Elastomer means a compound containing virgin polychloroprene (neoprene).

Manufacturer means a fabrication company that is certified according to CSA W47.1, Division 1 or 2.

Nosing Angle means the angle that forms the outside edges of the joint blockout.

Preformed Seal means an extruded elastomer that, when retained in recesses in the deck joint assembly, prevents the passage of water and other materials.

Separation Beam means a steel section which conveys wheel loads that spans between support bars.

Support Bar means a member upon which a traffic bearing separation beam rests.

1210.04 DESIGN AND SUBMISSION REQUIREMENTS

1210.04.01 Design Requirements

1210.04.01.01 General

Deck joint assemblies shall be designed to function satisfactorily under the critical combinations of loads, translations, and rotations according to CSA S6 and the Structural Manual, Division 1.

1210.04.01.02 Modular Expansion Joints

Loading for modular joints shall be as specified in the Structural Manual, Division 1.

Modular joints shall be equipped with a mechanism capable of ensuring all openings of the joint are of uniform width as follows:

- a) Stiffness of the mechanism shall not exceed 8.5 kN per metre along the length of the expansion joint.
- b) The width of individual openings shall not vary by more than 6 mm along the length of the joint.
- c) The range of widths of openings shall not vary by more than 6 mm.

Field splices in modular joints are not permitted.

1210.04.01.03 Fasteners and Anchorage

Fasteners and anchorage devices shall be designed to transfer all the static and dynamic loads from each side of the deck joint assembly to the structure.

1210.04.01.04 Preformed Seal

All deck joint assemblies and the bearings in modular deck joint assemblies shall be designed so that the entire preformed seal is replaceable without damage to the structure and without removal of any concrete, welds, or anchorages permanently attached to the structure.

Seals shall not be bent in a vertical plane more than 30° at any one location.

1210.05 MATERIALS

1210.05.01 Bearings

All material forming parts of the bearing component of the deck joint assembly shall be according to OPSS 1202 and OPSS 1203.

Virgin polytetrafluoroethylene element shall have a minimum thickness of 1.5 mm.

1210.05.02 Preformed Seal

The preformed seal shall be manufactured from an elastomer with physical requirements according to Table 1.

Manufacturer's storage and handling requirements shall be followed. The seal shall not be exposed to ultraviolet rays for more than three Days prior to installation.

1210.05.03 Steel

Structural steel components shall be according to OPSS 906, Grade 300W.

Stainless steel shall have a minimum corrosion resistance according to ASTM A240, Type 304.

Steel fasteners other than stainless steel shall be according to ASTM F3125 (Grade A325M, Type 1, galvanized) or ASTM F835 (zinc phosphate coated).

1210.05.04 Anchors

Anchors shall be headed type stud shear connectors according to CSA W59, Annex H.

1210.05.05 Anti-seize Compound

Anti-seize compound shall be LOCTITE Moly 50 manufactured by Henkel Corporation or an alternative acceptable to the Owner.

1210.05.06 Injection Hose System for Deck Joint Assembly

The injection hose system shall be installed on the deck joint assembly for both nosing and armouring angles. This system shall be long enough to extend between the barrier or parapet walls on each side of the structure, including the sidewalks and curbs.

The nosing and armouring angles shall not contain bleeder holes.

1210.07 PRODUCTION

1210.07.01 General

The deck joint assembly manufacturer shall have a copy of the deck joint assembly Working Drawings specified in OPSS 920 at the manufacturing plant during the deck joint assembly fabrication.

1210.07.02 Welding

Welding of structural quality steels shall be according to CSA W59.

Welding of stainless steel shall be according to OPSS 1203.

1210.07.03 Fasteners

The threaded portion of bolts and the underside of the bolt heads shall be coated with an anti-seize compound prior to installation.

1210.07.04 Steel Fabrication

Machining shall be carried out after welding, whenever possible.

All rough flame cut surfaces and metal-to-metal contact surfaces shall be machined ground smooth.

Re-entrant corners that are cut shall be free from notches and shall have the largest practical radius with a minimum radius of 14 mm. Bearing surfaces shall be in contact over the full area of the mating surfaces.

1210.07.05 Corrosion Protection

All structural steel components of the deck joint assembly shall be hot dip galvanized according to ASTM A123 after fabrication. Hardware shall be galvanized according to ASTM F2329.

1210.07.06 Preformed Seal

The preformed seal shall exceed the required length by at least 1 m to provide a sample to be submitted for testing that includes the entire identification label, which includes the name of manufacturer, product identification, the lot and date of manufacture.

1210.07.07 Identification

Each deck joint section shall be marked with the date of manufacture (i.e., yyyy-mm-dd-), and an individual alphanumeric identification. The alphanumeric identification shall consist of the identification letters of the supplier and source, followed by a sequential number. The characters shall be die stamped into an exposed surface at the gutter line at the barrier wall or curb. The characters shall not be less than 10 mm high with the indentations not less than 0.5 mm in width and 0.2 mm in depth.

The preformed seal shall be clearly and indelibly marked at one metre intervals indicating manufacturer, lot number, date of manufacture (i.e., yyyy-mm-dd), and model number.

1210.07.08 Designation of Lifting Points

The lifting points shall be clearly marked on the deck joint assembly.

TABLE 1
Preformed Seal Physical Requirements

Preformed Seal Physical Requirements Property	Physical Requirements	Test Procedure
Tensile Strength	Minimum 13.5 MPa	ASTM D412 Test Method A
Ultimate Elongation	Minimum 250%	ASTM D412 Test Method A
Hardness,	55 Shore A, + 7, -5	ASTM D2240
Oven Aging Test, 70 h @ 100 °C Change in Tensile Strength	Maximum 20%	ASTM D573 ASTM D412 Test Method A
Change in Elongation	Maximum 20%	ASTM D412 Test Method A
Change in Hardness	Maximum 10 points	ASTM D2240
Permanent set at break	Maximum 10%	ASTM D412 Test Method A
Low Temperature Crystallization Hardness, Shore A 7 d @ -10 °C Change in Hardness	Maximum 15 points	ASTM D832 ASTM D2240
Oil Swell, ASTM Oil No. 3, 70 h @ 100 °C Weight Change	Maximum 45%	ASTM D471
Ozone Resistance, 20% Strain, 150 pphm in air 70 h @ 40 °C	No cracks	ASTM D1149 Method B, Procedure B1
Notes:		
A. All tests shall be made on specimens prepared from the preformed seals.		



**MATERIAL SPECIFICATION FOR
HOT POURED RUBBERIZED ASPHALT
JOINT SEALING COMPOUND**

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1212.06	EQUIPMENT - Not Used
1212.07	PRODUCTION
1212.08	QUALITY ASSURANCE
1212.09	OWNER PURCHASE OF MATERIAL - Not Used

1212.01 SCOPE

This specification covers hot poured rubberized asphalt compounds for sealing joints and cracks with a small amount of movement either in Portland cement concrete pavements or hot mix asphalt pavements.

1212.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

ASTM International

D36-06	Standard Test Method for Softening Point of Bitumen (Ring and Ball Apparatus)
D70-08	Standard Test Method for Density of Semi-Solid Bituminous Materials (Pycnometer Method)
D5329-07	Test Methods for Sealants and Fillers, Hot-Applied, For Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

Ministry of Transportation Publications

LS-262	Method of Test for Bulk Relative Density of Compacted Bituminous Mixtures

National Standard Specifications

CAN/CGSB 37.50-M89 Hot Applied Rubberized Asphalt for Roofing and Waterproofing

1212.05 MATERIALS

1212.05.01 HRA Waterproofing Membrane

Shipments of hot-poured rubberized asphalt joint/crack sealant compounds shall meet the requirements given in Table 1.

1212.07 PRODUCTION

1212.07.01 Pouring Point

The pouring point for hot-poured rubberized asphalt joint/crack sealant compounds shall be at least 10 °C lower than the safe heating temperature recommended by the manufacturer.

For hot-poured rubberized asphalt joint/crack sealant compounds used for sealing joints and cracks in Portland cement concrete pavements, the pouring point shall also be the lowest temperature to which the material is heated and at which it is suitable for filling a 12.5 mm wide and 40 mm deep groove formed between two blocks of concrete without inclusions of large air voids or discontinuities and without damage to the material.

For hot-poured rubberized asphalt joint/crack sealant compounds used for sealing joints and cracks in asphalt pavements, the pouring point shall also be the lowest temperature to which the material is heated and at which it is suitable for filling a 40 mm wide and 10 mm deep groove cut in asphaltic concrete pavement without inclusions of large air voids or discontinuities and without damage to the material.

1212.07.02 Packaging and Marking

The sealing compound shall be packaged in 22 kg or smaller units. It shall be contained in a polyethylene bag, and the bags, shall, in turn be placed in a metal container. Each container shall be legibly marked with the following information:

- a) Designated trade name of the compound.
- b) Manufacturer's name.
- c) Batch number.
- d) Date of manufacture.
- e) Quantity contained.

1212.08 QUALITY ASSURANCE

1212.08.01 Testing Joint/Crack Sealant Compound

All samples of sealant compound that are used for sealing joints and cracks in hot mix asphalt pavements and Portland cement concrete pavements shall/will be tested for all of the attributes listed in Table 2, with the exceptions as noted.

TABLE 1
Testing Requirements

Test	Sealant Designation	
	“Southern Ontario Only”	“All Districts” (Note 1)
Cone Penetration @ 25 °C	≤ 90 units	-
Flow (mm)	≤ 5	≤ 3
Bond - 3 cycles @ 50% extension at -18°C	Pass	-
Notes: 1. A successful field trial is required before a product is accepted for placement on the DSM.		

TABLE 2
Testing Requirements

Test	Procedures Required for Hot-Poured Rubberized Joint / Crack Sealing Compounds Used in Hot Mix Asphalt Pavements	Procedures Required for Hot-Poured Rubberized Joint / Crack Sealing Compounds Used in Portland Cement Concrete Pavements
Sample Preparation	CAN/CGSB 37.50-M	CAN/CGSB 37.50-M
Cone Penetration	ASTM D5329	ASTM D5329
Resilience	ASTM D5329	ASTM D5329
Asphalt Compatibility (tested to 80 °C)	ASTM D5329 - (Note 1)	Not Required
Bond (Non-Immersed) (Note 2)	ASTM D5329	ASTM D5329
Flow	ASTM D5329	ASTM D5329
Softening Point	ASTM D36 - (Note 1)	Not Required
Relative Density	ASTM D70 - (Note 1)	LS-262
Toughness	Not Required	CAN/CGSB 37.50-M
Notes: 1. For each batch of sealant compound used in hot mix asphalt pavements, the Contractor shall provide results for all of these tests. However, for re-heated sealant compounds that are sampled during construction, these tests will be completed at the discretion of the Bituminous Section in Downsview. 2. For each batch of “All Districts” products used as joint/crack sealant compound in hot mix asphalt pavements, the Contractor shall provide test results based on bond testing that is conducted in 3 cycles at -29°C with both 50% and 200% extension. For each batch of “Southern Ontario Only” sealant used as joint/crack sealant compound in hot mix asphalt pavement, the Contractor shall provide test results based on bond testing that is conducted in 5 cycles at -18°C with 50% extension. All re-heated sealant compounds sampled during construction will be tested in 5 cycles at -18°C with 50% extension, or when used as joint/crack sealant compound in hot mix asphalt pavements, the samples will be tested, as specified by the Bituminous Section in Downsview.		



**MATERIAL SPECIFICATION FOR
HOT-APPLIED RUBBERIZED ASPHALT
WATERPROOFING MEMBRANE**

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1213.07	PRODUCTION
1213.08	QUALITY ASSURANCE
1213.09	OWNER PURCHASE OF MATERIAL - Not Used
1213.01	SCOPE

This specification covers the material requirements for hot-applied rubberized asphalt (HRA) waterproofing membrane for structures.

1213.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction:

OPSS 914 Waterproofing Bridge Decks and Culverts with Hot-Applied Rubberized Asphalt Waterproofing Membrane

Ontario Ministry of Transportation Publications:

Laboratory Testing Manual:

LS-350 Low Temperature Flexibility of Hot-Applied Rubberized Asphalt Waterproofing Membrane

LS-351 Cone Penetration and Relative Density of Hot-Applied Rubberized Asphalt Waterproofing Membrane

LS-352 Flow of Hot-Applied Rubberized Asphalt Waterproofing Membrane

LS-353	Toughness and Ratio of Toughness to Peak Force and Adhesion of Hot-Applied Rubberized Asphalt Waterproofing Membrane
LS-354	Heat Stability of Hot-Applied Rubberized Asphalt Waterproofing Membrane
LS-360	Oven Aged Low Temperature Flexibility of Hot-Applied Rubberized (HRA) Asphalt Waterproofing Membrane

1213.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Hot-Applied Rubberized Asphalt (HRA) Waterproofing Membrane means as defined in OPSS 914.

1213.05 MATERIALS

1213.05.01 HRA Waterproofing Membrane

The HRA waterproofing membrane, including oven aged samples, shall be according to Table 1.

1213.07 PRODUCTION

1213.07.01 Markings and Packaging

The following information shall be clearly shown on each package of HRA waterproofing membrane:

- a) Product name.
- b) Name of manufacturer.
- c) Manufacturer's batch or lot number.

1213.08 QUALITY ASSURANCE

1213.08.01 Sampling and Lot Size

Sampling and lot size for the HRA waterproofing membrane shall be according to OPSS 914.

1213.08.02 Acceptance of HRA Waterproofing Membrane

The HRA waterproofing membrane shall be considered acceptable when all the properties listed above meet the acceptance values specified in Table 1.

Unacceptable HRA waterproofing membrane shall be subject to removal and replacement.

TABLE 1
HRA Waterproofing Membrane Properties - Acceptance Values

Test	Test Number	Acceptance Value
Low Temperature Flexibility at -25 °C	LS-350	Pass according to the requirements in LS-350 (no breaks or cracks).
Cone Penetration at 25 °C	LS-351	Max. 110 (0.1 mm)
Cone Penetration at 50 °C	LS-351	Max. 160 (0.1 mm)
Flow at 60 °C	LS-352	Max. 3 mm
Toughness	LS-353	Min. 5.5 joules
Toughness/Peak Force	LS-353	Min. 0.040 joules/newton
Adhesion	LS-353	A minimum of 2 of the 3 samples shall pass according to the requirements in LS-353.
Relative Density	LS-351	For Information
Heat Stability	LS-354	Pass all tests
Oven Aged Low Temperature Flexibility	LS-360	Pass according to the requirements in LS-360 (no breaks or cracks).



**MATERIAL SPECIFICATION FOR
PROTECTION BOARD**

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1215.08	QUALITY ASSURANCE
1215.09	OWNER PURCHASE OF MATERIALS - Not Used

1215.01 SCOPE

This specification covers the material requirements for protection board for use with hot-applied rubberized asphalt (HRA) waterproofing membranes.

1215.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standards Specifications, Construction:

OPSS 914 Waterproofing Bridge Decks and Culverts with Hot-Applied Rubberized Asphalt Waterproofing Membrane

MTO Publications

MTO Laboratory Testing Manual:

LS-282	Method of Test for Quantitative Extraction of Asphalt Cement and Analysis of Extracted Aggregate
LS-355	Water Absorption of Protection Board
LS-356	Indentation/Puncture Test
LS-357	Compatibility
LS-358	Weather Simulation and Bond of Protection Board
LS-359	Thickness of Protection Board

1215.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Hot-Applied Rubberized Asphalt (HRA) Waterproofing Membrane means as defined in OPSS 914.

1215.05 MATERIAL

1215.05.01 Protection Board

1215.05.01.01 General

Protection board shall be formed of asphalt and fillers between two fibreglass sheet materials. The thickness of the protection board shall be 3.60 ± 0.40 mm when tested according to this specification.

1215.05.01.02 Compatibility

When tested according to LS-357, the protection board shall show no evidence of puncture, delamination, pumping, stripping of the aggregates, or any signs of incompatibility between the boards and the asphaltic concrete or the HRA waterproofing membrane.

1215.05.01.03 Indentation/Puncture

When tested according to LS-356, the protection board shall have no punctures, tears or separations, and indentations shall be a minimum of 0.25 mm deep and not greater than 0.9 mm deep.

1215.05.01.04 Separation Material Between Boards

The protection board separation material, used to separate the boards and prevent bonding, shall be sand.

1215.05.01.05 Visual Appearance

The protection board shall have a uniform appearance and the fibre glass mesh shall be properly coated. Excess sand shall not be present on the protection board prior to placement.

1215.05.01.06 Water Absorption

When tested according to the Quality Assurance section, the specimens shall have a water absorption of less than or equal to 5.0% and shall show no deterioration such as stripping emulsification or loss of mass.

1215.05.01.07 Weather Simulation and Bond

When tested according to LS-358, the edge of the upper board shall not curl up more than 5 mm from the original horizontal position, and shall not delaminate within itself or debond from the HRA waterproofing membrane.

1215.07 PRODUCTION

1215.07.01 General

The protection board or the board separation material shall not be changed without the prior approval of the Owner.

Protection boards shall be coated on each side with a separation material.

1215.07.02 Dimensions

The thickness of the protection board shall be $3.6 \text{ mm} \pm 0.4 \text{ mm}$. The width of the protection board shall be $1100 \text{ mm} \pm 200 \text{ mm}$ and the length of the board shall be $1500 \text{ mm} \pm 200 \text{ mm}$. The board shall have straight edges, square corners, and edges free of burrs and breakaways.

Notwithstanding the size tolerance above, all sheets in a shipment shall be of the same length and width within a tolerance of $\pm 5 \text{ mm}$ and of uniform thickness within a tolerance of $\pm 0.25 \text{ mm}$.

1215.07.03 Storage

After manufacturing, protection boards shall be stored within the manufacturer's recommended temperature range, and in conditions that prevent water penetration and exposure to the elements.

1215.07.04 Markings and Packaging

The following information shall be clearly shown on each bundle of protection board:

- a) Product name.
- b) Name of manufacturer.
- c) Date of manufacture.

The material shall be packaged to permit shipping, handling, and storage without damage to the protection board.

1215.08 QUALITY ASSURANCE

1215.08.01 Sampling and Lot Size

Sampling and lot size for the protection board shall be as specified in OPSS 914.

1215.08.02 Acceptance of Thickness

Measurement of protection board thickness shall according to LS-359. Protection board shall be acceptable if the test result for thickness is $3.6 \text{ mm} \pm 0.4 \text{ mm}$.

1215.08.03 Acceptance of Water Absorption

The protection board shall be tested for water absorption according to LS-355. The protection board shall be acceptable if the water absorption is less than or equal to 5.0% and the protection boards shows no deterioration such as stripping emulsification or loss of mass.

1215.08.04 Acceptance of Indentation/Puncture

The protection board shall be tested for indentation/puncture according to LS-356. The protection board shall be acceptable if:

- a) The protection board shows no punctures; and
- b) Indentations are a minimum of 0.25 mm deep and not greater than 0.9 mm deep.

1215.08.05 Acceptance of Compatibility

The protection board shall be tested for compatibility according to LS-357. The protection board shall be acceptable if the board shows no evidence of puncture, delamination, pumping, stripping of the aggregates, or any signs of incompatibility between the boards and the asphaltic concrete or the HRA waterproofing membrane.

1215.08.06 Acceptance of Weather Simulation and Bond

Protection board shall be tested for weather simulation and bond according to LS-358. The protection board shall be acceptable if the edge of the upper board does not curl up more than 5 mm from the original horizontal position, and does not delaminate within itself or debond from the HRA waterproofing membrane.

1215.08.07 Asphalt Content

Protection board shall be tested for asphalt content according to LS-282. The asphalt content of the protection board shall be tested for information purposes only.



**MATERIAL SPECIFICATION FOR PRIMER USED
WITH HOT-APPLIED RUBBERIZED ASPHALT
WATERPROOFING MEMBRANE**

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1216.07	PRODUCTION
1216.08	QUALITY ASSURANCE
1216.09	OWNER PURCHASE OF MATERIAL - Not Used
1216.01	SCOPE

This specification covers the material requirements for primer used with hot-applied rubberized asphalt (HRA) waterproofing membranes.

1216.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction:

OPSS 914 Waterproofing Bridge Decks and Culverts with Hot-Applied Rubberized Asphalt Waterproofing Membrane

ASTM International

D5/D5M-20	Test Method for Penetration of Bituminous Materials
D36/D36M-14(2020)	Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D88/D88M-07(2019)e1	Test Method for Saybolt Viscosity
D95-13(2018)	Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D402/D402M-14	Test Method for Distillation of Cutback Asphaltic
D2042-22	Test Method for Solubility of Asphalt Materials in Trichloroethylene or Toluene

1216.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Hot-Applied Rubberized Asphalt (HRA) Waterproofing Membrane means as defined in OPSS 914.

Primer means as defined in OPSS 914.

1216.04 DESIGN AND SUBMISSION REQUIREMENTS

1216.04.01 Submission Requirements

1216.04.01.01 Volatile Organic Compound (VOC) Test Results

At least 14 Days prior to the application of primer, test results for the VOC content of the primer shall be submitted to the Contract Administrator.

1216.05 MATERIAL

1216.05.01 Primer

Primer shall meet the requirements of Table 1.

The primer used shall be as recommended by the HRA waterproofing membrane manufacturer.

The primer shall not be cutback or diluted.

1216.07 PRODUCTION

1216.07.01 Labeling

The following information shall be shown on the container of primer:

- a) Product name.
- b) Name of manufacturer.
- c) Batch/lot number.

1216.08 QUALITY ASSURANCE

1216.08.01 General

The laboratory designated by the Owner shall carry out quality assurance testing for purposes of ensuring that primer used in the work is according to the requirements of this specification. Individual test results shall be forwarded to the Contractor, as they become available.

1216.08.02 Sampling and Lot Size

Sampling and lot size for the primer shall be according to OPSS 914.

1216.08.03**Acceptance of Primer**

The primer shall be acceptable if the requirements of this specification are met.

A lot shall be deemed to be acceptable if all the test results for the sample of primer representing the lot meet the requirements of Table 1. Unacceptable lots shall be rejected.

TABLE 1
Primer Properties

Property	Test Method	Acceptance Requirement
Distillate obtained, expressed as a percentage of total volume to 360°C (%)	ASTM D402	190 °C 25% minimum 225 °C 70% minimum 260 °C 80% minimum 315 °C 92% minimum
Distillate obtained as a percentage of volume of original cutback asphalt, distilled to 360 °C (%)	ASTM D402	Min. 30%
Water Content (%)	ASTM D95	Max. 0.5%
Matter soluble in trichloroethylene tested on distillate heated to 360 °C (%)	ASTM D2042	Min. 98%
Penetration (100 g/25 °C/5 sec) tested on distillate heated to 360 °C (1/10 mm)	ASTM D5	25 to 85 (1/10 mm)
Softening Point tested on distillate heated to 360 °C (°C)	ASTM D36	49 to 80 °C
Saybolt Viscosity at 25 °C (seconds)	ASTM D88	50 to 400 seconds



**MATERIAL SPECIFICATION FOR MEMBRANE REINFORCEMENT
USED WITH HOT-APPLIED RUBBERIZED ASPHALT
WATERPROOFING MEMBRANE**

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1217.01 SCOPE

This specification covers the material requirements for membrane reinforcement used with hot-applied rubberized asphalt (HRA) waterproofing membranes.

1217.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction:

OPSS 914 Waterproofing Bridge Decks and Culverts with Hot-Applied Rubberized Asphalt Waterproofing Membrane

ASTM International

D1777-96 (2019)	Test Method for Thickness of Textile Materials
D3776/D3776M-20	Test Method for Mass Per Unit Area (Weight) of Fabric
D4533/D4533M-15(2023)	Test Method for Trapezoid Tearing Strength of Geotextiles
D4632/D4632M-15a(2023)	Test Method for Grab Breaking Load and Elongation of Geotextiles

1217.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Hot-Applied Rubberized Asphalt (HRA) Waterproofing Membrane means as defined in OPSS 914.

1217.05 MATERIAL

1217.05.01 Membrane Reinforcement

Membrane reinforcement shall be a non-woven polyester material meeting the requirements specified in Table 1.

The membrane reinforcement product used shall be as recommended by the HRA waterproofing membrane manufacturer.

1217.07 PRODUCTION

1217.07.01 Labeling

Each meter of membrane reinforcement shall be labelled with the product name and grade.

1217.08 QUALITY ASSURANCE

1217.08.01 Sampling and Lot Size

Sampling and lot size for the membrane reinforcement shall be according to OPSS 914.

1217.08.02 Acceptance of Reinforcement

The membrane reinforcement shall be acceptable if the requirements of this specification are met.

A lot shall be deemed to be acceptable if all the test results for the sample of membrane reinforcement representing the lot meets the acceptance requirements specified in Table 1. Unacceptable lots shall be rejected.

TABLE 1
Membrane Reinforcement Properties

Property	Acceptance Requirement	Test Method
Colour	White	Not applicable
Unit Weight (g/m ²)	46	ASTM D3776
Thickness (mm)	0.26 ± 0.02	ASTM D1777
Grab Tensile (N) MD x XD	131 x 98	ASTM D4632
Trapezoid Tear (N) MD x XD	28 x 35	ASTM D4533



MATERIAL SPECIFICATION FOR ADMIXTURES FOR CONCRETE

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APPENDICES

1303-A	Commentary

1303.01 SCOPE

This specification covers the materials for use as air entraining, chemical, and superplasticizing admixtures for concrete.

1303.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1303.01.02

Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1303.02

REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

Laboratory Testing Manual:

- LS-413 Method of Test for Non-volatile Content of Chemical Admixtures, Latex Admixtures and Curing Compounds
- LS-422 Method of Test for Evaluation of Air Entraining Admixtures for Concrete
- LS-423 Method of Test for Evaluation of Chemical Admixtures for Concrete
- LS-424 Method of Test for Evaluation of Superplasticizing Admixtures

ASTM International

- C 494 Chemical Admixtures for Concrete
- E 70-97 (2002) Test Method for pH of Aqueous Solutions with the Glass Electrode

1303.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Air Entraining Admixture means a type of admixture according to ASTM C 260 that causes development of a system of microscopic air bubbles in concrete during mixing, to increase the workability of the concrete and its resistance to freezing and thawing.

Chemical Admixture means Types A, B, C, D, E, and S admixtures according to ASTM C 494.

Non-Chloride Admixture means an admixture that contains not more than 0.01% chloride by mass of cement.

Superplasticizer means Types F and G admixtures according to ASTM C 494.

Type A means a water reducing admixture that reduces the quantity of mixing water required to produce concrete of a given consistency.

Type B means a retarding admixture that retards the setting of concrete.

Type C means an accelerating admixture that accelerates the setting and early strength development of concrete.

Type D means a water reducing and retarding admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.

Type E means a water reducing and accelerating admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.

Type F means a superplasticizing admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater.

Type G means a superplasticizing and retarding admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater and retards the setting of concrete.

Type S Admixture means a specific performance admixture that provides desired performance characteristics, other than reducing water content or changing the time of setting of concrete or both, without any adverse effects on fresh, hardened, and durability properties of concrete.

1303.04 DESIGN AND SUBMISSION REQUIREMENTS

1303.04.01 Submission Requirements

1303.04.01.01 Admixtures

The supplier shall submit documentation verifying that each admixture used on the Contract is included on the ministry's DSM.

1303.05 MATERIALS

All admixtures shall be in liquid form.

All admixtures shall be non-chloride, with the exception of admixtures used in fast-track full-depth repairs to concrete pavements or concrete base.

Admixtures shall be according to LS-422, LS-423, and LS-424.

In addition, required performance characteristics of each Type S chemical admixture shall be demonstrated on Owner approved field trials prior to use in the work.

Admixtures shall be sampled and tested as specified in the Contract Documents.

Relative density and pH of air entraining admixtures, and non-volatile content and relative density of chemical and superplasticizing admixtures shall be according to the product data shown on the DSM, within the following tolerances:

a) Relative density:

- i. Where relative density is 1.050 or less, the tolerance shall be ± 0.005 .
- ii. Where relative density is greater than 1.050, the tolerance shall be calculated according to the following formula:

$$\text{Tolerance} = (\text{relative density of acceptance sample} - 1.000) / 10$$

b) Non-volatile content $\pm 2.5\%$.

c) pH ± 1.5 .

Appendix 1303-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



Note: The PROV published in April 2019 replaces OPSS 1305 COMMON, November 2008 with no technical content changes.

MATERIAL SPECIFICATION FOR MOISTURE VAPOUR BARRIERS

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1305.01	SCOPE
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1305.03	DEFINITIONS - Not Used
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1305.05	MATERIALS
1305.06	EQUIPMENT - Not Used
1305.07	PRODUCTION - Not Used
1305.08	QUALITY ASSURANCE

1305.01 SCOPE

This specification covers the requirements for materials in sheet form used to inhibit moisture loss in concrete during its curing period.

1305.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

ASTM International

C 171-16 Sheet Materials for Curing Concrete

1305.05 MATERIALS

The material shall be a white opaque polyethylene film according to ASTM C 171.

1305.07 PRODUCTION

1305.07.01 Labelling

Each roll shall be labelled with following information:

- a) Name of manufacturer.
- b) Type of material.
- c) Batch number.
- d) Film thickness.
- e) Roll number.

1305.08 QUALITY ASSURANCE

1305.08.01 Sampling

The Owner may take quality assurance samples of film or sheeting from rolls selected at random at the jobsite from each shipment representing material of the same type.

1305.08.02 Testing

Testing of sheeting and film shall be according to ASTM C 171.

1305.08.03 Acceptance or Rejection

Material represented by a quality assurance sample failing to meet the requirements of this specification shall be rejected.



Note: The PROV published in April 2019 replaces OPSS 1306 COMMON, November 2011 with no technical content changes.

MATERIAL SPECIFICATION FOR BURLAP

TABLE OF CONTENTS

1306.01	SCOPE
1306.02	REFERENCES
1306.03	DEFINITIONS - Not Used
1306.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
1306.05	MATERIALS
1306.06	EQUIPMENT - Not Used
1306.07	PRODUCTION - Not Used
1306.08	QUALITY ASSURANCE

1306.01 SCOPE

This specification covers the requirements for burlap used for curing concrete and for use in surface texturing of concrete pavement.

1306.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

American Association of State Highway and Transportation Officials (AASHTO)

M182-05 (2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

1306.05 MATERIALS

1306.05.01 Burlap

Burlap shall be according to AASHTO M182, Class 4, and shall be free of substances that are deleterious to concrete. The burlap shall have no tears or holes.

1306.08 QUALITY ASSURANCE

1306.08.01 Sampling

The Owner may take quality assurance samples of the burlap selected at random at the job site from each shipment representing material of the same type.

1306.08.02 Testing

Testing of burlap shall be according to AASHTO M182.

1306.08.03 Acceptance or Rejection

Material represented by a quality assurance sample failing to meet the requirements of this specification shall be rejected.



MATERIAL SPECIFICATION FOR CONCRETE - MATERIALS AND PRODUCTION

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1350.08	QUALITY ASSURANCE
1350.09	OWNER PURCHASE OF MATERIAL - Not Used

1350.01 SCOPE

This specification covers the requirements for materials and methods for proportioning, mixing, transporting, field testing, acceptance, and payment adjustments of concrete material, including provisions for referee testing of compressive strength, air void system parameters, and rapid chloride.

1350.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 904 Concrete Structures

Ontario Provincial Standard Specifications, Material

OPSS 1002 Aggregates - Concrete
OPSS 1301 Cementing Materials
OPSS 1302 Water
OPSS 1303 Air Entraining and Chemical Admixtures for Concrete

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

Laboratory Testing Manual:

LS-100	Method of Rounding-off Data and Other Numbers
LS-101	Method for Calculation of Per Cent Within Limits
LS-407	Method of Test for Compressive Strength of Moulded Cylinders
LS-413	Method of Test for Non-Volatile Content of Chemical Admixtures, Latex Admixtures and Curing Compounds
LS-414	Method of Test for Relative Density of Chemical Admixtures, Air Entraining Admixtures, Latex Admixtures and Curing Compounds
LS-415	Method of Test for pH of Aqueous Solutions by Glass Electrode
LS-426	Method of Testing Compressive Strength of High Performance Concrete Cylinders
LS-431	Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete, for Conformance Testing
LS-432	Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-433	Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
LS-435	Method of Test for Linear Shrinkage of Concrete

MTO Forms:

PH-CC-322	Concrete Construction Report
PH-CC-340	Field Sample Data Sheet - Concrete
PH-CC-433A	Concrete Mix Design Submission Form A
PH-CC-433B	Concrete Mix Design Submission Form B
PH-CC-434	Sample Letter to Contractor - Concrete Mix Design

CSA Standards

A23.1/A23.2-19 Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete

A23.2-1C	Sampling Plastic Concrete*
A23.2-3C	Making and Curing Concrete Compression and Flexural Test Specimens*
A23.2-4C	Air Content of Plastic Concrete by the Pressure Method*
A23.2-5C	Slump and Slump Flow of Concrete*
A23.2-6C	Density, Yield, and Cementing Materials Factor of Plastic Concrete*
A23.2-14C	Obtaining and Testing Drilled Cores for Compressive Strength Testing*
A23.2-17C	Temperature of Freshly Mixed Hydraulic Cement Concrete*
A23.2-1D	Moulds for Forming Concrete Test Cylinders Vertically*
A3004-B6	Physical Test Methods for Cementitious Materials for Use in Concrete and Masonry **
A3001	Cementitious Materials for Use in Concrete**
* [Part of A23.1-14/A23.2-19 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]	
** [Part of A3000-18 - Cementitious Materials Compendium]	

1350.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

High Performance Concrete (HPC) means concrete with a minimum specified 28-Day compressive strength of at least 50 MPa that includes silica fume and may include other supplementary cementing materials and having specified rapid chloride permeability at 28 to 32 Days of 1,000 coulombs or less.

High Strength Concrete means concrete with a minimum specified 28-Day compressive strength of 40 MPa or greater.

Limestone Filler means an aggregate of divided limestone powder that may be used in concrete for the purpose of reducing the total amount of Portland cement used. Its use is limited to appropriate applications and exposure conditions after its suitability is determined through physical, chemical and mineralogical testing.

Portland Limestone Cement means cement obtained by intergrinding limestone with Portland cement clinker, as defined in CSA A3001.

Stationary Mixer means a non-mobile mixer installed at a plant for the purpose of mixing concrete.

Steel Reinforcement means all types of steel reinforcement for concrete, including reinforcing steel bars, stainless steel reinforcing bars, splice bars, welded steel wire fabric, and prestressing strands and bars.

Tremie Concrete means a concrete mix specifically designed to be placed under water by means of a tremie.

1350.04 DESIGN AND SUBMISSION REQUIREMENTS

1350.04.01 Design Requirements

1350.04.01.01 General

The concrete mix shall be designed to provide adequate strength and durability for the intended use and to meet the requirements as specified in the Contract Documents.

1350.04.01.01.01 Use of Admixtures

Water reducer Type A or D according to OPSS 1303 shall be used in all concrete, except in applications where plant addition of superplasticizer is permitted, in which case water reducer may be used at the Contractor's option.

Retarding of concrete set shall be provided when specified in the Contract Documents. If no retarding of set is specified, retarders may be used at the Contractor's option to delay setting of concrete for a maximum of three hours. Longer periods of set retardation shall be used only when specified in the Contract Documents.

Accelerators shall be used only when specified in the Contract Documents.

Superplasticizers shall be used in concrete containing silica fume and concrete in expansion joint end dams as specified in the Contract Documents. Superplasticizers may be used in other applications at the Contractor's option providing the superplasticized concrete meets the contract requirements and there is no evidence of segregation or inadequate consolidation.

Where rapid chloride permeability is an acceptance requirement, superplasticizers may be added at the Contractor's option to the concrete at the plant or at the site. In all other applications superplasticizer shall be added to the concrete at the site.

Type S admixtures listed on the DSM may be used and concrete containing Type S admixture shall meet all requirements of this specification.

1350.04.02 Submission Requirements

1350.04.02.01 Mix Design

1350.04.02.01.01 General

A complete mix design submission shall be provided for concrete of each specified compressive strength that is to be placed in the work, for each of the following:

- a) Cast-in-place concrete.
- b) Slip formed concrete.
- c) Mixes with different sources of materials.
- d) Mixes with different admixtures.
- e) Precast concrete.
- f) Special purpose or unique mixes.

A complete mix design submission shall be provided for each specific concrete mix prior to the placement of that mix in the work. A complete mix design submission consists of the following:

- a) A completed MTO form PH-CC-433A (Form A).
- b) A completed MTO form PH-CC-433B (Form B).
- c) Mix design-supporting documentation.

Form A and Form B shall identify all materials to be used in the concrete. No material shall be used in the concrete without the knowledge of the Owner.

If the same mix design (i.e., same materials and sources in the same proportions) is to be supplied by multiple plants, submission of separate mix designs and separate supporting documentation is not required.

The mix shall not be placed until the Contract Administrator provides written confirmation that Form A and the mix design supporting information meet the requirements as specified in the Contract Documents. Within 4 Business Days following the delivery of all required documentation by the Contractor, the Contract Administrator shall provide the Contractor with a completed MTO form PH-CC-434 indicating the above confirmation or advising the Contractor of any requirements that have not been met.

1350.04.02.01.02 Changes to Mix Design Submission

The following adjustments to the submitted mix design may be made without having to submit a new mix design or supporting data:

- a) Total cementing material content: $\pm 5\%$ of quantity stated on Form B.
- b) Supplementary cementing materials: $+0/-5\%$ of quantity stated on Form B.
- c) Admixtures: Variation within range of dosage stated on Form B.
- d) Water: Variation within range stated on Form B.

Removal of a material from the mix or addition of retarding admixture Type B or D according to OPSS 1303 requires submission of a new mix design but does not require submission of supporting test data.

A new mix design, including supporting documentation, shall be provided prior to placing concrete, if the Contractor proposes to change the mix in any of the following ways:

- a) Changing sources of materials used in the concrete.
- b) Substituting a material or product for another from the same source.
- c) Adding any material to the concrete that was not on the original mix design, except retarding admixture Type B or D according to OPSS 1303.
- d) Adjusting the quantities of the stated materials in the concrete outside of the ranges provided above.

The submission process for new or modified mix designs is the same as for the original mix design, except that when supporting documentation is not required, the confirmation by the Contract Administrator shall be provided within one Business Day.

1350.04.02.01.03 Submission of Form A

At least 7 Business Days prior to the placement of concrete, an accurately completed Form A shall be submitted to the Contract Administrator.

Each mix design submitted shall be identified by the Contractor with a mix design number consisting of the following:

- a) 8-digit Contract number, followed by
- b) 2 digits indicating the specified compressive strength of concrete, followed by
- c) 2 digits indicating the number of the submission for that Contract (e.g., 01 for the first mix design of a specified strength, 02 for the second, and so on) followed, if applicable, by
- d) 1 digit indicating the number of revisions of a mix design submitted previously (e.g., 1 for first revision, 2 for second revision, and so on).

1350.04.02.01.04 Submission of Form B

Prior to the placement of concrete of a given mix design, the Contractor shall ensure that for each Form A submitted, a corresponding Form B is accurately completed by the concrete supplier and submitted directly to the Regional Head of Quality Assurance with a copy to the MTO Concrete Section electronic mix design depository.

The Form B shall bear the mix design number assigned by the Contractor to the corresponding Form A.

1350.04.02.01.05 Mix Design Supporting Documentation

Form A shall be accompanied by all material quality test data and other information for the mix design and for component materials required by the Contract Documents. All required supporting test data and certificates shall be less than 12 months old at the time the concrete mix design is submitted.

Supporting documentation shall include the following:

- a) A currently valid Certificate of Ready Mixed Concrete Production Facilities as issued by the Ready Mixed Concrete Association of Ontario (RMCAO) for any plant to be used on the Contract.

- b) The range of concrete production rates required for the work.
- c) A certificate or letter verifying the compatibility of the admixtures to be used in the concrete, if admixtures are supplied from different manufacturers.
- d) Water test results, if water other than municipal drinking water is used, demonstrating compliance with the requirements as specified in the Contract Documents.
- e) A certificate verifying the cement is free from early stiffening tendencies when tested according to CSA A3004-B6, if non-agitating trucks are used.
- f) Any other requirements specified elsewhere in the Contract Documents.

Documentation applicable to multiple mix designs need only be submitted once for a Contract.

1350.04.02.02 Certification of Ready Mixed Concrete Production Facilities

For multi-year Contracts, the Contractor shall submit annually for all plants supplying concrete to the work, verification that the plant continues to hold a valid Certificate of Ready Mixed Concrete Production Facilities, as issued by the RMCAO.

1350.05 MATERIALS

1350.05.01 Cementing Materials

Cementing materials shall be according to OPSS 1301 and CSA A3001, except:

- a) For all concrete other than silica fume overlays and HPC, Portland cement shall be used. A portion of it may be replaced by ground granulated blast furnace slag or fly ash or both. At the Contractor's option, silica fume in the form of a blended cement containing silica fume, may be added to the concrete mix to achieve reduced permeability. Where silica fume is used, the allowable limit for concrete permeability shall be reduced to 1,000 coulombs and the curing requirements of OPSS 904 for HPC shall apply.
- b) For silica fume overlays and HPC, blended hydraulic cement containing silica fume shall be used. A portion of it may be replaced by Portland cement, or ground granulated blast furnace slag or fly ash, or both.
- c) Portland limestone cement may be used in place of Portland cement when the supplier of the Portland limestone cement is included in the Designated Sources for Material listing for Hydraulic Cements and Supplementary Materials. Concrete made with Portland cement and Portland limestone cement shall not be used in the same component. Portland limestone cement shall not be used in concrete in combination with limestone filler.

Ground granulated blast furnace slag or fly ash or a combination of the two materials and shall be restricted to the following proportions by mass of the total cementing material:

- a) Slag up to 25%.
- b) Fly ash up to 10%, except for silica fume overlays and HPC where up to 25% is permitted.
- c) A mixture of slag and fly ash up to 25%, except the amount of fly ash shall not exceed 10% by mass of the total cementing materials, in concrete other than silica fume overlays and HPC.

For tremie concrete, the minimum cementing material content shall be 415 kg per cubic metre of concrete.

1350.05.02 Aggregates

1350.05.02.01 General

Aggregates shall be according to OPSS 1002.

1350.05.02.01 Limestone Filler

Limestone filler shall be according to the following:

- a) The requirements for mineral filler as specified in OPSS 1002 with the exception that use of limestone filler is not confined to self-consolidating concrete.
- b) The requirements of CSA A23.1, Annex L, L2 Organic Impurities.
- c) The requirements of CSA A 3001, Clause 4.4.3 a) for calcium carbonate content.
- d) Limestone filler shall be restricted to a maximum of 15% of the cement by mass.

1350.05.03 Water

Water used for production shall be according to OPSS 1302.

1350.05.04 Admixtures for Concrete

Air entraining, chemical, and superplasticizing admixtures for concrete shall be according to OPSS 1303.

1350.05.05 Concrete

1350.05.05.01 General

The selection of materials and design of the concrete mix shall be optimized to achieve GHG reduction of a minimum of 10% while maintaining the concrete performance requirements for the application and environment.

The 10% GHG reduction shall be obtained through the use of one or a combination of the following options:

- 1) Use of Portland-limestone cement.
- 2) Use of ground granulated blast furnace slag or fly ash to replace at least 10% of the cement content of the mix.
- 3) Use of limestone filler to reduce the cement content of the mix by at least 10% through enhanced particle packing, optimized aggregate gradation or other means.

Self-Consolidating Concrete (SCC) will be considered on an individual contract basis subject to the Owner's approval. If permitted for use, SCC shall be according to the Owner's current specification for SCC. A copy of the specification can be obtained from the

Concrete Section,
Materials Engineering and Research Office
Ontario Ministry of Transportation,
145 Sir William Hearst Avenue
Downsview, Ontario, M3M 0B6

1350.05.05.02 Plastic Concrete Requirements

Target values for air content and slump shall be identified for all plastic concrete on mix design Forms A and B.

The plastic concrete shall meet the following requirements:

- a) Concrete shall be free of lumps and segregation and shall have consistent air content and slump throughout each load.
- b) Plastic air content shall meet the requirements as shown in Table 1.
- c) Slump shall meet the requirements of Table 1. The maximum allowable slump, including tolerance, shall be 100 mm, except for tremie concrete, which shall be 180 mm.

When superplasticizer is to be added to the concrete according to the Use of Admixtures clause, the following shall apply:

- i. For superplasticizers added at the plant, the Contractor shall identify target slump for the concrete after the addition of superplasticizer. The tolerance on measurement of concrete slump after addition of superplasticizer shall be ± 30 mm and the maximum slump including tolerance shall not exceed 230 mm.
 - ii. For superplasticizers added at the site, the Contractor shall identify target slumps for the concrete both prior to and after the addition of superplasticizer. The tolerance on measurement of concrete slump prior to the addition of superplasticizer shall be ± 20 mm and the maximum slump including tolerance shall not exceed 100 mm. The tolerance on measurement of concrete slump after addition of superplasticizer shall be ± 30 mm and the maximum slump, including tolerance, shall not exceed 230 mm.
- d) The concrete temperature at the time of discharge from the truck shall be at or between 10 and 28 °C, with the exception of HPC and silica fume overlays, which shall be at or between 10 and 25 °C.

1350.05.05.03 Hardened Concrete Requirements

The hardened concrete shall meet the following requirements:

- a) Concrete compressive strength shall be as specified in the Contract Documents.
- b) Rapid chloride permeability at 28 to 32 Days shall be less than or equal to:
 - i. 1,000 coulombs for HPC, silica fume overlays and any other concrete containing silica fume.
 - ii. 2,500 coulombs for all other concrete.
- c) Air void system parameters as determined on the hardened concrete shall meet the following requirements:
 - i. Each core shall have a minimum air content of 3.0 %.
 - ii. Each core shall have a maximum spacing factor of 0.230 mm, except for HPC and silica fume overlays for which each core shall have a maximum spacing factor of 0.250 mm.

1350.06 EQUIPMENT

1350.06.01 Batching Plant

The batching plant and equipment shall be certified by the RMCAO prior to producing concrete for the work, including concrete for any trial batches, and shall meet the requirements for certification throughout the production of concrete.

1350.06.02 Delivery Equipment

Delivery equipment shall be truck mixers, agitator trucks, or non-agitating equipment. Use of non-agitating equipment shall be restricted to delivery for placement of concrete base or concrete pavement.

Truck mixers shall consist of concrete mixers mounted on a truck or other vehicle used for the complete mixing of concrete ingredients after they have been batched at the plant. All truck mixers shall be certified by RMCAO and shall display valid certification stickers.

Agitator trucks shall consist of drums or containers mounted on trucks or other vehicles in which completely mixed concrete is kept sufficiently agitated during delivery to prevent segregation.

Non-agitating equipment shall consist of containers mounted on trucks for delivering completely mixed concrete. The body of the container shall be smooth, watertight, made of steel, and equipped with gates that permit control of the discharge of the concrete.

1350.07 PRODUCTION

1350.07.01 General

Concrete shall be produced at a batching plant. Use of mobile mixers is not permitted. A back-up plant shall be identified for all post-tensioned deck placements.

When multiple plants supply concrete for the same component, all plants, including primary and back-up, shall produce the same mix design using the same aggregates, cementing materials, and admixtures.

The supplementary cementing material shall be weighed separately from the cement, except when the cement and supplementary cementing materials are supplied in blended form.

The entire contents of the mixer shall be discharged and the mixer completely emptied of wash water prior to loading of a new concrete batch. When a truck mixer is used for complete mixing, it shall not be loaded beyond its maximum mixing capacity.

Cementing materials shall not be added by bags or sacks or from a storage facility remote from the ready mix plant.

1350.07.02 Temperature Control

Any method of heating aggregates shall be such as to produce uniform conditions, without local hot spots.

Frozen lumps of aggregate shall not be added to the concrete.

When ice is used as part of mixing water, the ice shall be measured by mass and shall be completely melted by the time concrete mixing is completed.

1350.07.03 Mixing Time and Mixing Rate

The minimum mixing time for concrete shall be as recommended by the equipment manufacturer or the minimum time required to produce concrete meeting the requirements of this specification, whichever is greater.

When a stationary mixer is used for partial mixing of concrete prior to transferring to a truck mixer, the mixing time shall be no more than is required to intermingle the ingredients. After transfer to a truck mixer, further mixing at the designated mixing speed shall be carried out.

After completion of mixing, the truck mixer drum shall be rotated at the designed agitating speed until discharge of concrete commences.

1350.07.04 Delivery

1350.07.04.01 General

Concrete that is transported in non-agitating equipment shall be covered. Concrete delivered by means of agitator trucks or truck mixers shall be transported after completion of mixing.

1350.07.04.02 Discharge Time

When concrete is transported to the site by means of agitating or mixing equipment, discharge of the concrete shall be completed within 1.5 hours after introduction of the mixing water to the cement and aggregates, except when the air temperature exceeds 28 °C and the concrete temperature exceeds 25 °C, the concrete shall be discharged within 1 hour after the introduction of the mixing water.

When concrete is transported by means of non-agitating equipment, discharge shall be completed within 30 minutes after introduction of the mixing water to the cement and aggregates.

Use of retarders or other admixtures does not change the specified concrete discharge time.

1350.07.04.03 Delivery Ticket

Each load shall be accompanied by a delivery ticket. The following information shall be printed on each ticket at the plant using an automated printing device:

- a) Name and location of plant.
- b) Date, including year, month, and day.
- c) Contract number.
- d) Truck number.
- e) Time of batching concrete. Where an electronic ticketing system is not used, time shall be stamped by a time clock within 5 minutes of batching.
- f) Mix design number assigned by the Contractor or the supplier's unique mix design number verified to correspond to the mix design number assigned by the Contractor.
- g) Specified minimum 28-Day compressive strength of concrete.

In addition, the following shall be recorded in writing on the delivery ticket:

- a) The amount of any material added after batching.
- b) Rejection of a load or part thereof, if applicable.
- c) Time truck arrived at the job site.
- d) The time the truck finished discharging.

1350.07.05 Material Sampling and Testing

1350.07.05.01 Contractor Sampling for Quality Control Purposes

The Contractor may obtain samples of plastic concrete for quality control purposes. The Contractor shall not carry out sampling or destructive testing of hardened concrete in the work for quality control purposes without obtaining the written permission of the Owner in advance. The Owner's denial of permission shall not relieve the Contractor of responsibility for the quality of concrete placed or to be placed in the work.

1350.07.05.02 Sampling of Water, Admixtures, Limestone Filler and Cementing Materials

Samples of all cementing materials, admixtures, limestone filler and water (when other than municipal drinking water is used) shall be obtained according to the frequencies shown in Table 7, in the presence of the Contract Administrator, for testing by the Owner.

Samples of admixtures and water shall be protected from freezing and high temperatures. Cementing materials samples shall be protected from moisture.

1350.07.05.03 Testing of Plastic Concrete

Field sampling and testing of concrete shall be performed by a person holding either of the following certifications:

- a) CCIL Certified Concrete Testing Technician, or
- b) ACI Concrete Field Testing Technician, Grade 1.

This person shall have a valid original card issued by the certifying agency in their possession at all times.

Samples for determining acceptance of concrete for air and slump shall be grab samples taken according to CSA A23.2-1C after approximately 10% of the load has been discharged. The discharge shall be stopped and no additional concrete shall be discharged or placed into the work until samples have been tested and found acceptable. If the test results indicate that the concrete does not meet the specified requirements and adjustments permitted in the Acceptance and Field Adjustments of Plastic Concrete clause cannot produce acceptable concrete, the remainder of the load shall be rejected.

Temperature shall be measured according to CSA A23.2-17C. Slump shall be measured according to CSA A23.2-5C. Air content shall be measured according to CSA A23.2-4C. The air meter shall be calibrated at least once a year according to CSA A23.2-4C and a copy of the calibration certificate shall be with the air meter and available for review when requested by the Contract Administrator.

1350.07.05.04**Frequency of Testing Slump, Air Content, and Temperature**

For all concrete, quality control testing consisting of slump, air content, and temperature determinations shall be carried out on each load or batch of concrete until satisfactory control is established. Satisfactory control shall be established each Day. It is established when concrete from five consecutive loads or batches is within the specified requirements without field adjustments as defined in the Acceptance and Field Adjustments of Plastic Concrete clause. If any field adjustments are required, testing on each load shall be continued until five consecutive loads or batches meet the requirements with no field adjustment. After satisfactory control has been established, testing shall be carried out on every third load. If testing indicates that a load does not meet the requirements, testing shall resume on each load until satisfactory control is established.

If multiple plants supply concrete, satisfactory control shall be established for each plant.

In addition to the above, air content, slump, and temperature tests shall be carried out whenever compressive test cylinders are cast.

1350.07.05.05**Acceptance and Field Adjustments of Plastic Concrete**

The Contractor shall be responsible for all quality control inspection and testing required to ensure that plastic concrete included in the work is according to the submitted mix design and meets the specified requirements for air content, slump, temperature, delivery time, and uniformity.

Concrete which does not meet the specified requirements for air content, slump, temperature, delivery time or uniformity shall be rejected and not used in work.

Slump of concrete shall be measured prior to and after the addition of superplasticizer. When superplasticizer is added at the plant according to the Use of Admixtures clause, the slump shall be measured after the addition of superplasticizer. Air content shall be measured after any addition of superplasticizer.

For non-superplasticized concrete, when the measured slump is higher than that specified and there is time available to discharge the concrete within the specified time limit, the Contractor shall be permitted to retest the slump once using the unused portion of the same concrete sample. Slump shall be retested within 5 minutes of the completion of the original test.

For superplasticized concrete, when the measured slump is higher than that specified and there is time available to discharge the concrete within the specified time limit, the Contractor shall be permitted to wait and retest the slump using a new sample of concrete when superplasticizer is plant added and rapid chloride permeability is an acceptance requirement, or superplasticizer is added on site and the measured slump prior to addition of superplasticizer is within specified limits.

When the measured plastic air content exceeds the upper test limit and there is time available within the discharge time limit specified, the Contractor shall be permitted to rotate the load at agitation speed and retest the air content. The use of additives to reduce the air content shall not be permitted.

When a truck mixer is used, the following field adjustments may be carried out prior to acceptance of the load:

1. When the measured air content is low, air-entraining admixture may be added.
2. When the measured or estimated slump is low, the following adjustments may be made:
 - a) For concrete mixes that do not include superplasticizer, water may be added:
 - i. Prior to discharge of concrete from the truck has started, or
 - ii. When the measured slump of concrete is lower than the maximum targeted range.

- b) For concrete mixes with site-added superplasticizer:
 - i. Water may be added before superplasticizer is added at the site. Water additions may be done prior to discharge of concrete from the truck has started or when the measured slump of concrete is lower than the maximum targeted range,
 - ii. No water shall be added after the addition of a superplasticizer. Additional doses of superplasticizer may be added.
- c) For concrete mixes with plant added superplasticizer:
 - i. No water shall be added.
 - ii. Superplasticizer may be added.

No field adjustments shall be carried out after concrete has been accepted, with the exception of superplasticized concrete. For superplasticized concrete, addition of a superplasticizer to increase the slump to assist in placing shall be permitted.

When any material is added to the concrete, the load of concrete shall be mixed for 30 revolutions or more at the designated mixing speed to ensure that the concrete is uniformly mixed. The load shall be re-tested for acceptance.

1350.07.05.06 Visual Acceptance of Plastic Concrete

The Contractor shall visually inspect plastic concrete during discharge and placement to identify the presence of any segregation or lumps.

If any segregation is identified, the Contractor shall immediately reject the entire load of concrete.

Any visible lumps present in the concrete shall be removed before concrete is placed in the work. If more than 3 visible lumps are present in a load of concrete, the remainder of the load shall be immediately rejected and no further concrete from that truckload shall be placed in the work.

If more than three truckloads during the day's work are observed to contain more than 3 lumps per truck, concrete placement shall be stopped at the end of the Day or at the end of the placement of the specific structure component, whichever comes first.

No further concrete shall be placed until all of the following occur:

- a) The Contractor has provided an explanation of the reasons for the lumps and identified the steps that shall be taken to eliminate the reoccurrence of lumps in future work.
- b) A trial batch has been carried out in the presence of the Contract Administrator and the Contract Administrator has verified that the concrete is free of lumps.
- c) The Contract Administrator has granted written approval for placement to proceed.

1350.07.05.07 Within-Batch Uniformity of Plastic Concrete

When required by the Contract Administrator, determination of the within-batch uniformity of the plastic concrete shall be carried out by testing air content, slump, and density according to CSA A23.2-4C, 5C, and 6C, respectively. The Contractor shall be granted 24 hours' notice when density testing is required as part of within-batch uniformity determination. No advance notice shall be granted for carrying out the slump and air portion of the uniformity testing.

Tests shall be carried out on samples of concrete obtained when approximately 10%, 50%, and 90% of the batch has been discharged while the mixer is being emptied at normal operating rate. The minimum size of sample shall be 30 litres. Between samples, the mixer shall not be allowed to turn in the mixing direction.

The acceptance and rejection limits for uniformity shall be as shown in Table 2. When the result of each test is equal to or less than the acceptance limit, the concrete is uniform. When the result of any single test is greater than the rejection limit, the concrete is considered to be non-uniform.

If the result of any single test exceeds the acceptance limit and is not greater than the rejection limit, all tests shall be made on the next consecutive batch or load delivered by that mixing equipment.

If, after testing one additional batch or load, the test result is greater than the acceptance limit, the concrete is non-uniform.

When the concrete is non-uniform and the mixing equipment is a stationary mixer, no more concrete shall be produced in it until within batch uniformity has been demonstrated. If the unit is a truck mixer, the truck mixer shall not be used again.

1350.07.05.08 Submission of Plastic Concrete Test Results

After each Day's work, a copy of the delivery ticket for each load of concrete and a daily summary shall be submitted to the Contract Administrator. The daily summary shall include air contents, slumps prior to and after any additions, concrete temperature, and all adjustments made to each load of concrete, including volume of any water or superplasticizer added, and shall identify rejected material.

1350.07.05.09 Compressive Strength

1350.07.05.09.01 General

Prior to placing concrete, an estimate of concrete volumes for each minimum specified 28-Day compressive strength shall be provided to the Contract Administrator. Acceptance method A shall be used when the quantity of concrete of a specified minimum strength is 100 m³ or more. Acceptance method B shall be used for concrete in expansion joints, tremie concrete, or when the quantity of concrete of a specified minimum strength is less than 100 m³. The Contract Administrator shall confirm the method(s) to be used.

1350.07.05.09.02 Acceptance Method A

The Contract Administrator shall determine the lot and subplot size after discussion with the Contractor and before any concrete is placed. Each lot shall contain concrete of one specified minimum 28-Day strength. There shall be only one lot of each specified strength of concrete; however, if the quantity of concrete of one specified strength is greater than 5,000 m³, the Contract Administrator shall consider requests to divide the concrete into two lots based on placement in separate structures or in different construction seasons.

Each lot shall be divided into sublots of approximately 10 m³ to a maximum of 100 m³. Sublot sizes shall be established based on the estimated concrete quantity such that each lot contains a minimum of 10 sublots. One set of acceptance and one set of referee cylinders shall be made from each subplot. The loads of concrete to be sampled shall be selected by the Contract Administrator on a random basis.

In addition to acceptance cylinders cast on a random basis, the Contractor shall also cast test cylinders as required by the Contract Administrator. The results from these cylinders shall be used for assessment of structural adequacy, for information purposes, or for other uses by the Owner.

1350.07.05.09.03 Acceptance Method B

One set of acceptance and referee cylinders, each shall be cast for every 20 m³ of concrete placed or one set per day, whichever is more frequent.

1350.07.05.09.04 Test Cylinders

The Contractor shall cast, cure, and transport cylinders for compressive strength testing by the Owner.

Every time a set of acceptance cylinders is cast, a second set of cylinders shall be cast for referee testing purposes, unless otherwise specified in the Contract Documents.

Concrete test cylinders for compressive strength testing for acceptance and for referee testing purposes, where required, shall be cast, cured, and transported according to CSA A23.2-3C. Referee cylinders shall be cured and transported to the Regional Quality Assurance Laboratory, along with the acceptance cylinders. A set of cylinders for concrete made with aggregate of nominal maximum size larger than 19 mm shall consist of two 150 mm diameter x 300 mm long cylinders. For all other concrete, a set of cylinders shall consist of three 100 mm diameter x 200 mm long cylinders.

Concrete test cylinders for early strength determination shall be cast, cured, and transported as specified in the Contract Documents.

No referee cylinders shall be cast when cylinders are prepared for determination of early strength or are requested by the Owner, for information purposes.

All concrete test cylinders shall be cast in moulds. The moulds shall be single use moulds according to CSA A23.2-1D and made of plastic with a lid. The lids shall be chemically and physically compatible with the concrete and shall provide watertight closure for the moulds.

Test information shall be recorded on MTO form PH-CC 322, a copy of which shall be submitted with each set of the concrete cylinders.

The Contractor shall continuously record and monitor temperature immediately adjacent to the cylinders during the field-curing period. The maximum time interval for recording the temperature shall be every 15 minutes.

1350.07.05.09.05 Submission of Cylinder Curing Records

Cylinder curing temperature records shall be submitted to the Contract Administrator at the completion of the field-curing period.

1350.07.05.10 Air Void System Parameters

Cores for evaluation of air void system parameters shall be required for the categories of concrete shown in Table 3.

The Contractor shall remove cores from the hardened concrete for testing by the Owner. Cores shall be taken at random locations specified by the Contract Administrator. All cores shall be removed when the concrete is between 7 to 10 Days of age, and cores from bridge decks shall be removed prior to application of any waterproofing membrane.

The lot sizes, core size, and number of cores shall be as shown in Table 3. When two cores are required for a lot, the lot shall be divided into two, and one core shall be removed at a random location within each half of the lot. For concrete barriers and barrier walls on structures, the cores shall be removed from the lower sloped portion of the wall at the designated locations. For parapet walls, the cores shall be removed from the lower one-third of the wall at the designated locations. Steel reinforcement and other embedded material shall be avoided when possible while coring and the Contractor shall use a covermeter to establish reinforcement location, prior to coring.

For concrete patches and refacing where the total area of patches or refacing on a structure is less than 20 m², no cores shall be required, but one 100 x 200 mm cylinder shall be cast and tested.

The Contract number, lot number and exact location of each individual core shall be marked legibly on the core with durable ink. Cores shall be placed in a plastic bag and given to the Contract Administrator along with Form A of the concrete mix design for the component, for testing by the Owner.

1350.07.05.11 Rapid Chloride Permeability

Cores for evaluation of rapid chloride permeability shall be required for the categories of concrete shown in Table 3.

The lot sizes, core sizes, and number of cores shall be as identified in Table 3. If the total quantity of concrete in a category or quantity of concrete in a category during a construction stage is less than that shown in Table 3, two cores per stage shall be removed except for overlays, concrete patches and refacing for which four cores per stage shall be removed.

One core shall be removed at a random location specified by the Contract Administrator and the second core shall be removed at a location no more than 1 m from the location of the first core. When four cores are required from a lot, the same procedure shall be followed with a second random location selected within the lot. Cores shall not contain steel or GFRP reinforcement, or other embedded material. The Contractor shall use a covermeter to establish reinforcement location, prior to coring.

All cores shall be removed when the concrete is between 7 to 10 Days of age and cores from bridge decks shall be removed prior to the application of any waterproofing membrane. Cores from footings shall be removed from the above ground portion of the footing.

The Contract number, lot number and exact location of each individual core shall be marked legibly on the core with durable ink. Cores shall be placed in a plastic bag sealed to prevent loss of moisture and given to the Contract Administrator along with Form A of the concrete mix design for the component, for testing by the Owner.

1350.07.06 Filling of Core Holes

Each core hole shall be filled immediately after coring with a proprietary patching material from the Owner's pre-qualified product list. The patching material shall be comparable to the surrounding concrete in terms of strength and permeability. The patching material shall be mixed, handled, and cured according to the manufacturer's instructions. Immediately prior to filling, the inside surface of each core hole shall be cleaned of the paste left from the coring operation by nylon brushing and all free water shall be removed. The patch shall be finished flush with the surface of the surrounding concrete. All excess material shall be removed from the surface of the concrete.

1350.08 QUALITY ASSURANCE

1350.08.01 Acceptance of Concrete Compressive Strength

1350.08.01.01 General

Lots for compressive strength shall be as identified in the Acceptance Method A or Acceptance Method B clause, as applicable.

Compressive strength shall be determined according to LS-407 and LS-426.

The compressive strength result of a subplot shall be the average of the set of 3 acceptance cylinders made from the subplot, rounded to one decimal place, except for concrete made with aggregate of nominal maximum size larger than 19 mm where the subplot result shall be the average of 2 cylinders.

The individual test results shall be forwarded to the Contractor, as they become available. The Contractor shall forward individual test results and monthly summaries to the concrete supplier.

When any individual strength test result falls below the specified minimum 28-Day strength by more than 4.0 MPa, the Contract Administrator may require the Contractor to take and test 100 mm diameter concrete cores to determine whether individual sections of concrete are structurally adequate and whether remedial work or removal is required. When required, cores shall be removed in groups of 3 at locations specified by the Contract Administrator. Cores shall be removed, moisture conditioned, and tested for compressive strength according to CSA A23.2-14C.

Where required, determination of structural adequacy is independent of and in addition to any payment reduction. Core results shall not replace cylinder results in any bonus or penalty calculations. Where extensive design calculation is required in order to confirm structural adequacy, the Contractor shall reimburse the Owner for all costs incurred up to a maximum of \$2,000.00 per occurrence.

1350.08.01.02 Acceptance Method A

Acceptance of concrete compressive strength for each lot shall be based on the mean and standard deviation of the compressive strength results of all sublots contained in the lot.

The mean and standard deviation of the results and forecast potential bonus or penalty, if any, shall be submitted to the Contractor at monthly intervals.

The Contract Administrator shall calculate the percent within limits (PWL) according to LS 101, using the specified compressive strength as the lower limit.

When the lot PWL is greater than 95%, the Contractor shall receive a bonus, in \$/m³, as calculated by the following:

$$\text{Bonus} = \text{PWL} - 95$$

When the lot PWL is greater than or equal to 90% and less than or equal to 95%, there shall be no bonus or penalty due to concrete compressive strength.

When the lot PWL is less than 90% and greater than or equal to 50%, the Contractor shall be assessed a penalty, in \$/m³, as calculated by the following:

$$\text{Penalty} = 90 - \text{PWL}$$

When the lot PWL is less than 50%, the lot is unacceptable and is subject to removal and replacement. The Contractor may submit an alternative in writing for the Owner's consideration for unacceptable lots. If the Contract Administrator determines that an unacceptable lot may remain in the work, it shall be subject to the calculated penalty.

For the purpose of penalty or bonus, the quantity of concrete in each lot shall be calculated by the Contract Administrator as the sum of the following:

- a) The payment quantity for items paid by unit price per cubic metre of concrete.
- b) The theoretical quantity indicated in the Contract Documents for items paid by lump sum, provided the actual quantity is within $\pm 3\%$ of the theoretical quantity.
- c) The quantity of concrete in each lot shall be calculated from the quantities indicated in the Contract Drawings for items, where these quantities are listed.

- d) The quantity based on the neat lines called for in the Contract Drawings, where none of the above methods are applicable.

1350.08.01.03 Acceptance Method B

Concrete compressive strength shall be considered acceptable when it meets all of the following:

- a) The average of all groups of three consecutive compressive strength tests shall be equal to or greater than the specified strength.
- b) No individual strength test shall be more than 4.0 MPa below the specified strength.

Unacceptable concrete shall be subject to removal and replacement.

The Contractor may submit an alternative in writing for the Owner's consideration for unacceptable concrete.

1350.08.01.04 Referee Testing Based on Duplicate Cylinders

The referee testing process for concrete compressive strength is based on duplicate cylinders cast at the same time as the acceptance cylinders.

Referee testing of compressive strength for a subplot may only be invoked by the Contractor within five Business Days of receiving the test results for that subplot.

The referee laboratory shall be designated by the Owner based on the applicable roster. Referee test results shall be forwarded to the Contractor, as they become available.

If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is then confirmed and the acceptance test result shall be used in the determination of acceptance and payment for the concrete. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is then not confirmed and the acceptance test result shall be disregarded and not used in the determination of acceptance and payment. The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance cylinders, expressed to one decimal place.

If the referee test result is more than 4.0 MPa below the specified strength, the result shall be reviewed to determine if structural adequacy is in question and, if so, the relevant provisions of this specification shall be followed.

When acceptance results are eliminated from the analysis as a result of referee process, the concrete shall be assessed based on the available strength results for the lot.

If acceptance test results from multiple sublots are eliminated such that there are fewer than 4 acceptance test results available for the lot, Acceptance Method B shall be used for acceptance of the concrete.

1350.08.01.04.01 Referee Testing Cost

The cost of compressive strength referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of compressive strength referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

1350.08.02 Acceptance of Air Void System in Hardened Concrete

1350.08.02.01 General

The lots for air void system shall be as shown in Table 3.

One half of each core shall be tested to determine the acceptability of concrete. The core shall be tested according to LS-432. The other half of each core shall be retained by the Owner for audit purposes.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.02.02 Basis of Acceptance

For a lot to be considered acceptable, each core shall have air content of 3.0% or more and spacing factor of 0.230 mm or less in all concrete, except for silica fume overlays and HPC where the spacing factor shall be 0.250 mm or less. Acceptable lots shall be subject to full payment or bonus payment.

An unacceptable lot is a lot represented by one or two cores that fail to meet the air void system parameters. Unacceptable lots shall be removed and replaced except where the Owner permits the work to remain in place. The removal and replacement of unacceptable lots shall be at no additional cost to the Owner. The replacement lots shall be evaluated for acceptance on the same basis as the original lot. When the Owner permits the work to remain in place, it shall be subject to the calculated penalty and shall not be eligible for bonus.

For the purpose of calculating a bonus or penalty, the Contract Administrator shall round-off spacing factor test data to two decimal places and air content test data to one decimal place according to LS-100 and shall determine the quantity of concrete in lots using the dimensions as specified in the Contract Documents.

When two cores are tested per lot, the bonus payment for an acceptable lot shall be calculated by averaging bonus values corresponding to individual core results. When one core is tested per lot, the bonus payment for an acceptable lot shall be the bonus value corresponding to the core.

Bonus payment for a lot represented by two cores shall be calculated according to the following:

$$B = (B1 + B2)/2$$

Where: B = bonus in \$/m³ of concrete in the lot
B1 and B2 = bonus for cores 1 and 2 in \$/m³ of concrete in the lot from Table 4

Bonus for acceptable lot = lot quantity (m³) x B

Payment for unacceptable lots shall be calculated by averaging the pay factors corresponding to individual core results. Where one core in an unacceptable lot meets the specified requirements for air void system, the core shall be assigned a pay factor of 100%. When only one core is tested per lot, the payment for an unacceptable lot shall be the pay factors corresponding to the individual core result.

Payment for unacceptable lot represented by two cores shall be calculated according to the following:

$$P = (P1 + P2)/2$$

Where: P = pay factor for the lot (%)
P1 and P2 = pay factor for cores 1 and 2 in % as shown in Table 5 or 6, as applicable

Payment reduction for a lot = lot quantity/tender quantity x tender lump sum price x ((100-P)/100)

Where: Lot quantity and tender quantity are in cubic metres

1350.08.02.03 Referee Testing

Referee testing of air void system parameters may only be invoked by the Contractor within five Business Days of receiving the test result.

When referee testing is invoked, all core samples representing a lot shall be referee tested and the acceptance test results discarded. The lot referee test results shall replace the acceptance test result in the acceptance requirements of this specification.

Referee testing shall be carried out on the same half of the core sample that was tested for acceptance.

Cores shall be tested according to LS-431. Referee test results shall be forwarded to the Contractor, as they become available.

1350.08.02.03.01 Referee Testing Cost

The cost of air void system referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed lot is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed lot is not acceptable, the Contractor shall be charged the cost of the air void system referee testing.

1350.08.03 Acceptance of Rapid Chloride Permeability

1350.08.03.01 General

Cores shall be tested according to LS-433. Acceptance testing shall be carried out at 28 to 32 Days.

For cores that are a minimum of 125 mm long, one of the two cores representing a lot shall be cut to obtain 2 - 50 mm long samples and tested to determine the acceptance of the lot. The second core shall be retained for referee testing.

For overlays, patches and refacing represented by cores that are less than 125 mm long, two of the four cores representing a lot, both from the same location, shall be cut to obtain 2 - 50 mm samples, one sample from each core. The two cut samples shall be tested to determine the acceptance of the lot. The remaining two cores shall be retained for referee testing.

Individual test results shall be forwarded to the Contractor as they become available.

1350.08.03.02 Basis of Acceptance

Acceptance of rapid chloride permeability shall be based on the average of 2 results obtained on 2 - 50 mm long samples representing a lot.

For HPC, silica fume overlays and any other concrete containing silica fume, lots with an average value of rapid chloride permeability exceeding 1,000 coulombs and less than or equal to 2,000 coulombs shall be accepted with a payment reduction. Lots with rapid chloride permeability value exceeding 2,000 coulombs shall be considered unacceptable. Unacceptable lots shall be removed and replaced at no additional cost to the Owner.

For all other concrete, lots with an average value of rapid chloride permeability exceeding 2,500 coulombs and less than 3,500 coulombs shall be accepted with a payment reduction. Lots with rapid chloride permeability value exceeding 3,500 coulombs shall be considered unacceptable. Unacceptable lots shall be removed and replaced at no additional cost to the Owner.

For the purpose of calculating the payment reduction, the Contract Administrator shall determine the volume of concrete in the lots using the dimensions specified in the Contract Documents.

The payment reduction shall be calculated based on individual lots and applied as follows:

For silica fume overlays, HPC and any other concrete containing silica fume = lot quantity x (C-1000)/5

For all other concrete = TODRF x lot quantity x (C-2500)/5

Where:

Payment reduction = payment reduction of a lot (\$)
C = average rapid chloride permeability of a lot (coulombs)
Lot quantity = volume of concrete in a lot (m³)
TODRF = tender opening reduction factor as given below.

Year of Tender Opening	Tender Opening Date Reduction Factor (TODRF)
2019	0.50
2020	0.75
2021	1.00

1350.08.03.03 Referee Testing

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 5 Business Days of receipt of the acceptance test result.

Referee testing shall be carried out on 2 - 50 mm long samples obtained from the reserved core representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot. For overlays, patches and refacing, referee testing shall be carried out on 2 - 50 mm long samples cut from the two reserved cores representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to LS-433 by that laboratory.

Referee test results shall be forwarded to the Contractor as they become available.

For silica fume overlays, HPC and any other concrete containing silica fume:

- a) When the referee result is greater than the acceptance test result or no more than 300 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid.
- b) When the referee test result for the lot is more than 300 coulombs below the acceptance test result, the acceptance test result is then not confirmed and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

For all other concrete:

- a) When the referee result is greater than the acceptance test result or no more than 500 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid.
- b) When the referee test result for the lot is more than 500 coulombs below the acceptance test result, the acceptance test results is then not confirmed and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

1350.08.03.03.01 Referee Testing Cost

The cost of referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be responsible for the cost of rapid chloride permeability referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

1350.08.04 Acceptance of Admixtures, Water and Cementing Materials

1350.08.04.01 Admixtures

1350.08.04.01.01 General

Air entraining admixtures shall be tested by the Owner for pH and relative density. Chemical and superplasticizing admixtures shall be tested by the Owner for relative density and non-volatile content. Testing shall be according to LS-413, LS-414, and LS-415, as applicable.

One 750 ml admixture sample shall be used for acceptance testing. The other 750 ml admixture sample shall be reserved for referee testing.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.04.01.02 Basis of Acceptance

Relative density, pH and non-volatile content shall be according to OPSS 1303. Admixtures represented by sample test results that fail to fall within the specified tolerances for pH, relative density, or non-volatile content shall be deemed unacceptable and no further concrete shall be produced with that supply of admixture.

For each admixture represented by sample test results that exceed the tolerances specified by OPSS 1303 and before any additional concrete can be placed, the Contractor shall remove and replace the admixture with a new supply of admixture meeting the requirements of OPSS 1303.

For each sample of air-entraining admixture that exceeds the tolerances for relative density, or pH, or both, as shown in Table 8, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

For each chemical admixture sample that exceeds the tolerances for relative density, or non-volatile content or both, as shown in Table 8, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

For each superplasticizing admixture sample that exceeds the tolerances for relative density, or non-volatile content or both, as shown in Table 8, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

Notwithstanding the above, concrete made with admixtures that do not meet the specified requirement may be subject to additional financial penalty or removal if the deficiency has the capacity to adversely impact the short or long term performance of the concrete.

1350.08.04.01.03 Referee Testing

Referee testing of admixtures may only be invoked by the Contractor within five Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

The referee laboratory shall be designated by the Owner based on the applicable roster. Referee samples shall be transported from the Regional Quality Assurance laboratory to the Referee Laboratory by the Owner, and testing shall be carried out according to LS-413, LS-414, and LS-415, as applicable.

Referee test results shall be forwarded to the Contractor, as they become available.

The referee test results shall replace the original results.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the admixture referee testing.

1350.08.04.02 Water Other than Municipal Drinking Water

1350.08.04.02.01 General

Samples of water, other than municipal water, shall be tested by the Owner according to OPSS 1302.

One 1-litre water sample shall be used for acceptance testing. The other 1-litre water sample shall be reserved for referee testing.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.04.02.02 Basis of Acceptance

Water that fails the requirements of OPSS 1302 shall be deemed unacceptable and the source of water represented by the failed samples shall not be used for making of concrete.

Concrete made with water that does not meet the specified requirements is unacceptable and may be subject to financial penalty or removal if there is potential for the short-term or long-term performance of the concrete to be adversely affected.

1350.08.04.02.03 Referee Testing

Referee testing of water may only be invoked by the Contractor within 5 Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

The referee laboratory shall be designated by the Owner based upon the applicable roster. Referee samples shall be transported from the Regional Quality Assurance laboratory to the Referee Laboratory by the Owner, and testing shall be carried out according to OPSS 1302.

Referee test results shall be forwarded to the Contractor, as they become available.

The referee test results shall replace the original result.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the water referee testing.

1350.08.04.03 Cementing Materials

1350.08.04.03.01 General

Cementing materials shall be tested by the Owner for fineness, soundness by autoclave, initial time of set, compressive strength, and slag activity index or pozzolanic strength activity index, as applicable, according to CSA A 3000.

One 10-kilogram sample shall be taken and divided into two 5-kilogram samples. One 5-kilogram sample shall be used for acceptance testing. The second 5-kilogram sample shall be reserved for referee testing.

Individual test results shall be forwarded to the Contractor as they become available.

1350.08.04.03.02 Basis of Acceptance

Cementing materials that do not comply with the requirements of OPSS 1301 and CSA A3001 shall not be used for making of concrete.

Concrete made with cementing materials that do not meet the specified requirements is unacceptable and may be subject to financial penalty or removal if there is potential for the short-term or long-term performance of the concrete to be adversely affected.

1350.08.04.03.03 Referee Testing

Referee testing of cementing materials may only be invoked by the Contractor within five Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

Referee testing shall be carried out according to CSA A 3000 by the Owner's laboratory or an independent laboratory acceptable to the Contractor and the Owner in the presence of the Contractor or his designate.

Referee results shall be reported to the Contractor, as they are available.

The referee test results shall replace the original result.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the cementing material referee testing.

TABLE 1
Slump and Air Content of Plastic Concrete

Component	Slump mm (Note 1)	Air Content in Plastic Concrete %
Cast-In-Place, Slip formed Concrete Barriers	Target slump ± 10	Target air ± 1.5
Tremie Concrete	Target slump ± 30	When required 5.0 ± 1.5
All Other Concrete	Target slump ± 20	Target air ± 1.5
Note: 1. When the use of superplasticizer is permitted, requirements shall be as specified in the Concrete clause.		

TABLE 2
Determination of Within-Batch Uniformity of the Concrete

Test	Range Between Highest and Lowest Values of 3 Test Samples	
	Acceptable If Equal to or Less Than	Rejectable If More Than
Density, kg/m ³	32	50
Air Content in Plastic Concrete, %	0.7	1.0
Slump, mm	30	50

TABLE 3
Cores for Air Void System (AVS) & Rapid Chloride Permeability (RCP) Determination

Category	Lot Size	Core Size	Number of Cores Per Lot for AVS	Number of Cores Per Lot for RCP
Sidewalk on Structure and Curb on Structure	500 lineal metres per stage.	100 mm diameter and 200 mm long.	2	2
Median on Structure	500 lineal metres per stage.			
Parapet or Barrier Wall on Structure	500 lineal metres per structure per stage.			
Toe Wall	500 lineal metres per stage.			
Bridge Deck-Thin Slab Deck	500 m ² per stage.			
Bridge Deck-Post-Tensioned Deck	300 m ² per stage.			
Abutment, Wingwall, Cast-In-Place Retaining Wall	1 abutment, wingwall, cast-in-place retaining wall or a stage thereof.			
Pier	1 pier. (Note 1)			
Arches and Spandrels	Between piers or between pier and abutment.			
Culvert	1,000 m ² of floor area of cast-in-place concrete culvert. (Note 2)			
	All cast-in-place concrete associated with a precast culvert.			
Approach Slab	500 m ² per stage.			
Concrete Barrier	Cast-in-place, slip formed: 1,000 lineal metres. (Note 3)			
	Cast-in-place, formed, including transitions: 250 lineal metres. (Note 3)			
Concrete Footings (for high mast poles and sign supports which extend above ground)	40 m ³ (Note 4)			
Sidewalk	500 lineal metres. (Note 3)	100 mm diameter and full depth of concrete.	2	Not Required
Curb with Gutter	500 lineal metres. (Note 3)	100 mm diameter and a minimum of 125 mm long.	2	Not Required

Category	Lot Size	Core Size	Number of Cores Per Lot for AVS	Number of Cores Per Lot for RCP
Concrete Patches and Refacing	Approximately equal in size and not greater than 100 m ² for each individual structure.	150 mm diameter and a minimum of 70 mm long.	1	0
		100 mm diameter and a minimum of 70 mm long.	0	4
Overlays	300 m ² per placement per individual structure.	150 mm diameter and a minimum of 70 mm long.	1	0
		100 mm diameter and a minimum of 70 mm long.	0	4
Concrete Pavement and Concrete Base	Covered by OPSS 350			
Notes for Table 3: 1. A pier consists of columns and a pier cap. 2. The total floor area of a component shall be added together and then divided into lots of specified size. Where a culvert has no floor, the area of the upper surface shall be used as the basis of determining lots. 3. The total length of a component shall be added together and then divided into lots of specified size. 4. The total volume of concrete in footings for high mast poles and sign supports per contract shall be added together and then divided into lots of specified size. Cores shall be taken from above ground portion of the footing. 5. If typical depth of overlay is less than 70 mm, the Contract Administrator shall identify areas for coring that provide the required core lengths.				

TABLE 4
Bonuses for Air Void System Parameters in All Hardened Concrete
\$/m³

		Air Content, %																																
		3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1
Spacing Factor, mm	<0.10	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.100	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.110	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.120	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.130	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.140	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.150	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0
	0.160	0	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1	0
	0.170	0	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1	0
	0.180	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	0
0.190	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	
0.200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Notes:

- A. For silica fume overlays and HPC, when a core has an air content of 3% or higher and a spacing factor of 0.250 mm or lower, but its air void system parameters are outside the range shown in Table 4, it shall be assigned a value of 0 \$/m³ for the purpose of calculating a bonus.
- B. For all other concrete, when a core has an air content of 3% or higher and a spacing factor of 0.230 mm or lower, but its air void system parameters are outside the range shown in Table 4, it shall be assigned a value of 0 \$/m³ for the purpose of calculating a bonus.

TABLE 5
Pay Factor for Air Void System Parameters of Hardened Concrete for Concrete Other Than Silica Fume Overlays and HPC
Pay Factor in % of Tender Item Price Per Lot

	Air Content, %																					
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	>2.9	
Spacing Factor, mm	<0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.110	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.120	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.130	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.140	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.150	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.160	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.170	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.180	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.190	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.200	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.210	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.220	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.230	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
	0.240	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95
	0.250	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95
	0.260	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93
	0.270	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90
	0.280	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88
	0.290	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86
	0.300	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83
	0.310	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81
	0.320	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79
	0.330	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76
	0.340	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74
	0.350	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71
	0.360	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69
	0.370	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67
	0.380	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64
	0.390	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62
	0.400	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59
0.410	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	
0.420	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	
0.430	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	
0.440	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	
0.450	0	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	
>0.450	0	0	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	

Note:

- A. When a core in an unacceptable lot has an air content of 3% or higher and a spacing factor of 0.230 mm or lower, the core shall be assigned a value of 100% for the purpose of calculating a penalty.
- B. Thick line between 0.230 and 0.240 mm spacing factor indicates maximum acceptable spacing factor.

TABLE 6
Pay Factor for Air Void System Parameters of Hardened Concrete for HPC and Silica Fume Overlays
Pay Factor in % of Tender Item Price Per Lot

	Air Content, %																				
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	>2.9
Spacing Factor, mm																					
<0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.110	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.120	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.130	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.140	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.150	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.160	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.170	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.180	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.190	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.200	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.210	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.220	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.230	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.240	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.250	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.260	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95
0.270	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95
0.280	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93
0.290	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90
0.300	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88
0.310	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86
0.320	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83
0.330	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81
0.340	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79
0.350	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76
0.360	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74
0.370	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71
0.380	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69
0.390	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67
0.400	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64
0.410	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62
0.420	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59
0.430	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57
0.440	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55
0.450	0	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52
>0.450	0	0	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50

Notes:

- A. When a core in an unacceptable lot has an air content of 3% or higher and a spacing factor of 0.250 mm or lower, the core shall be assigned a value of 100% for the purpose of calculating a penalty.
- B. Thick line between 0.250 and 0.260 mm spacing factor indicates maximum acceptable spacing factor.

TABLE 7
Admixtures, Water, and Cementing Materials - Minimum
Frequencies for Sampling and Testing

Material	Use or Type of Construction	Minimum Sampling Frequency (Note 1)	Minimum Sample Size (Note 2)
Air Entraining and Chemical and Superplasticizing Admixtures	All concrete.	One sample shall be taken at the beginning of concrete placement in each calendar year, no more than 30 Days prior to concrete placement.	Two samples shall be taken. Each shall be at least 750 ml.
Water Other Than Municipal Drinking Water	All concrete.	One additional sample shall be taken during the calendar year.	Two samples shall be taken. Each shall be at least 1 litre.
Cementing Materials: Portland Cement, Ground Granulated Blast Furnace Slag, Fly Ash, Blended Silica Fume Cement, and Portland Limestone Cement	Concrete pavement and base.	One sample per Contract or one sample per each 10, 000 m³ of concrete, whichever is more frequent.	10 kg of each cementing material used.
	Precast components.	One sample per calendar year.	
	All other concrete.	One sample per Contract or one sample per each 5,000 m³ of concrete, whichever is more frequent.	
Notes:			
1. Additional samples shall be taken every time there is a change in material source.			
2. Admixture and water samples shall be contained in a 1 litre bottle of a suitable plastic with a lid. Cementing material samples shall be contained in a canvas bag with plastic insert, accompanied by MTO form PH-CC-340.			
3. Minimum sampling and testing frequencies for limestone filler shall be the same as those shown for Cementing Materials.			

TABLE 8
Admixture Test Result Tolerances for Acceptance Purposes

Test Result	Air Entraining Admixtures	Chemical and Superplasticizing Admixtures
Relative Density	a) ± 0.010 where the value of relative density shown on DSM is 1.050 or less b) $\pm X$ where the value of relative density shown on DSM is greater than 1.050; Where $X = (\text{relative density shown on DSM} - 1.000) / 5$	
Non-volatile Content	Not required	$\pm 3.0\%$ of the value shown on DSM *
pH	± 2.0 of the value shown on DSM	Not required
* Example: If value shown on DSM is 10.0 %, no payment reduction will be applied if the result is between 7.0% and 13.0 %.		



Note: The PROV published in November 2017 replaces OPSS 1430 COMMON, November 2012 with no technical content changes.

MATERIAL SPECIFICATION FOR GABION BASKETS AND MATS

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1430.07	PRODUCTION
1430.08	QUALITY ASSURANCE

1430.01 SCOPE

This specification covers the requirements for gabion baskets or gabion mats and related accessories.

1430.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

ASTM International

A 90/A 90M-11	Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
A 313/A 313M-10e1	Stainless Steel Spring Wire
A 370-11a	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
A 641/A 641M-09a	Zinc-Coated (Galvanized) Carbon Steel Wire
A 764-07	Metallic Coated Carbon Steel Wire, Coated at Size and Drawn to Size for Mechanical Springs
A 975-11	Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire with Poly (Vinyl Chloride) (PVC) Coating)

Underwriters Laboratories

746B-96 Polymeric Materials - Long-Term Property Evaluations

1430.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Gabion Baskets means rectangular containers made of double twisted steel wire mesh produced to the dimensions shown in Table 1.

Gabion Mats means rectangular containers made of double twisted steel wire mesh produced to the dimensions shown in Table 2.

Lacing Wire means a galvanized steel wire or galvanized steel wire with PVC coating used to assemble and interconnect gabion basket or gabion mat containers and to close and secure stone filled containers.

1430.05 MATERIALS

1430.05.01 Gabion Baskets and Gabion Mats

Gabion baskets shall be manufactured from galvanized steel wire mesh or PVC coated galvanized steel wire mesh as specified in the Contract Documents. When the type of mesh is not specified in the Contract Documents, the gabion baskets shall be manufactured from PVC coated galvanized steel wire mesh.

Gabion mats shall be manufactured from PVC coated galvanized steel wire mesh.

Gabion baskets and the base section of gabion mats shall have all components connected in such a manner that the strength at the point of connection meets the requirements of Table 3 as tested according to ASTM A 975, Section 13.1.

1430.05.02 Wire Mesh

The mesh shall be woven from wire using a double twist pattern to create uniform hexagonal openings of 83 x 114 mm. The wire mesh shall be non-ravelling and shall provide the strength listed in Table 3 as tested according to ASTM A 975, Section 13.1.

The perimeter edges of the wire mesh shall be woven around a selvage wire in a manner designed to prevent slippage and to create a selvage.

1430.05.02.01 Wire

The wire for wire mesh, selvage wire, lacing wire, and internal connections shall be galvanized wire, soft temper, Class 3 coating, according to ASTM A 641. The wire diameter shall be according to Table 4. The tensile strength of the wire shall be according to ASTM A 641 as tested according to ASTM A 370. Galvanizing on the wire shall meet the requirements of Table 4 as tested according to ASTM A 90M.

1430.05.02.02 PVC Coating

PVC coating shall be according to ASTM A 975 and shall have a minimum thickness of 0.38 mm with a nominal thickness of 0.50 mm. Prior to UV and abrasion degradation, the PVC polymer coating shall have a projected durability life of 60 years as tested according to UL 746B.

1430.05.03 Fasteners

1430.05.03.01 General

Fasteners shall be fabricated such that when the ends of the fastener are brought together and properly locked, the fastener forms a closed loop. The inside area of the closed loop shall be at least 325 mm² to enclose up to four selva wires.

Locked fasteners shall be able to resist a minimum direct force across any axis of 3 kN while remaining closed and locked.

1430.05.03.02 Stainless Steel Rings

Stainless steel rings shall be manufactured from 3 mm diameter stainless steel spring wire Type 302, Class 1, according to ASTM A 313M.

1430.05.03.03 Interlocking Wire Fasteners

Interlocking fasteners shall be manufactured from 3 mm diameter steel mechanical spring wire Class 1, Finish 2, Type B, Tensile Class 2, according to ASTM A 764.

1430.07 PRODUCTION

1430.07.01 General

Gabion baskets and gabion mats shall be manufactured so that the sides, ends, lid, base, and diaphragms can be readily assembled into rectangular units.

Where the length of the gabion basket exceeds its horizontal width, the gabion basket shall be divided into equal cells by diaphragms. Cell length shall not exceed its horizontal width. Diaphragms shall be made of wire mesh and shall be secured in the proper position on the base section. Gabion mats shall have diaphragms spaced at 1.0 m across the width of the mat and 3.0 m along the length of the mat.

Gabion baskets or gabion mats shall be manufactured with all components connected at the production facility with the exception of the gabion mat lid. Gabion baskets manufactured from galvanized wire mesh shall be assembled using either lacing wire or fasteners. Gabion baskets and gabion mats manufactured from PVC coated galvanized wire mesh shall be assembled using stainless steel ring fasteners. Fasteners shall be installed at a maximum spacing of 150 mm with at least one fastener per gabion mesh opening.

1430.07.02 Dimensions and Tolerances

Gabion baskets and gabion mats shall be produced to the sizes and dimensions shown in Tables 1 and 2. All dimensions are subject to a tolerance limit of $\pm 5\%$, except depth dimensions, which are subject to tolerance limit of $\pm 5\%$ for gabion baskets and $\pm 10\%$ for gabion mats.

1430.07.03 Packaging and Marking

Each gabion basket and gabion mat shall be clearly colour coded according to Tables 1 and 2 or otherwise suitably identified to indicate its size.

Gabion baskets shall be shipped folded flat in bundles. Each bundle shall contain an equal number of one size of gabion baskets, except as necessary to complete an order. Each bundle shall be clearly marked to show the size and number of baskets it contains. The maximum weight of one bundle shall be 850 kg.

Gabion mats shall be shipped in rolls with ends, sides, and dividers attached to the base. The gabion mat lid and base units are to be shipped unattached, but rolled together as one. The maximum weight of one roll shall be 850 kg.

1430.08 QUALITY ASSURANCE

1430.08.01 Inspection and Testing

The Owner reserves the right to make inspections and tests and at times the Owner may consider necessary to ensure that the materials supplied are in accordance with this specification.

All materials failing to comply with the requirements of this specification shall be rejected.

TABLE 1
Gabion Basket Sizes and Dimensions

Size Number	Number of Diaphragms	Approximate Dimensions and Volumes				Colour Code
		Length m	Width m	Depth m	Capacity m ³	
1	1	2.00	1.00	0.30	0.60	Blue/Red
2	1	2.00	1.00	0.50	1.00	Red
3	1	2.00	1.00	1.00	2.00	Blue
4	2	3.00	1.00	0.30	0.90	Blue/Yellow
5	2	3.00	1.00	0.50	1.50	Green
6	2	3.00	1.00	1.00	3.00	White
7	3	4.00	1.00	0.30	1.20	Blue/Green
8	3	4.00	1.00	0.50	2.00	Yellow
9	3	4.00	1.00	1.00	4.00	Black
10	1	2.00	0.50	0.50	0.50	White/Yellow
11	2	3.00	0.50	0.50	0.75	White/Green

TABLE 2
Gabion Mat Sizes and Dimensions

Size Number	Number of Dividers	Number of Diaphragms	Approximate Dimensions and Areas				Colour Code
			Length m	Width m	Depth m	Area m ²	
12	1	18	30	2	0.23	60	Black/Green
13	2	27	30	3	0.23	90	Black/Yellow
14	1	18	30	2	0.30	60	Black/Blue
15	2	27	30	3	0.30	90	Black/White

TABLE 3
Minimum Strength Requirements of Mesh and Connections

Test Description	Galvanized Gabion Basket	PVC Coated	
		Gabion Basket	Gabion Mat
Parallel to Twist	51.1 kN/m	42.3 kN/m	33.6 kN/m
Perpendicular to Twist	26.3 kN/m	20.4 kN/m	13.1 kN/m
Connection to Selvages	20.4 kN/m	17.5 kN/m	10.2 kN/m
Panel to Panel Connection Using Lacing Wire or Fasteners	20.4 kN/m	17.5 kN/m	10.2 kN/m
Punch Test	26.7 kN	23.5 kN	17.8 kN

TABLE 4
Gabion Baskets and Gabion Mats

	Galvanized Gabion Basket	PVC Coated	
		Gabion Basket	Gabion Mat
Mesh Type	80 x 100 mm	80 x 100 mm	80 x 100 mm
Mesh Opening	83 x 114 mm	83 x 114 mm	83 x 114 mm
Wire Diameter for Mesh	2.95 mm	2.70 mm	2.20 mm
Wire Diameter for Selvages and Corners	3.85 mm	3.40 mm	2.65 mm
Wire Diameter for Lacing and Internal Connections	2.20 mm	2.20 mm	2.20 mm
Galvanizing for Mesh Wire	244 g/m ² min	244 g/m ² min	213 g/m ² min
Galvanizing for Selva ge Wire	274 g/m ² min	260 g/m ² min	244 g/m ² min
Galvanizing for Lacing Wire	213 g/m ² min	213 g/m ² min	213 g/m ² min



MATERIAL SPECIFICATION FOR STEEL REINFORCEMENT FOR CONCRETE

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1440.08	QUALITY ASSURANCE
1440.09	OWNER PURCHASE OF MATERIAL - Not Used
1440.01	SCOPE

This specification covers the requirements for all steel reinforcement used in concrete work.

1440.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 905 Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

Structural Manual

Laboratory Testing Manual:

LS-448 Method of Test for Determination of Tensile Properties of Welded Wire Reinforcement

CSA Standards

G30.18-09 (R2019)	Carbon Steel Bars for Concrete Reinforcement
G40.20-13/G40.21-13	General Requirements for Rolled or Welded Structural Quality Steel Structural Quality Steels
S6-19	Canadian Highway Bridge Design Code

ASTM International

A276 / A276M - 17	Stainless Steel Bars and Shapes
A416 / A416M - 18	Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete
A421 / A421M - 15	Stress-Relieved Steel Wire for Prestressed Concrete
A722 / A722M - 18	High-Strength Steel Bars for Prestressed Concrete
A955 / A955M - 20	Deformed and Plain Stainless Steel Bars for Concrete Reinforcement
A1064 / A1064M - 18a	Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

International Organization for Standardization/International Electrotechnical Commission

ISO/IEC 17025:2005	General Requirements for the Competence of the Testing and Calibration Laboratories

Others

Reinforcing Steel Institute of Canada - Reinforcing Steel Manual of Standard Practice - 2004

1440.03 DEFINITIONS

For the purpose of this specification the following definitions apply:

Lot means a quantity of steel that can be identified. For each size designation of prestressing steel strand, a lot shall be reels or coils produced from one heat. For each nominal diameter of prestressing steel bar and for each size designation of reinforcing steel bar, a lot shall be all the supplied bars from one heat.

Prestressing Steel means as defined in OPSS 905.

Prestressing Steel Bar means a high strength alloy steel bar having a nominal diameter greater than 9 mm.

Reinforcing Steel Bars means as defined in OPSS 905.

Spacer means a rolled steel shape punched to form hooks that are bent over the spiral to maintain a specified pitch.

Spiral means continuously wound reinforcing steel in the form of a cylindrical helix.

Splice Bar means as defined in OPSS 905.

Stainless Steel Reinforcing Bars means as defined in OPSS 905.

Steel Reinforcement means as defined in OPSS 905.

Strand means as defined in OPSS 905.

1440.04 DESIGN AND SUBMISSION REQUIREMENTS

1440.04.01 Submission Requirements

1440.04.01.01 Mill Certificates for Reinforcing Steel Bars, Stainless Steel Reinforcing Bars, Steel Welded Wire Reinforcement, Splice Bars, and Stainless Steel Splice Bars

Two copies of the mill certificates for each lot shall be submitted to the Contract Administrator prior to shipment of reinforcing steel bars, stainless steel reinforcing bars, welded wire reinforcement, splice bars, and stainless steel splice bars. The certificates shall show that the material is as specified in the Contract Documents.

1440.04.02 Mill Certificates and Stress-Strain Curves for Prestressing Steel

Two copies of the mill certificates and stress-strain curves for each lot shall be submitted to the Contract Administrator prior to shipment of prestressing steel. The certificates shall show that the material is as specified in the Contract Documents.

When mill test certificates originate from a mill outside Canada or the United States of America, the Contractor shall have the information on the mill test certificate verified by testing by a Canadian laboratory. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC DIS 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and appropriate wording stating that the material is in conformance with the specified Contract requirements. The stamp shall include the appropriate material specification number, testing date (i.e., yyyy- mm-dd), and the signature of an authorized officer of the Canadian laboratory.

1440.05 MATERIALS

1440.05.01 Reinforcing Steel Bars, Splice Bars, Tie Bars, Dowel Bars, Spirals, and Spacers

Reinforcing steel bars shall be according to CSA G30.18.

All reinforcing steel bars shall be Grade 400W according to CSA G30.18.

Deformed steel bars for spirals shall be according to CSA G30.18 type W. Steel spacers according to CSA G40.20/G40.21, Grade 350 G shall be provided with the spirals.

1440.05.02 Stainless Steel Reinforcing Bars, Stainless Steel Splice Bars, Tie Bars, Dowel Bars, Spirals, Spacers, and Stainless Steel Mechanical Connectors

Stainless steel reinforcing bars and spirals shall be according to ASTM A276 and ASTM A955, minimum Grade 420.

Nominal dimensions, unit masses, and deformation requirements for metric bar sizes shall be according to CSA G30.18. Stainless spirals shall be provided with stainless spacers in conformance with ASTM A276.

Stainless steel reinforcing bars, stainless steel spirals, stainless steel spiral spacers, and mechanical connectors shall be of a stainless steel type shown in Table 1.

Imperial and soft-converted metric bar size substitutions for metric bar sizes shall be permitted on a one-for-one basis without adjustment as shown in Table 2.

Other Imperial and soft-converted metric stainless steel reinforcing bar sizes may be substituted for metric bar sizes, subject to the following:

- a) The area of substituted steel reinforcement for the concrete component per linear metre or per gross cross-section area, as applicable, shall not be less than that shown for the concrete component on the Contract Drawings; and,
- b) The spacing of substituted steel reinforcement for the concrete component shall be according to CSA-S6 and the Structural Manual, Division 1.

Nominal cross-sectional areas of metric and imperial bar sizes used for determining substitutions shall be according to ASTM A955 and CSA G30.18, respectively.

1440.05.03 Plain and Deformed Steel Wire

Plain and deformed steel wire shall be according to ASTM A1064.

1440.05.04 Steel Welded Steel Wire Reinforcement

Welded wire reinforcement shall be according to ASTM A1064 with the following exceptions:

- a) The yield strength shall be calculated according to LS-448 and shall meet or exceed the minimum value specified.
- b) The average minimum elongation of welded wire reinforcement shall be 4% with no individual valid test result less than 3.2% elongation when tested according to LS-448.
- c) The minimum diameter of the wire in welded steel wire reinforcement shall be 3.14 mm.

1440.05.05 Prestressing Steel

Prestressing steel strand shall be weldless, low relaxation grade according to ASTM A416. Prestressing steel strand shall be certified by its manufacturer to bond to concrete of normal strength and consistency.

Prestressing steel wire shall be according to ASTM A421.

Prestressing steel bars shall be according to ASTM A722. The bars shall not be welded.

1440.07 PRODUCTION

1440.07.01 Manufacture of Reinforcing Steel Bars

The manufacture of reinforcing steel bars shall be by a manufacturer listed under "Mill" in the Designated Sources for Materials listing for Reinforcing Steel, Uncoated, Fabricators and Mills.

1440.07.02 Manufacture of Stainless Steel Reinforcing Bars

The manufacture of stainless steel reinforcing bars shall be by a manufacturer listed under "Mills" in the Designated Sources for Materials listing for Reinforcing Steel, Stainless, Mills and Fabricators.

1440.07.03 Fabrication of Reinforcing Steel Bar, Stainless Steel Reinforcing Bar, Splice Bar, and Stainless Steel Splice Bars

Bars shall be cold bent at the fabricator's shop listed under "Fabricators" in the Designated Sources for Materials listings for Reinforcing Steel.

The standard fabricating tolerances for all bars, straight or bent, shall be according to the Reinforcing Steel Manual of Standard Practice of the Reinforcing Steel Institute of Canada.

Fabrication of stainless steel reinforcing bars shall be so that the bar surfaces are not contaminated with deposits of iron or non-stainless steels, and the bar is not damaged by straightening from coil.

1440.07.04 Identification

1440.07.04.01 Prestressing Steel

All steel strand from each manufactured reel used and all high strength alloy bars used shall be assigned an individual lot number and shall be tagged with the lot number.

1440.07.04.02 Reinforcing Steel Bars, Stainless Steel Reinforcing Bars, Splice Bars, and Stainless Steel Splice Bars

All bars shall be shipped in bundles.

Each lot of reinforcing steel bars, stainless steel reinforcing bars, splice bars, and stainless steel splice bars shall be assigned an individual lot number and shall be tagged with the lot number.

In addition, tags for reinforcing steel bars, and stainless steel reinforcing bars shall identify the manufacturer, the stainless steel type and grade or reinforcing steel grade, and bar size.

1440.08 QUALITY ASSURANCE

1440.08.01 Inspection and Testing

The Owner reserves the right to carry out inspections and tests at such times as the Owner may consider necessary to ensure that the materials supplied are according to this specification.

Materials failing to comply with the requirements of this specification shall be rejected.

The Owner's representative shall be permitted free entry to the manufacturing and fabrication plants, as well as the finished product storage and loading areas for inspection purposes.

TABLE 1
Type of Stainless Steel

Common or Trade Name	AISI Type	UNS Designation
Type 316 LN	316 LN	S31653
Type 2205 Duplex	2205	S31803
Note: A. Condition/Finish: Reinforcing stainless steel bars and shapes shall be hot rolled and pickled, or hot rolled and descaled to the required mechanical properties and dimensions.		

TABLE 2
Size Conversions

Metric Bar Size	Imperial Bar Size	Bar Designation No.
15M	# 5	16
25M	# 8	25
35M	# 11	36



**ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION**

**OPSS.PROV 1441
NOVEMBER 2017**
(Formerly OPSS 1441, September 1988)

Note: The PROV published in November 2017 replaces OPSS 1441, September 1988 with no technical content changes.

**MATERIAL SPECIFICATION FOR
LOAD TRANSFER ASSEMBLIES**

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1441.05	MATERIALS
1441.06	EQUIPMENT - Not Used
1441.07	PRODUCTION
1441.08	QUALITY ASSURANCE - Not Used

1441.01 SCOPE

This specification covers the requirements for load transfer assemblies for use in concrete pavement expansion joints.

1441.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standards Specifications, Materials

OPSS 1442 Epoxy Coated Steel Reinforcement for Concrete

Canadian Standards Association Standards:

CAN/CSA-G40.21-M87 Structural Quality Steels

1441.05 MATERIALS

Side ladders and spacer bars shall be plain round bars according to CAN/CSA-G40.21.

Dowel bars shall be plain round bars of grade 300 or better according to CAN/CSA-G40.21. They shall be epoxy coated according to OPSS 1442.

Dowel caps shall be cold rolled deep drawn quality steel.

Compressible spacers shall be cold rolled blue tempered spring steel.

The Owner will consider approval of supporting structures (ladders) spacer bars and compressible spacers made of materials other than steel.

1441.07 PRODUCTION

1441.07.01 Fabrication

Dowel bars shall be cut and handled in such a manner as to avoid distortion or burrs that would inhibit free movement in the concrete. Welds shall be resistance or arc type. The assembly shall be readily separable into two parts to permit the greasing of the dowels and the addition of bulkheads and joint fillers.

Dowel bars shall not deviate from the prescribed angle of skew by more than one degree and shall be parallel to each other within a tolerance of zero degrees forty-five minutes. Dowel cap assemblies shall be fabricated with sufficient accuracy to permit the free movement of all dowels within the dowel caps.

Suitable wire ties shall be provided to hold the assembly in normal position during shipping and installation and to permit the fastening and unfastening of the dowel cap assembly.

1441.07.02 Patching

After fabrication, all areas of the dowel bar with damaged epoxy coating shall be cleaned and painted with a patching material according to OPSS 1442.



MATERIAL SPECIFICATION FOR CABLE GUIDE RAIL

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1503.06	EQUIPMENT - Not Used
1503.07	PRODUCTION
1503.08	QUALITY ASSURANCE - Not Used
1503.09	OWNER PURCHASE OF MATERIAL

1503.01	SCOPE

This specification covers the requirements for cable guide rail and associated components including anchor blocks, fabricated bases, and hardware.

1503.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specification, Material

OPSS 1350 Concrete - Materials and Production

CSA Standards

G12-14 (R2019)	Zinc-Coated Steel Wire Strand
G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
G164-18	Hot Dip Galvanizing of Irregularly Shaped Articles
W59-18	Welded Steel Construction

ASTM International

A47/A47M-99(2018)e1 Ferritic Malleable Iron Castings
B30-20 Copper Alloys in Ingot and Other Remelt Forms

SAE International

J403-2014-06-30 Chemical Compositions of SAE Carbon Steels

1503.05 MATERIALS

1503.05.01 Cable

Guide rail cable and cable used for the pressed ferrule and cable fittings shall be according to CSA G12, grade 800 steel wire strand and hot zinc-coated or class A electro-zinc-coated. Cable shall be 12 mm diameter, 7-wire strand weighing approximately 760 kg/1000 m with a minimum breaking strength of 74 kN and a maximum breaking strength of 100 kN.

1503.05.02 Fittings

Ferrous castings for the end fitting and splicer shall be according to ASTM A47M, grade 32510 for malleable iron.

The tension bolt for the end fitting shall be SAE 1035 hot rolled fine grained steel and the ferrule shall be SAE 1020 rolled steel according to SAE J403. As an option, the tension bolt may contain a square or hex nut welded as specified in the Contract Documents. All welds shall be according to CSA W59. The ferrous castings, tension bolt, and ferrule shall be hot dip galvanized according to CSA G164. The ferrule shall be galvanized after it has been pressed onto the cable.

Wedges shall be bronze according to ASTM B30 for alloy suitable for sand casting.

1503.05.03 Anchor Blocks

1503.05.03.01 Fabricated Steel Sections

The fabricated steel section and angle iron braces in the precast anchor block shall be according to CSA G40.20/G40.21. After fabrication, the section shall be hot dip galvanized according to CSA G164.

1503.05.03.02 Precast Concrete Anchor Blocks

Precast concrete anchor blocks shall be as specified in the Contract Documents. The concrete shall be according to OPSS 1350 with a nominal minimum 28-Day compressive strength of 30 MPa.

1503.05.04 Cable Clamps and Nails

Nails shall be 65 mm long standard spiralled, flat heads with diamond points. Clamps shall be 2.5 mm minimum thickness mild steel. After fabrication, clamps and nails shall be hot dip galvanized according to CSA G164.

1503.05.05 Fabricated Steel Bases

Fabricated steel bases shall be according to CSA G40.20/G40.21. After fabrication, the steel bases shall be hot dip galvanized according to CSA G164.

All welding shall be according to CSA W59. All welds shall be continuous.

1503.07 PRODUCTION

1503.07.01 Pressed Ferrule and Cable Fitting

The ferrule shall be pressed onto the end of the cable fitting. The ferrule shall not slip from the cable when tested under a tensile static load to the limit of cable breakage.

1503.07.02 Marking

Coils and reels of guide rail cable shall be identified by an attached durable tag with the following information indelibly recorded:

- a) CSA standard designation.
- b) Grade of steel.
- c) Nominal diameter of strand.
- d) Manufacturer's name and location.
- e) Length of strand in metres.
- f) Weight of strand in kilograms per coil.

1503.09 OWNER PURCHASE OF MATERIAL

1503.09.01 Packaging

Guide rail cable shall be supplied either in coils or on expendable reels. All reels shall be of sufficient strength to withstand transportation and normal handling. Coils shall be securely and suitably fastened.

The tension bolt and ferrous castings for the end fitting shall be pre-assembled. Splices and end fittings including wedges shall be supplied in cartons containing one type of assembly. Each carton shall be clearly marked as to the number and type of assembly it contains.

Pressed ferrules and cable fittings shall be supplied in bundles of six fittings banded with steel straps.

Cable clamps and nails shall be supplied in separate containers having a maximum gross weight of 20 kg. Containers shall be clearly marked with their contents and weight.

1503.09.02 Measurement and Payment

Guide rail cable and cable clamps and nails shall be measured in the units specified in the purchasing order delivered and accepted.

For measurement purposes, a count shall be made of the number of end fittings, splicers, and pressed ferrule and cable fittings of each type specified in the purchasing order delivered and accepted.

For measurement purposes, a count shall be made of the number of fabricated steel sections delivered and accepted.

For measurement purposes, a count shall be made of the number of fabricated steel bases delivered and accepted.

Payment at the price specified in the purchasing order shall be for the supply of guide rail cable, cable clamps and nails, end fittings, splicers, pressed ferrule and cable fittings, fabricated steel sections, and fabricated steel bases delivered to the destination or destinations at the dates and times specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.



MATERIAL SPECIFICATION FOR STEEL BEAM GUIDE RAIL

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1504.06	EQUIPMENT - Not Used
1504.07	PRODUCTION
1504.08	QUALITY ASSURANCE - Not Used
1504.09	OWNER PURCHASE OF MATERIAL
1504.01	SCOPE

This specification covers the requirements for steel beam guide rail, terminal sections, fabricated bases, and installation hardware.

1504.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

CSA Standards

G40.20/G40.21-04 (R2009)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steels
G164-M92 (R2003)	Hot Dip Galvanizing of Irregularly Shaped Articles
W59-03 (R2008)	Welded Steel Construction (Metal Arc Welding) (Metric Version)

ASTM International

A307 - 07 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

American Association of State Highway Transportation Officials (AASHTO)

M180-18 Standard Specification for Corrugated Sheet Steel Beams for Highway Guardrail

1504.05 MATERIALS

1504.05.01 Rail and Terminal Sections

Rail elements shall have a minimum yield strength of 345 MPa.

After fabrication, all rail elements and terminal sections shall be hot dip batch galvanized according to CSA G164. Rail elements that are continuous hot dip galvanized shall be supplied from a source named on the ministry's DSM. Zinc coating thickness shall be according to AASHTO M180, Type II.

1504.05.02 Fabricated Steel Bases

Steel bases shall be fabricated according to CSA G40.20/G40.21. After fabrication, steel bases shall be hot dip galvanized according to CSA G164.

1504.05.03 Installation Hardware

All bolts, nuts, and washers shall be according to ASTM A307 and hot dip galvanized according to CSA G164.

1504.07 PRODUCTION

1504.07.01 Steel Beam Guide Rail and Terminal Sections

Steel beam guide rail shall consist of rail elements fabricated to develop continuous beam strength with a cross-section as specified in the Contract Documents.

Bolt holes in rail elements, terminal sections, and fabricated bases shall be perpendicular to the surface and shall not deviate more than 1.0 mm in any direction from the true location. Rail element and terminal section ends shall be cut square.

After fabrication, prefabricated curved steel rail elements shall be galvanized according to CSA G164.

Steel beam guide rail components furnished under this specification shall be interchangeable with similar components regardless of the source or manufacturer.

1504.07.02 Marking

As a minimum, each rail element shall be marked with the following information:

- a) Name, trademark, or brand of the manufacturer.
- b) Standard designation 1504. M180A2 will be accepted as an equivalent standard designation.
- c) Identification symbols or code for heat.

d) Week number and year of production.

Markings shall be clearly and permanently stamped in the valley of the centre corrugation, placed at a location clear of the splice overlap, and shall not be obscured after installation. The height of the letters and numerals shall be within the range of 19 to 32 mm.

1504.07.03 Welding

All welds shall be according to CSA W59 and shall be continuous.

1504.09 OWNER PURCHASE OF MATERIAL

1504.09.01 Measurement and Payment

For measurement purposes, a count shall be made of the number of steel beam guide rail elements delivered and accepted.

For measurement purposes, a count shall be made of the number of terminal sections delivered and accepted.

For measurement purposes, a count shall be made of the number of fabricated steel bases for guide rail posts delivered and accepted.

Installation hardware shall be measured in the units specified in the purchasing order, delivered and accepted.

Payment at the price specified in the purchasing order shall be for the supply of steel beam guide rail elements, terminal sections, fabricated steel bases, and installation hardware delivered to the destination or destinations at the dates and times specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.



Note: The PROV implemented in April 2017 replaces OPSS 1505 COMMON, November 2010 with no technical content changes.

MATERIAL SPECIFICATION FOR CHANNEL COMPONENTS FOR STEEL BEAM GUIDE RAIL

TABLE OF CONTENTS

1505.01	SCOPE
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1505.06	EQUIPMENT - Not Used
1505.07	PRODUCTION
1505.08	QUALITY ASSURANCE - Not Used
1505.09	OWNER PURCHASE OF MATERIAL
APPENDICES	Not Used

1505.01 SCOPE

This specification covers the requirements for steel channel and installation hardware.

1505.01.01 Specification Significance and Use

This specification has been developed for use in provincial oriented Contracts. The administration, testing, and payment policies, procedures, and practices reflected in this specification correspond to those used by the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1505.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1505.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

G164-M92 (R2003) Hot Dip Galvanizing of Irregularly Shaped Articles
S136-07 Cold Formed Steel Structural Members

ASTM International

A 307-07 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

1505.05 MATERIALS

1505.05.01 Cold Rolled Channel

Channels shall be cold rolled steel sections according to CSA S136 and have a minimum yield strength of 345 MPa. After fabrication, sections shall be hot dip galvanized according to CAN/CSA G164.

1505.05.02 Installation Hardware

All bolts, nuts, and washers shall be according to ASTM A 307 and be hot dip galvanized according to CAN/CSA G164.

1505.07 PRODUCTION

1505.07.01 Fabrication Tolerances and Workmanship

Bolt holes in steel channels shall be perpendicular to the surface and shall not deviate more than 1.0 mm in any direction from the true location. Steel channel ends shall be cut square.

After fabrication, curved steel channels shall be hot dip galvanized according to CAN/CSA G164.

1505.07.02 Marking

As a minimum, each steel channel section shall be marked with the following information:

- a) Name, trademark, or brand of the manufacturer.
- b) Standard designation 1505.
- c) Identification symbols or code for heat.
- d) Week number and year of production.

Markings shall be clearly and permanently stamped in the valley of the steel channel, placed at a location clear of the splice overlap, and shall not be obscured after installation. The height of the letters and numerals shall be within the range of 19 to 32 mm.

1505.09 OWNER PURCHASE OF MATERIAL

1505.09.01 Measurement and Payment

For measurement purposes, a count shall be made of the number of steel channel sections delivered and accepted.

Installation hardware shall be measured in the units specified in the purchasing order, delivered and accepted.

Payment at the price specified in the purchasing order shall be for the supply of steel channels and installation hardware delivered to the destination or destinations at the dates and times specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.



MATERIAL SPECIFICATION FOR STANDARD HIGHWAY FENCE COMPONENTS

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1540.07	PRODUCTION
1540.08	QUALITY ASSURANCE - Not Used
1540.09	OWNER PURCHASE OF MATERIAL - Not Used

1540.01 SCOPE

This specification covers the requirements for highway fence components and hardware.

1540.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1601 Wood, Preservation Treatment, and Shop Fabrication

Canadian General Standards Board (CGSB)

138.2-96 Steel Framework for Chain-Link Fence

ASTM International

A 116-11 Metallic-Coated, Steel-Woven Wire Fence Fabric
A 641/A 641M-09a Zinc-Coated (Galvanized) Carbon Steel Wire
A 702-89 (2006) Steel Fence Posts and Assemblies, Hot Wrought

Others

NLGA Standard Grading Rules for Canadian Lumber (2003)

1540.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Chain and Hook means hardware to hold the gate in place when closed.

Hinge Bolt means hardware that attaches to the gatepost and fits into the hinge clip to permit the gate to swing.

Hinge Clip means hardware that attaches to the gate frame and functions with the hinge bolt.

Sweep means the deviation of a wooden brace from straightness.

1540.05 MATERIALS

1540.05.01 Fence Fabric

The fence fabric shall be one type as shown in Table 1.

Locks or fastening at the intersections of the line and stay wires of the woven fence fabric shall prevent longitudinal and vertical slipping.

Fence fabric shall be galvanized prior to fabrication to provide a minimum weight of metallic coating according to ASTM A 641, Class 3.

1540.05.02 Wooden Posts

Wooden posts shall be according to OPSS 1601.

Wooden terminal posts shall have a minimum diameter of 200 mm. Wooden line posts shall have a minimum diameter of 150 mm. The maximum diameter of the large end of any wooden post shall be 330 mm.

1540.05.03 Steel Posts

Steel line posts shall be T-rail posts.

T-rail posts and angle iron posts shall be galvanized and according to ASTM A 702.

T-rail posts shall be 2.4 m long and punched so that the fence fabric can be secured to the broad face of the post. Each post shall be supplied with nine steel wire ties for securing the fence fabric.

1540.05.04 Steel Wire Ties

Steel wire ties shall be galvanized and according to ASTM A 702.

1540.05.05 Diagonal Wooden Braces

Diagonal wooden braces shall be round or sawn Eastern White Cedar, Jack Pine, Red Pine, or Southern Yellow Pine according to OPSS 1601. Round braces shall be a minimum diameter of 110 mm and

maximum diameter of 165 mm. Sawn braces shall be a minimum 100 x 100 mm and in sound condition according to NLGA Standard Grading Rules for Canadian Lumber, Utility Light Framing. Diagonal wooden braces shall have a maximum sweep of 25 mm.

1540.05.06 Diagonal Brace Wire

Diagonal brace wire shall consist of four strands of 3.5 mm diameter, galvanized, soft steel.

When installing fence fabric with design number 949-12-12.5, the diagonal brace wire shall consist of four strands of 2.51 mm diameter, Class 3, high tensile wire.

1540.05.07 Staples

Staples for wooden posts shall be 4.0 mm diameter, galvanized, with a minimum driving length of 45 mm.

1540.05.08 Gates

Gates shall be constructed from 43 mm outside diameter galvanized steel pipe for the frame and 32 mm outside diameter galvanized steel pipe for the braces according to the requirements for galvanized standard-weight pipe, CAN/CGSB 138.2. All joints shall be electrically welded and coated with a zinc rich paint.

All required hardware and galvanizing of such parts shall be according to CAN/CGSB 138.2.

1540.05.09 Mechanical Splicing Units and Crimp Sleeves

Mechanical splice units or crimping sleeves shall provide a maximum load carrying capacity that meets or exceeds the minimum breaking strength of the fence fabric line wires. For 3.50 mm and 3.76 mm diameter line wire, the minimum breaking strength of the splice shall be 4,590 N.

For 2.51 mm diameter line wire, the minimum breaking strength of the splice shall be 5,990 N.

1540.07 PRODUCTION

1540.07.01 Gates

Gates shall be supplied completely assembled, including the fence fabric. The fabric and other components used on the gates shall match the adjacent fence.

All gates shall be supplied with galvanized chain and hook, hinge bolts, and hinge clips.

TABLE 1
Fence Fabric

Fence Fabric Design Number	Number of Horizontal Wires	Minimum Height mm	Wire Diameter mm	Stay Wire Spacing mm	Standard
948-12-9.75	9	1219	3.50	305	ASTM A 641
949-12-9	9	1219	3.76	305	ASTM A 116
949-12-12.5	9	1219	2.51	305	ASTM A 116



MATERIAL SPECIFICATION FOR CHAIN-LINK FENCE COMPONENTS

TABLE OF CONTENTS

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1541.08	QUALITY ASSURANCE - Not Used
1541.09	OWNER PURCHASE OF MATERIAL - Not Used

1541.01 SCOPE

This specification covers the requirements for chain-link fence components and hardware.

1541.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 772 Chain-Link Fence

Canadian General Standards Board (CGSB)

138.1-2019 Fabric for Chain Link Fence
138.2-2019 Steel Framework for Chain Link Fence
138.4-2019 Gates for Chain Link Fence

ASTM International

A27/A27M-20 Steel Casting, Carbon, for General Application
A153/A153M-16a Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A824-01(2022) Metallic-Coated Steel Marcellled Tension Wire for Use With Chain-Link Fence
F626-14(2019) Fence Fittings
F1043-18(2022) Strength and Protective Coatings on Steel Industrial Fence Framework

1541.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 772 apply.

1541.05 MATERIALS

1541.05.01 Barbed Wires

Barbed wires shall be according to CAN/CGSB 138.2.

1541.05.02 Diagonal Wire Braces, Top and Bottom Wires for use with Galvanized Steel Fence Fabric

Top wire, bottom wire, and diagonal wire braces shall be 4.50 mm diameter marcelled tension wire Type II according to ASTM A824 with a minimum Class 5 galvanized coating.

1541.05.03 Diagonal Wire Braces, Top and Bottom Wires for use with Vinyl-Coated Fence Fabric

Top wire, bottom wire, and diagonal wire braces shall be 4.50 mm diameter marcelled tension wire Type II according to ASTM A824 with a minimum Class 3 galvanized coating. The wire shall be vinyl-coated to match the class and colour of the vinyl-coated fence fabric and shall be according to CAN/CGSB 138.1

1541.05.04 Fasteners

1541.05.04.01 General

Wire ties for attaching fence fabric to line posts, bottom wires, top rails, and top wires shall be according to ASTM F626.

1541.05.04.02 Fasteners for Galvanized Steel Fence Fabric

Round wire ties used for attaching fence fabric to line posts and top rails shall be manually or power fastened, 3.76 mm diameter steel wire, with a minimum 488 g/m² galvanized coating.

Wire ties used for attaching the fence fabric to the bottom or top wires shall be round wire hog rings, 2.69 mm diameter steel wire, with a minimum 488 g/m² galvanized coating.

1541.05.04.03 Fasteners for Vinyl Coated Fence Fabric

Round wire ties used for attaching the fence fabric to the line posts and top rails shall be manually or power fastened, 3.76 mm diameter zinc or aluminum coated steel core wire, with a vinyl.

Wire ties used for attaching the fence fabric to the bottom or top wires shall be round wire hog rings, 2.69 mm diameter zinc or aluminum coated steel core wire, with a vinyl coating.

Fasteners shall be vinyl-coated to match the class and colour of the vinyl-coated fence fabric and shall be according to CAN/CGSB 138.1.

1541.05.05 Fence Fabric

The fence fabric shall be 1,200 mm or 1,800 mm wide according to the Contract Documents, with a uniform 50 mm diamond pattern chain-link mesh closed at one edge by knuckling and at the other edge by twisting. The steel wire for chain-link fence fabric shall be according to CAN/CGSB 138.1. The fence fabric shall be one of the types listed in Table 1.

The vinyl coating for wire fabric shall be black in colour.

1541.05.06 Fittings

Tension bars, tension bands, brace bands, top rail sleeves, and rail ends shall be according to ASTM F626.

Barbed wire arms shall be fabricated from galvanized pressed steel or cast iron according to CAN/CGSB 138.2 or ASTM F626.

Terminal and line post caps shall be according to ASTM F626.

When vinyl-coated fence fabric is used, the fittings shall be vinyl-coated to match the class and colour of the vinyl-coated fence fabric and shall be according to CAN/CGSB 138.1

1541.05.07 Gates

Gates shall be constructed from galvanized steel pipe frames and braces according to CAN/CGSB 138.4. All joints shall be electrically welded and coated with a zinc rich paint after welding.

When vinyl-coated fence fabric is used, gate frames and braces shall be vinyl-coated to match the class and colour of the vinyl-coated fence fabric and shall be according to CAN/CGSB 138.1.

1541.05.08 Hardware

All required hardware including, but not limited to carriage bolts and nuts, shall be hot dip galvanized according to ASTM A153M.

1541.05.09 Posts and Rails

All posts, post sleeves, and rails shall be galvanized steel pipe or roll-formed steel shapes. Galvanized steel pipe shall be according to CAN/CGSB 138.2. Roll-formed steel shapes shall be according to ASTM F1043.

When vinyl-coated fence fabric is used, all posts, post sleeves, and rails shall be vinyl-coated to match the class and colour of the vinyl-coated fence fabric and shall be according to CAN/CGSB 138.1.

1541.05.10 Turnbuckles

Turnbuckles shall be drop forged steel according to ASTM A27M and shall be galvanized according to ASTM A153M.

The average overall length shall be approximately 300 mm with ends in the closed position. Bolt diameter shall be approximately 10 mm and capable of taking up a minimum of 150 mm slack.

1541.07 PRODUCTION

1541.07.01 Gates

All gates shall be supplied with galvanized malleable iron or pressed steel hinges, latch, latch catch, and shall be capable of opening approximately 180 degrees. Gate latches shall be suitable for use with padlocks that can be attached and operated from either side of the gate.

Gates shall be supplied completely assembled, including the fabric. The gate fabric and wire ties used on the gate shall match the adjacent fence fabric and be subjected to the same quality requirements.

TABLE 1
Fence Fabric

Type	Nominal Diameter of Zinc-Coated Wire mm	Minimum Weight of Galvanized Coating g/m²	Nominal Diameter of Vinyl-Coated Wire mm	Minimum Wire Breaking Strength N	Standard
Class B – Zinc-Coated Galvanized Before Weaving (WGW) Steel Fabric	3.5	488	n/a	5000	CAN/CGSB 138.1
Class D – Vinyl-Coated Steel Fabric	3.5	90	4.26	5000	CAN/CGSB 138.1



MATERIAL SPECIFICATION FOR WOOD, PRESERVATIVE TREATMENT, AND SHOP FABRICATION

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1601.01	SCOPE
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1601.07	PRODUCTION
1601.08	QUALITY ASSURANCE
1601.09	OWNER PURCHASE OF MATERIAL - Not Used

APPENDICES

1601-A	Commentary

1601.01 SCOPE

This specification covers the requirements for wood used in permanent and temporary structures and posts for signs, highway fence, and guide rail.

1601.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1601.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1601.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

O56-M79 (R2006)	Round Wood Piles (Metric Version)
O80 Series-97 (R2002)	Wood Preservation
O122-06	Structural Glued-Laminated Timber
O141-05	Softwood Lumber
O177-06	Qualification Code for Manufacturers of Structural Glued-Laminated Timber

American Wood-Preservers Association (AWPA)

P1/P13-06	Creosote Preservative
P5-06	Waterborne Preservatives

Others

National Lumber Grades Authority (NLGA):
Standard Grading Rules for Canadian Lumber, 2005

1601.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Check means separation of the wood along the grain, the greater part of which occurs across the rings of annual growth. When the depth of a check exceeds half the thickness of the member, it shall be deemed a split.

Decay means a disintegration of the wood substance due to the action of wood-destroying fungi that causes the wood to become unsound. Also known as dote or rot.

Dressed Wood means wood that is surfaced by a planing machine to attain a standard of smoothness and uniformity of size.

Glued-Laminated Wood means a structural wood member produced by gluing together a number of wood pieces according to CSA O122.

Grade means the designation of the size or quality of a piece of wood according to the NLGA Standard Grading Rules for Canadian Lumber.

New Wood means wood that is free from deterioration such as that caused by decay, chemical or insect attack, or physical damage and has not been remanufactured since the time of its original grading.

Preservative Treatment means a pressure process that impregnates wood with toxic agents to prevent decay and insect attack.

Shake means a lengthwise separation of the wood that occurs between or through the rings of annual growth.

Short Crook means a localized deviation from straightness that is more than half the mean diameter of the crooked section within any section five feet or less in length.

Species means the tree source from which the wood was taken.

Split means a lengthwise separation of the wood due to the tearing apart of the wood cells that usually extends from surface to surface of a wooden pile.

Sweep means the deviation of a post from straightness.

Used Wood means wood other than that defined as new wood.

Wane means bark or lack of wood from any cause on the edge or corner of a piece of lumber.

Wood means that generic term covering all wood including glued-laminated members.

1601.05

MATERIALS

1601.05.01

General

All wood in permanent structures shall be new and shall be according to the grade, species, size, and surface finish as specified in the Contract Documents. All sizes of sawn wood shall be dressed sizes.

1601.05.02 Wood for Highway Fence, Cable Guide Rail, and Delineator Posts

Round wooden posts for highway fence, cable guide rail, and delineators shall be Eastern White Cedar, Jack Pine, Red Pine, or Southern Yellow Pine. Allowable defects shall be according to CAN3/CSA O56M, except that the posts shall be free from loose or unsound knots, short crooks, reverse sweep, shakes, decay, and checks that exceed 6 mm in width. Posts having a sweep exceeding 2% of the length of the post shall be rejected.

1601.05.03 Wood for Steel Beam Guide Rail and Sign Posts

Wooden posts and wooden offset blocks for steel beam guide rail shall be Jack Pine, Red Pine, or Southern Yellow Pine.

Wooden posts for signs shall be Jack Pine, Red Pine, Western Red Cedar, Lodgepole, or Ponderosa Pine.

Except for maximum allowable wane, posts and blocks for steel beam guide rail and posts for signs shall be No. 1 Grade - Structural Posts and Timbers graded according to the NLGA Standard Grading Rules for Canadian Lumber.

Wane on blocks and on the portion of posts to be set above ground shall not exceed a total width of 25 mm on any one face. Wane on the lower 1.2 m or on the portion of posts to be set below ground shall not exceed a total width of 60 mm on any one face. The total width of wane on any face shall be determined by deducting the portion of the face that is entirely free from wane from the minimum permissible dimension as specified in the Contract Documents.

1601.05.04 Round Wooden Piles

Wooden piles shall be cleaned and peeled and according to CAN3/CSA O56M.

1601.05.05 Structural Glued-Laminated Wood

Structural glued-laminated wood shall be according to CSA O122 and shall be produced by a manufacturer certified according to CSA O177.

1601.05.06 Preservatives

Preservatives shall be according to CSA O80 Series and shall be selected from the following:

- a) Creosote shall be according to AWP A P1.
- b) Pentachlorophenol in Type A hydrocarbon solvent. The mixture shall be not less than 5% pentachlorophenol and petroleum solvent.
- c) Chromated Copper Arsenate (CCA) shall be according to AWP A P5, Type A, B, or C.
- d) Ammoniacal Copper Arsenate (ACA) shall be according to AWP A P5.
- e) Alkaline Copper Quaternary (ACQ) shall be according to AWP A P5.

1601.05.07 Painting of Preservative Treated Wood

Only waterborne preservatives CCA or ACA shall be permitted for use on wood that is to be painted.

1601.05.08 Marking of Wood for Identification

All wood shall be marked using a grade stamp of an association or independent grading agency according to CAN/CSA O141.

1601.05.09 Marking of Wood for Identification of Preservative Treatment

All wood with preservative treatment shall be marked using a certification mark authorized by the Canadian Wood Preservers Bureau (CWPB).

1601.05.10 Certificates of Compliance

1601.05.10.01 Identification of Wood

When the grade stamp is obscured or is nonexistent, the following certificates shall be provided by the fabricator:

- a) Verification of compliance with grade and species by an agency approved by the Canadian Lumber Standards Accreditation Board (CLSAB).
- b) Verification that all structural glued-laminated wood has been produced by a certified manufacturer.

1601.05.10.02 Preservative Treatment

When the certification mark is obscured or is nonexistent, a certificate shall be provided by the fabricator verifying that the material was treated at a plant authorized by the CWPB.

1601.05.11 Used Wood

Used wood shall not be used as posts for delineator, steel beam guide rail, or cable guide rail installations.

Used wood shall be permitted for use in temporary structures, provided that the wood is of known history and the grade and species are identifiable. The wood shall be the stress level for new wood of the same grade and species, provided that the previous use has not damaged the wood in such a way that the grade requirements are no longer met. Where wood has been damaged, has deteriorated due to decay or to chemical or insect attack, or its planned use is in a structure to which the public has access, the wood shall not be used, unless it is regraded by a grading agency approved by CLSAB.

1601.07 PRODUCTION

1601.07.01 Preservative Treatment

Preservative treatment shall be according to CSA O80 Series.

All wood for permanent applications shall be pressure preservative treated except Eastern White Cedar for cable guide rail posts, guide posts, delineator posts, and highway fence posts and Western Red Cedar for sign posts.

All wood, except cedar posts, in temporary structures with an intended service life exceeding one year shall be pressure preservative treated.

Wood treated using oil borne preservatives shall be subjected to a vacuum expansion bath at a treatment plant according to CSA O80 Series to produce a material that is free of excessive surface oil. Wood treated using water borne preservatives shall have an average moisture content not exceeding 25% at 25 mm depth below the surface prior to preservative treatment.

1601.07.02 Shop Fabrication

Cutting, framing, drilling, and grooving of wood shall be performed prior to preservative treatment.

1601.07.03 Handling, Storage and Care of Wood

Handling and storage of wood shall be according to CSA O80 Series.

Wood shall be kept free of dirt and stored in a location that will not create an excessive increase in temperature through the green house effect resulting in rapid drying of the material. Wood shall be stored in a manner that will prevent ponding or trapping of excess moisture between surfaces where it cannot dry readily.

When oil treatment is used, the wood shall be given three coats of creosote oil to repair all cuts, abrasions, and holes made after the initial pressure preservative treatment. Each coat shall be dry before the next coat is applied.

Repair of cuts, abrasions, and holes in material treated with water-borne preservatives shall be according to CSA O80 Series.

1601.07.04 Quality Control - Wood Preservation

The wood preserving plant shall use quality control procedures according to CSA O80 Series.

1601.07.05 Tolerances

1601.07.05.01 Dimensions

The following tolerances shall apply:

Diameter of round wooden posts for highway fence, cable guide rail, and delineator posts	± 10 mm
Diameter of other round wooden posts	± 6 mm
Dressed cross-sectional dimensions	± 2 mm
Length	± 10 mm

1601.07.05.02 Splits and Checks

Splits and checks in all treated wood shall not exceed the following limits:

Cedar and Treated Posts

- a) The width of splits and checks at the surface shall not exceed 10 mm, regardless of their length or depth.
- b) The depth of splits or checks shall not exceed the depth of 40% of the post diameter or thickness, regardless of their length or width.

Other Treated Wood

- a) The width of splits and checks at the surface shall not exceed 6 mm.
- b) Splits shall not exceed in length any of the following:
 - i. Twice the member thickness.
 - ii. One and one half times the member width.
 - iii. One quarter of the member length.

1601.08 QUALITY ASSURANCE

1601.08.01 Inspection

The quality of all materials and finished products shall be subject to inspection and approval by the Owner. The manufacturer shall afford the Owner all reasonable facilities and access to ensure that the wood products furnished are according to this specification.

Appendix 1601-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



MATERIAL SPECIFICATION FOR EXTRUDED EXPANDED POLYSTYRENE PAVEMENT INSULATION

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1605.01 SCOPE

This specification covers extruded expanded polystyrene for use as pavement insulation for frost heave treatment of pavements.

1605.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Underwriters Laboratories of Canada (ULC)

CAN/ULC S701-11 Thermal Insulation, Polystyrene, Boards and Pipe Covering

1605.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Extruded Expanded Polystyrene Pavement Insulation means insulation in the form of rigid boards made by extrusion of expanded polystyrene beads.

Production Lot means the quantity of insulation boards produced in a continuous period of manufacturing the same grade and thickness of product within the same production day.

Truckload means a truck, including trailer, loaded with rigid insulation boards.

1605.05 MATERIALS

The extruded expanded polystyrene boards shall be according to the requirements of CAN/ULC S701, Type 4, with the exception of the compressive strength.

The minimum compressive strength for each grade shall be according to Table 1.

1605.07 PRODUCTION

Each board of the same production lot shall be stamped with the same production code showing plant identification, type, grade, and date of production (i.e., yyyy-mm-dd).

1605.08 QUALITY ASSURANCE

1605.08.01 Certificate of Compliance

Test certificates for each production lot supplied showing compliance with all requirements of this specification shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.

1605.08.02 Sampling

One board from each production lot on each truckload shall be selected at random by the Contract Administrator when the material arrives at the job site. The samples shall be tested by a laboratory designated by the Owner for compliance with this specification.

1605.08.03 Testing

All test procedures shall be according to CAN/ULC S701.

The compressive strength shall be the average of 5 specimens taken at different places across the width of the board and determined on the face perpendicular to the extrusion plane.

1605.08.04 Acceptance or Rejection

Failure of any one of the sample boards to comply with any requirement of this specification shall be cause for rejection of the production lot from which it was taken. Culling of the rejected material by the Contractor shall be permitted and a proposal for retesting the remaining material shall be submitted to the Contract Administrator to demonstrate conformance with the specification. Retesting of material remaining from culling rejected material shall be at no cost to the Owner.

TABLE 1
Minimum Compressive Strength

Grade	Minimum Compressive Strength, kPa at 5% Deflection or Yield
A	275
B	400
C	690



**MATERIAL SPECIFICATION FOR
PAINT COATING SYSTEMS FOR STRUCTURAL STEEL**

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APPENDICES

1704-A	Commentary

1704.01 SCOPE

This specification covers the material requirements of paint coating systems for structural steel. It also covers the procedure to be followed for initial approval and subsequent acceptance testing of paint coatings and paint coating systems.

1704.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1704.01.02

Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1704.02

REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 911 Coating Structural Steel Systems

ASTM International

A 123/A123M-12	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
B 117-11	Standard Practice for Operating Salt Spray (Fog) Apparatus
D 523-14	Standard Test Method for Specular Gloss
D 562-10	Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using the Stormer-Type Viscometer
D 609-00 (2012)	Standard Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products
D 610-08 (2012)	Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
D 660-93 (2011)	Standard Test Method for Evaluating Degree of Checking of Exterior Paints
D 661-93 (2011)	Standard Test Method for Evaluating Degree of Cracking of Exterior Paints
D 714-02 (2009)	Standard Test Method for Evaluating Degree of Blistering of Paints
D 772-86(2011)	Standard Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
D 1210-05 (2010)	Standard Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage
D 1475-13	Standard test Method for Density of Liquid Coatings, Inks, and Related Products
D1640 -03(2009)	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature

D 1654-08	Standard test method for Evaluation of Painted or Coated Specimens subjected to Corrosive environment
D 2369-10e1	Standard Test Method for Volatile Content of Coatings
D 2371-85(2010)	Standard Test Method for Pigment Content of Solvent-Reducible Paints
D 2621-87(2011)	Standard Test Method for Infrared Identification of Vehicle Solids From Solvent-Reducible Paints
D 3271-87(2012)	Standard Practice for Direct Injection of Solvent-Reducible Paints Into a Gas Chromatograph for Solvent Analysis
D 3723-05(2011)	Standard Test Method for Pigment Content of Water-Emulsion Paints by Low-Temperature Ashing
D 3960-05(2013)	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paint and Related Coatings
D 4214-07	Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
D 4400-99(2012)e1	Standard Test Method for Sag Resistance of Paints Using a Multinotch Applicator
D 4451-02(2008)	Standard Test Method for Pigment Content of Paints by Low-Temperature Ashing
D 4541-09e1	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
D 4587-11	Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings
D 5894-10	Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
D 6386-10	Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
E 1347-06 (2011)	Standard Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry

ASTM International Manual Series: MNL 17

Paint and Coating Testing Manual, 15th Edition, 2012

The Society for Protective Coatings (SSPC)

Good Painting Practice, SSPC Painting Manual, Volume 1, 4th Edition, 2002

SP 3-82 (2004) Power Tool Cleaning

VIS 1-02 Visual Standard for Abrasive Blast Cleaned Steel

VIS 3-93(2004) Visual Standard for Power and Hand Tool Cleaned Steel

SSPC and National Association of Corrosion Engineers (NACE) Joint Publications

SP 5 / NACE No. 1, Jan 2007 White Metal Blast Cleaning

SP 10 / NACE No. 2, September 2000 Near-White Blast Cleaning

SSPC, American Welding Society (AWS) and NACE Joint Publications

SSPC-CS 23.00 / AWS C2.23M/NACE No.12-2003 Application of Thermal Spray Coatings (metalizing) of Aluminum, Zinc, and Their Alloys and Composites for Corrosion Protection of Steel

Others

U.S. General Services Administration:
Federal Standard 595C Colors, 2008

1704.03 DEFINITIONS

For the purpose of this specification, the definitions in the SSPC, Good Painting Practice Manual Volume 1, 4th Edition; and the following definitions apply:

Coating System means as defined in OPSS 911.

Low Volatile Organic Coating Material means coating material that contains not more than 340 g/L of volatile organic compounds (VOC) when tested according to ASTM D 3960.

Marginally Prepared Surface means a steel surface prepared by power tool cleaning according to SSPC-SP 3.

Paint Coating means as defined in OPSS 911.

Paint Coating System means as defined in OPSS 911.

Pot Life means the length of time a multi-component material is usable after all the components are mixed in the recommended portions.

Seal Coat means as defined in OPSS 911.

Structural Steel means as defined in OPSS 911.

Target Value means the value of various properties listed in OPSF 1704-1 submitted by the supplier with the initial submission of material samples for coating system approval.

1704.04 DESIGN AND SUBMISSION REQUIREMENTS

1704.04.01 Submissions Requirements

1704.04.01.01 Paint Coatings and Paint Coating System Approval

The supplier shall provide samples and a completed OPSF 1704-1 for each component of the paint coating system for approval and material acceptance testing. The sample shall be accompanied by the manufacturer's instructions for use; material safety data sheets; and material information, including documentation on laboratory and field tests carried out to establish the pot life; physical characteristics; and chemical composition as shown in OPSF 1704-1.

1704.05 MATERIALS

1704.05.01 Coating Material

1704.05.01.01 General

The requirements of the paint coating shall be according to the following:

- a) The concentration of lead in the dry film of each coating shall not exceed 0.01% or 100 ppm.
- b) The components shall be homogenous, well-dispersed to a uniform consistency and, when mixed according to manufacturer's instructions, shall be suitable for application by spray equipment.
- c) Each paint coating shall be a low VOC material.
- d) Zinc-rich touch up paint shall contain not less than 87% of zinc by mass of non-volatile matter.

- e) The paint coating system for marginally prepared surfaces shall be suitable for application over existing coatings of alkyd, vinyl, and currently approved low VOC paint coating systems.

1704.05.01.02 Colour

The prime coat shall be of such a colour as to assist the applicator in distinguishing between primed areas and the uncoated cleaned steel or other prepared surfaces.

Each coat shall be formulated to show a distinct colour difference. With the exception of coal tar epoxies, the colour of the finish coat shall be equivalent to 10045 brown for Atmospheric Corrosion Resistant steel, and a colour equivalent to 16307 grey for all other steels, both according to Federal Standard 595C Colors.

1704.05.01.03 Application Requirements

When applied according to the manufacturer's instructions and to the manufacturer's specified thickness, the paint coating shall show good levelling with no runs, sags, or mud cracks. Applied coatings shall have no pin-holes, holidays, bubbles, or craters.

Each coat shall be capable of application by spray, brush, or roller for a temperature range of 5 to 35 °C, without thinning.

After the components have been combined, multiple component paint coating shall have a minimum pot life of 3 hours at 25 °C.

1704.05.01.03.01 Two-Coat Zinc Rich Rapid Deployment Coating System

In order to qualify as a primer for a rapid deployment coating system, zinc rich coating material shall cure or dry sufficiently to be top coated within 3 hours at 15 °C when applied at a wet film thickness required for a DFT of 100 µm.

The coatings to be used as the top coat material shall cure or dry to touch within 4 hours when applied at a wet film thickness required for a DFT of 125 µm.

1704.05.01.04 Performance Requirements

1704.05.01.04.01 General

The entire coating system shall be tested on test panels for adhesion, weathering resistance, and corrosion resistance performance. Testing shall be as shown in Table 1.

1704.05.01.04.02 Accelerated Weathering

After 5,000 hours of exposure, the coating system on the test panel for abrasive blast cleaned surfaces shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. Chalk rating shall be 7 or higher, and the colour difference shall not exceed 6 units.

After 2,500 hours of exposure, the coating system on the test panel for marginally prepared surfaces shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. Chalk rating shall be 7 or higher and the colour difference shall not exceed 6 units.

After 5,000 hours of exposure, the coating system on the galvanized test panel shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. Chalk rating shall be 7 or higher and the colour difference shall not exceed 6 units.

After 5,000 hours of exposure, the coating system on the metallized test panel shall exhibit none of the characteristics of the paint failure as described in the chapter "Causes and Prevention of Paint Failure" in SSPC Vol. 1. Chalking shall be 7 or higher, and the colour difference shall not exceed 6 units when measured as shown in Table 1.

1704.05.01.04.03 Cyclic Corrosion Resistance Testing

After 12 cycles of exposure, the coating system on the test panel for abrasive blast cleaned surfaces shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. There shall not be any corrosion, except along the score lines. The average value of the rust creepage of all the scored panels tested shall not be more than 4 mm. However, the rust creepage on any individual panel may exceed 4.0 mm, but shall be below 5.0 mm. Chalk rating shall be 7 or higher and the colour difference shall not exceed 6 units.

After 6 cycles of exposure, the coating system on the test panel for marginally prepared surfaces shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. There shall not be any corrosion, except along the score lines. The average value of the rust creepage of all the scored panels tested shall not be more than 4 mm. However, the rust creepage on any individual panel may exceed 4.0 mm, but shall be below 5.0 mm. Chalk rating shall be 7 or higher and the colour difference shall not exceed 6 units.

After 12 cycles of exposure, the coating system on the galvanized test panel shall exhibit none of the characteristics of the paint failure as described in the Coating Failures chapter of the SSPC Good Painting Practice Manual, except for characteristics noted below. There shall not be any corrosion, except along the score lines. The average value of the rust creepage of all the scored panels tested shall not be more than 4 mm. However, the rust creepage on any individual panel may exceed 4.0 mm, but shall be below 5.0 mm. Chalk rating shall be 7 or higher and the colour difference shall not exceed 6 units.

After 12 cycles of exposure, the seal coatings on the metallized test panel shall exhibit none of the characteristics of the paint failure as described in the chapter "Causes and Prevention of Paint Failure" in SSPC Vol. 1. There shall not be any corrosion, except along the score lines where the total width of rust creepage shall not be more than 1.0 mm. Chalking shall be 7 or higher and the colour difference shall not exceed 6 units when measured as shown in Table 1.

1704.05.01.04.04 Salt Spray Resistance Testing

Salt spray resistance testing of zinc-rich touch up paint coated test panels shall be conducted according to ASTM B117 for 720 hours. There shall not be any corrosion, except along the score lines where the total width of rust creepage shall not be more than 1.00mm.

1704.05.01.05 Recoat Time

At an ambient temperature of 23 °C and a relative humidity of 80%, a paint coating shall dry or cure sufficiently to receive the next coat satisfactorily within 16 hours of application. It shall remain recoatable for a minimum of 30 Days.

1704.07 PRODUCTION

1704.07.01 Quality Control

1704.07.01.01 Physical Tests and Paint Coating Composition

The results for physical tests and paint coating composition of production batches shall be within the tolerances as shown in Table 2, when the results of testing are compared to the respective test results of the sample submitted for the coating system approval.

1704.07.01.02 Chemical Analysis

When the product from production batches of paint coatings is analyzed for chemical composition, the test results shall not vary by more than:

- a) $\pm$ 5% from the value of the original submission, if the amount of ingredient is greater than 50% by weight of the product.
- b) $\pm$ 10% from the value of the original submission, if the amount of the ingredient is from 5 to 50% by weight of the product.

1704.07.01.03 Infrared Analysis

The infrared spectrum of the product or any product fraction of production batches of paint coatings shall match the corresponding spectrum from the sample submitted for coating system approval.

1704.07.01.04 Gas Chromatogram of Volatiles

The gas chromatogram of production batches of paint coatings shall show the identical volatile components present in the same proportions as in the sample submitted for coating system approval.

1704.07.01.05 Colour Difference

Colour difference of production batches of paint coatings shall be within the tolerances as shown in Table 2. The reference colour for the finish coat shall be the appropriate colour specified in the Material section. For all other coats, the reference colour shall be the colour of the sample submitted for paint coating system approval.

1704.07.02 Packaging and Delivery

The paint shall be delivered in the manufacturer's originally sealed containers.

Containers shall be leak-free and constructed so that the contents can be thoroughly and completely mixed. They shall be provided with triple-tight lids. Containers 4 litres or larger shall have wire bail handles.

Each container and shipping case shall be marked to show the following information:

- a) Identification of the paint coating system.
- b) The contents of container (i.e., prime coat, second coat, third coat, or fourth coat).
- c) The colour and colour code.
- d) The manufacturer's name and address.

- e) The quantity of the contents in litres.
- f) The date of filling the container (i.e., yyyy-mm-dd).
- g) The manufacturer's code and coating batch numbers.

The markings shall be permanent and the coating batch number shall be prominently displayed.

1704.07.02.01 Certificate of Compliance

A certificate of compliance from the manufacturer indicating that the physical properties and chemical composition of the material supplied complies with the requirements of this specification shall be included with each shipment of paint.

1704.08 QUALITY ASSURANCE

1704.08.01 Test Panels

1704.08.01.01 Testing General

For the following tests, the number of panels specified below shall be made for the paint coating system being evaluated and the panels for the approved paint coating system to be used for reference purposes during paint coating operations.

1704.08.01.02 Weathering Resistance and Corrosion Resistance Testing

1704.08.01.02.01 Panel Preparation

1704.08.01.02.01.01 Abrasive Blast Cleaned Surfaces

Panels shall be cold-rolled carbon steel according to ASTM D 609, measuring 75 x 150 x 2.6 mm with rounded edges. Panels shall be blast cleaned to the requirements of SP 10/NACE NO. 2. The pictorial standards as shown in SSPC-VIS 1 shall be used to check conformance of the panel preparation in conjunction with SP 10/NACE NO. 2. The height of the surface profile shall be a minimum of 25 µm and a maximum of 75 µm.

1704.08.01.02.01.02 Marginally Prepared Surfaces

The panels shall be prepared as specified in the Abrasive Blast Cleaned Surfaces clause and then be subjected to 72 hours of salt spray according to ASTM B 117, after which, the rusted panels shall be power-tool cleaned to SSPC SP 3 condition by power wire brush. The pictorial standards as shown in SSPC-VIS 3 shall be used to check conformance of the panel preparation in conjunction with SSPC SP3.

1704.08.01.02.01.03 Paint Coating on Galvanized Surfaces

As the first step, cold-rolled carbon steel panels, measuring 75 x 150 x 5 mm with rounded edges shall be hot dip galvanized according to ASTM A123/A123M. Galvanized panel surfaces shall then be prepared according to ASTM D 6386. Thick edges due to excess zinc run-off, high spots, and rough edges shall be removed by power tools. Surface preparation shall be performed by sweep blasting to roughen the surface using an abrasive of a hardness that does not damage the galvanized coating.

1704.08.01.02.01.04 Seal Coating on Metallized Surfaces

As the first step, cold-rolled carbon steel panels measuring 75 mm x 150 mm x 2.6 mm, and shall be blast cleaned to the requirements of SP5/NACE NO. 1. The height of the surface profile shall be a minimum of 50 µm and a maximum of 75 µm. The blast cleaned panels shall then be coated on both surfaces and the edges with 85% zinc / 15% aluminum alloy by thermal metal spraying according to SSPC-CS 23.00 / AWS C2.23M/NACE No.12. The dry film thickness of the metallized coating shall be between 75 µm and 110 µm. The metallized panels shall be vacuum sealed or stored in a vacuum desiccator to prevent oxidation until the seal coat material is ready to be spray applied.

1704.08.01.02.02 Paint Coating and Seal Coating Application

The paint coating system shall be spray applied on both faces of the prepared test panels according to the manufacturer's recommendations and to the manufacturer's recommended thickness. When the painted faces are hard dry, the edges of the panels shall be covered with the same coating applied by brush. After the final coat, the panels shall be dried and cured for 7 Days prior to any further handling.

The coating on the panels intended for scoring shall be scored according to ASTM D1654.

1704.08.01.02.03 Test Method for Accelerated Weathering

Test panels shall be prepared and coated as specified in the Panel Preparation clause and the Paint Coating and Seal Coating Application clause.

Seven unscored panels shall be prepared for each cleaning requirement for each coating system. One panel from each set shall be set aside as reference for comparison purposes. The other panels from each set shall undergo exposure testing as shown in Table 1. Evaluation shall be done at 500 hour intervals of exposure to the maximum of 5,000 hours for coating systems on abrasive blast cleaned surfaces and galvanized surfaces, seal coating on metallized surfaces, and 2,500 hours for coatings on marginally prepared surfaces.

1704.08.01.02.04 Test Method for Cyclic Corrosion Resistance of Coatings

Test panels shall be prepared, coated, and scored as specified in the Panel Preparation clause and the Paint Coating and Seal Coating Application clause.

Eleven panels shall be prepared for each cleaning requirement for each coating system. One panel from each set shall be set aside as reference for comparison purposes. The other panels, 5 unscored and 5 scored from each set, shall undergo exposure testing as shown in Table 1. Evaluation shall be done after each cycle of exposure. At the completion of testing, the coating between the score lines on the bottom half of the scored panels shall be stripped and the mean rust creepage in millimetres for each panel shall be determined according to ASTM D 1654. The average rust creepage shall be calculated from the mean rust creepage values of the individual panels of the respective paint system.

1704.08.02 Coating System Approval

1704.08.02.01 General

Approval shall only be given for a complete paint coating system and for paint coating to be used as a seal coat for thermal spray metal coating.

Testing shall be performed by the Owner or by an independent laboratory chosen by the Owner.

When an independent laboratory is used, the paint manufacturer shall arrange for testing by the independent laboratory. The independent laboratory shall obtain samples of the approved paint coating and paint coating system to be used for comparison purposes from the Owner.

1704.08.02.02 Testing by Owner

When testing is carried out by the Owner for initial approval, the supplier shall be notified of the sample size, date, labelling, and other details regarding submission of samples, including cost.

1704.08.02.03 Testing for Coating System Approval and Approval of Subsequent Batches

The initial submission shall be evaluated for approval based on the requirements specified in the Materials section, using the testing methods as shown in Tables 1 and 2, and the data submitted on the completed OPSF 1704-1.

For comparison, an approved system from the Owner's list of approved coatings shall be subjected to the tests for accelerated weathering and cyclic corrosion resistance concurrently with the system under evaluation. Where possible, coatings of the same generic type shall be used for comparison.

When the testing is done by the approved independent laboratory, the Owner shall review the test results and may repeat any of the tests.

Subsequent batches of material shall be tested for acceptance as specified in the Quality Assurance section.

1704.08.02.05 Acceptance or Rejection

1704.08.02.05.01 Initial Approval

Approval shall only be given to paint coatings and paint coating systems satisfying the requirements of the Materials section.

1704.08.03 Sampling at Work Site

Samples of material for quality assurance testing shall be taken by the Owner from material delivered to the work site.

1704.08.03.01 Acceptance or Rejection on Site

Testing shall be done by the Owner according to the methods as shown in Table 2.

Acceptance shall be based on the testing requirements and allowable tolerances as shown in Table 2, when compared to the results of the testing conducted by the Owner on the initially approved material.

Failure to conform to the requirements of the Material section and the tolerances as shown in Table 2, changes made in the formulation after approval, inability to maintain production quality, and unsatisfactory field performance of paint coatings or paint coating systems shall be a cause for rejection.

TABLE 1
Performance Tests for Paint Coating Systems

Type of Test	ASTM Method	Requirements
Pull-Off Adhesion	D 4541	2.75 MPa minimum
Accelerated Weathering using Fluorescent UV - Condensation Light- and Water-Exposure Apparatus for evaluation of: Paint coating system on abrasive blast cleaned test panels Paint coating systems on hot dip galvanized test panels Seal coating on metallized test panels Paint coating system on marginally prepared test panels	D 4587 Test Condition D	Exposed to: 5,000 hours maximum 5,000 hours maximum 5,000 hours maximum 2,500 hours maximum
Cyclic Corrosion Resistance Testing by Alternating Exposures in a UV/Condensation Cabinet and a Salt Fog/Dry Cabinet for evaluation of: Paint coating system on abrasive blast cleaned test panels Paint coating systems on hot dip galvanized test panels Seal coating on metallized test panels Paint coating system on marginally prepared test panels	D 5894	Exposed to: 12 cycles maximum (Note 1) 12 cycles maximum (Note 1) 12 cycles maximum (Note 1) 6 cycles maximum (Note 1)
Evaluation of Test Panels After Accelerated Weathering Test / Cyclic Corrosion Resistance Test for: Gloss Colour Difference (ΔE) Chalking Checking Cracking Flaking Blistering Rusting Rust Creepage	D 523 E 1347 D 4214 D 660 D 661 D 772 D 714 D 610 D 1654	Test Method for Accelerated Weathering and the Test Method for Cyclic Corrosion Resistance of Coatings clauses (Note 2)
Notes: 1. One cycle represents a total exposure of 336 hours which comprises 168 hours or 1 week of exposure of test panels in the fluorescent UV condensation cabinet, followed by 168 hours of exposure of the test panels in the cyclic salt fog or dry exposure cabinet. 2. Clauses in this specification.		

TABLE 2
Test Methods for Physical Testing and Compositional Analysis of Paint Coatings
and Acceptance Criteria for Field Samples and Production Batches

	ASTM	Acceptance Criteria (Note 1)	
		Tolerance (Note 2)	Others
Physical Tests on Mixed Coating:			
Density	D 1475	5%	-
Consistency, Krieb Units (KU)	D 562	± 10 or 25% (Note 3)	-
Dry Time:			
To Touch	D1640	± 30%	-
Hard Dry	D1640	± 30%	-
Hiding Power Determination Using Pfund Black and White Cryptometer	Paint and Coating Testing Manual	± 1.5 (Note 4)	-
Skimming	-	-	-
Fineness of Grind, Hegman Units (HU)	D 1210	± 2	-
Sag Resistance	D 4400	± 20%	-
Coating Composition:			
Pigment Content by % mass	D 4451, D 2371, D 3723	± 5%	-
Vehicle Solids Content by % mass @ 24 hours	-	± 5%	-
Volatile Content by % mass @ 2 hours and 24 hours	D 2369	± 5%	-
Pigment Composition by Chemical and Instrumental Analysis	-	-	Chemical Analysis clause (Note 5)
VOC Content	D 3960	± 10% but the total not exceeding 340 g/L (Note 6)	-
Vehicle Solids Identification by Infrared Analysis	D 2621	-	Infrared Analysis clause (Note 5)
Determination of Paint Volatiles Composition by Gas Chromatography	D 3271	-	Gas Chromatogram of Volatiles clause (Note 5)
Determination of Thinner Composition by Gas Chromatography	D 3271	-	Gas Chromatogram of Volatiles clause (Note 5)
Tests on Cured Paint Coating:			
Gloss	D 523	± 30%	-
Colour Difference (ΔE)	E 1347	± 4 units	-
IR Fingerprinting	Paint and Coating Testing Manual	-	Infrared Analysis clause (Note 5)
Notes:			
1. Acceptance criteria for field samples and production batches. 2. Allowable tolerance for field samples or production batches based on the Owner's test results for the initially approved paint coating material. 3. Whichever is less. 4. Pfund black and white cryptometer, wedge #3.5. 5. Clause in this specification. 6. VOC content of Zinc -rich touch up paint shall not exceed 500g/L.			

PAINT COATING DATA FORM

A. MANUFACTURER INFORMATION

Name:
Address:
Telephone:
Fax:
Email:

B. SAMPLE IDENTIFICATION

Manufacturer's Code No.:	Coating Batch No.:
Colour of Coating:	Production Date:

C. TEST DATA OF MIXED COATING

	Test Method	Manufacturer's Test Results
Density, kg/L	ASTM D 1475	
VOC, g/L	ASTM D 3960	
Viscosity, KU	ASTM D 562	
Pot Life, hours @ 25 °C	Manufacturer's Procedure	
Sag Resistance, mm	ASTM D 4400	
Dry Time, hours @ 25 °C		
To touch	ASTM D1640	
Hard dry	ASTM D1640	

D. COMPOSITION OF MIXED COATING

	Test Method	% by Mass
Pigment and Fillers	ASTM D 2371, D 4451, D 3723	
Non Volatile	-	
Volatile	ASTM D 2369	

E. COMPOSITION OF PIGMENTS AND FILLERS IN EACH COMPONENT % BY MASS - List % lead to three decimal places

	Component A	%	Component B	%	Component C	%
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

F. PAINT VOLATILE COMPOSITION BY GAS CHROMATOGRAPHY - Attach chromatogram with peaks identified

	Chemical Name	%
1		
2		
3		
4		
5		

G. COMPOSITION OF THINNER BY GAS CHROMATOGRAPHY - Attach chromatogram with peaks identified

	Chemical Name	%
1		
2		
3		
4		
5		

H. VEHICLE SOLIDS IDENTIFICATION by Infrared Analysis - Attach spectrum with major peaks identified

I. MIXING RATIO OF COMPONENTS A, B, and C by weight _____

J. IR FINGERPRINT OF MIXED, CURED COATING - Attach Spectrum with major peaks identified

OPSF 1704-1

Appendix 1704-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



Note: The PROV implemented in July 2023 replaces OPSS 1712 COMMON, February 1991 with no technical content changes.

MATERIAL SPECIFICATION FOR ORGANIC SOLVENT BASED TRAFFIC PAINT

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1712.01	SCOPE

This specification covers the requirements for organic solvent based traffic paint which is suitable for application onto concrete and bituminous pavements.

1712.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1750 Traffic Paint Reflectoring Glass Beads

Canadian General Standards Board

CGSB-1-GP-12C-1983 Standard Paint Colours
CGSB-1-GP-71-1983 Testing Paints and Pigments:

American Society for Testing and Materials

D185-84 Coarse Particles in Pigments, Pastes and Paints
D562-81 (1985) Consistency of Paints Using the Stormer Viscometer.

D711-84	No Pick-Up Time of Traffic Paint
D713-87	Conducting Road Service Tests on Traffic Paint
D868-85	Evaluating Degree of Bleeding of Traffic Paint
D869-85	Evaluating Degree of Settling of Traffic Paint
D969-85	Degree of Bleeding of Traffic Paint
D2205-85	Traffic Paints
D2244-85	Calculation of Colour Differences from Instrumentally Measured Colour Coordinates
E97-82 (1987)	Test Method for 45-deg., 0-deg., Directional Reflectance Factor of Opaque Specimens by Broad-Band Filter
E303-83	Measuring Surface Frictional Properties Using the British Pendulum Tester

United States Federal Standard

U.S. FED-STD-595B Colours Used in Government Dec. 15, 1989 Procurement

International Commission on Illumination

CIE 1976 L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation

1712.03 DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

Compliance Certification means the procedure and requirements for establishing an approved source for materials.

Fingerprinting means the testing of organic solvent based traffic paint by gas chromatographic and infrared spectroscopic techniques for verification purposes.

No Tracking Time means the time required for a newly applied pavement marking line to show no visible deposition of the material to the pavement surface, outside the line when viewed from a distance of 15 metres, as determined by passing over the applied line at 60 km per hour in a simulated passing maneuver with a passenger car.

Organic Solvent Based Traffic Paint means a traffic paint whose components are carried in an organic solvent system and will form a solid paint film on evaporation of the solvent after application.

Pavement Marking Material means a material formulated for application onto bituminous or concrete pavement in order to delineate vehicle operating limits.

Reflectorization means a material, treatment, or process to enable incident light to be returned in high proportions in the general direction of the light source.

Service Test means the evaluation of pavement marking materials on a test deck and performance rating prior to compliance certification.

Traffic Paint means a paint specifically formulated for use as a pavement marking to delineate vehicle operating limits.

1712.05 MATERIALS

1712.05.01 General

Organic solvent based traffic paint shall be homogeneous and shall be well ground to a uniform smooth consistency. It shall be free from skin, dirt, and other foreign particles and shall be capable of being sprayed at the temperature intended for application. The organic solvent based traffic paint shall flow evenly and smoothly and cover solidly when applied to pavements.

Materials used in the manufacture of the traffic paint shall be of high quality and consistency such that the appearance will not change in service to impair the colour or visibility of the delineation. The organic solvent based traffic paint film shall be flat in finish and be visible under daylight and artificial light with the addition of the overlay glass beads.

1712.05.02 Colour

The organic solvent based traffic paint shall be according to the following colour requirements:

White	-	CGSB 1-GP-12C white 513-301
Yellow	-	Shall match either the yellow traffic paint chip of the Ministry of Transportation, Ontario or U.S. FED-STD-595B, Yellow 33538
Black	-	CGSB 1-GP-12C black 512-301

The tolerance in colour allowed is as follows in CIE L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation when calculated from instrumentally measured colour differences according to ASTM D2244:

White	$L^* = +2$ and -1.5 max $a^* = +1.5$ and -1 max $b^* = +4$ and -4 max
Yellow - MTO	$L^* = +2$ and -1.5 max $a^* = +3$ and -1.5 max $b^* = +7$ and -1.5 max
Yellow - US	$L^* = -2$ and $+4$ max $a^* = -6$ and $+4$ max $b^* = -9$ and $+10$ max

1712.05.03 Chemical Composition

The chemical composition of the organic solvent based traffic paint shall be at the discretion of the paint manufacturer and shall be certified by the Owner.

1712.05.04 ReflectORIZATION

The white and yellow organic solvent based traffic paints shall be used with overlay glass beads which are applied uniformly after application of the paint at a rate as shown below. The white and yellow organic solvent based traffic paints shall provide proper anchorage for overlay glass beads according to OPSS 1750.

Rate of application for overlay glass beads per litre of traffic paint.

% Volume Solids of Traffic Paint	Glass Beads Required in kg
40 - 56	0.7
57 - 70	0.8

Test samples of glass beads according to OPSS 1750 may be obtained from the Owner upon request.

1712.05.05 Physical Property Requirements

Organic solvent based traffic paints shall be supplied ready-mixed for use without any addition of solvents.

The handling and storage qualities must be acceptable with respect to degree of settling, uniform consistency, absence of skinning, and thixotropic properties. The organic solvent based traffic paint shall be capable of being sufficiently atomized to produce an uniformly applied paint stripe without side splatter and overspray within the limitation imposed by conventional striping equipment.

The physical properties of the organic solvent based traffic paints submitted for compliance certification shall be according to Table 1.

Samples are required by the Owner for laboratory testing. The supplier shall submit with each test sample, complete data on physical properties, application procedure, and material safety for the organic solvent based traffic paint.

1712.05.06 Service Test

Organic solvent based traffic paint, according to subsection 1712.05.05 and Table 1 shall be submitted for service test when requested by the Owner.

Organic solvent based traffic paints shall be service tested according to the following:

- a) Test deck location, time, and procedure of application shall be as specified by the Owner.
- b) Test stripe shall be 10 cm in width and applied transversely across the lanes of the road. Application of the organic solvent based traffic paint to a dry thickness of 230 microns $\pm$ 25 microns on bituminous or concrete pavement with about 20,000 AADT and the subsequent application of overlay glass beads according to OPSS 1750, at the approved rate immediately over the yellow and white striped line.
- c) The ease and uniformity of application, severity of overspray, covering properties, and drying time will be evaluated during application.
- d) The applied organic solvent based traffic paint will be inspected periodically and its service performance will be rated by the Owner, as specified in Table 2.
- e) Approval will be given after one year of service rating, providing the material conforms to Table 2 and meets the conditions of subsection 1712.09.02.

1712.07 PRODUCTION

1712.07.01 Plant Inspection

In order to qualify as a supplier of organic solvent based traffic paints, a manufacturer must satisfy the following minimum requirements:

- a) Adequate facilities to produce minimum batches of 3000 litres;

- b) A laboratory sufficiently equipped and staffed to provide a quality control program which will ensure compliance with this specification; and
- c) Properly documented production, sampling, and testing procedures and methods.

1712.07.02 Quality Control

A manufacturer shall be responsible for carrying out a quality control program to ensure that the organic solvent based traffic paints conform to this specification.

1712.08 QUALITY ASSURANCE

1712.08.01 Acceptance Criteria

The Owner may request samples to be taken from the shipments of organic solvent based traffic paints at any time for quality assurance testing. Samples shall be taken from each batch produced for delivery to the Owner. Criteria for accepting each production batch include the following requirements and manufacturing tolerances:

- a) Density shall be within 0.05 kg/L of the value established on the test sample according to CGSB-1-GP-71, Method 2.1.
- b) Viscosity shall be within ± 5 KU of the reference value.
- c) Colour Difference ΔE shall be within ± 1.5 of the value established on the reference sample.
- d) Composition shall not vary by more than $\pm 5\%$, based on fingerprinting and other tests, of the value of the reference sample.
- e) No pickup time of each production batch sample shall be within ± 1.5 minutes of the value established for the test sample according to ASTM D711.
- f) Hiding power with minimum value of 8.4 m²/L.
- g) Bleeding with minimum value of 5.0.
- h) Directional reflectance with:
 - i. Minimum value of 70% white.
 - ii. Minimum value of 50% yellow.

1712.08.02 Quality Control of Production Batches

A one litre sample from each production batch along with test results on density, viscosity at 25 °C and no pickup time shall be delivered to the Owner's laboratory within two days of manufacture of the respective batches.

Delivery records shall be kept by the supplier of the number of containers of each batch shipped to each delivery point and a list of such shipments during each calendar week shall be given to the Owner at the end of each week until the entire order is completed and shipped.

1712.08.03 Storage

The organic solvent based traffic paint shall conform to this specification after storage.

1712.09 OWNER PURCHASE OF MATERIAL

1712.09.01 Trial Batch Application

A trial batch of organic solvent based traffic paints according to this specification may be purchased by the Owner for evaluation of application properties using the Owner's painting equipment. The trial batch shall consist of a minimum quantity of 1,000 litres of organic solvent based traffic paint.

No tracking time will also be determined.

Those organic solvent based traffic paints according to this specification which exhibit satisfactory loading and application properties when used with the Owner's painting equipment will be considered for purchase.

1712.09.02 Certificate of Compliance

The manufacturer shall submit a certificate of compliance with tenders indicating that the physical properties and chemical composition of all of the manufacturer's production batches of traffic paint for the Owner shall conform to this specification and shall not deviate from the allowable tolerances, unless approved by the Owner.

1712.09.03 Delivery and Packaging of Organic Solvent Based Traffic Paint

The delivery schedule, delivery location, colour, type, and quantity shall be as specified on the Owner's purchase order.

The organic solvent based traffic paint shall be furnished in returnable drums with air tight liners.

Each drum shall be clearly marked on the side and the top with weather resistant markings to show the following information:

- a) Manufacturer's name and address.
- b) Type of traffic paint.
- c) Colour.
- d) Manufacturer's code and batch numbers.
- e) Date of filling the drum.
- f) Volume of contents in litres.

A small portion of the organic solvent based traffic paint may be required in twenty-litre containers. The quantity will be specified on the purchase order.

1712.09.04 Measurement and Payment

Measurement of organic solvent based traffic paint shall be by litres.

Payment at the price specified in the purchasing order shall be for the supply of organic solvent based traffic paint.

TABLE 1

**PHYSICAL PROPERTY REQUIREMENTS
FOR ORGANIC SOLVENT BASED TRAFFIC PAINT**

Test and Property	Requirements		Test Methods		
	Min.	Max.	CGSB 1-GP-71	ASTM	Other
Water Content % by mass		0.5	24.1		Pfund cyptometer with #3.5 wedge
Settling 6 months	8.0			D869	
Hiding Power m ² /l	8.4				
Skinning 48 hours	nil	nil	10.1		
Bleeding	5.0			D969 & D868	
Viscosity KU @ 7 °C @ 25 °C	80.0	135.0 90.0	4.5	D562	
Coarse Particles # 60 sieve - 250 µm #100 sieve - 150 µm	nil	nil 0.01		D185 & D2205	
No Pickup Time, mins.		8.0*		D711	
Directional Reflectance % White Paint Yellow Paint	70.0 50.0			E97	
Skid Resistance BPN Units	**			E303	

* For coning type of traffic paints, this value can be higher.

** Values to be established.

TABLE 2

**PERFORMANCE REQUIREMENTS FOR SERVICE TEST AT ABOUT 20,000 AADT
FOR ORGANIC SOLVENT BASED TRAFFIC PAINT**

Property	Performance Requirements					
	Newly Installed Paints	Service Life Ratings of				Test Method
		3 mths	1 yr	1.5 yrs	2 yrs	
Directional Reflectance %						ASTM E-97*
White	≥ 70	≥ 70	≥ 50	≥ 50	≥ 50	
Yellow	≥ 50	≥ 50	≥ 35	≥ 35	≥ 35	
Black	≤ 12	≤ 12				
Retroreflectance mcd/m ² /lux						Instrument Mirolux 12
White	**	**	**	**	**	
Yellow	**	**	**	**	**	
Black	**	**	**	**	**	
No Tracking Time, mins.	≤ 2					
Durability						
White and Yellow		≥ 90	≥ 85	≥ 75	≥ 70	MTO***
Black		≥ 90				
Appearance	10	≥ 8	≥ 7	≥ 6	≥ 5	ASTM D713 & MTO ****

* These values are based on markings placed on a typical asphalt surface.

** Values to be established.

*** Durability is calculated, first by estimating the % wear from the photographs/video images of stripes taken at test sites, and then deducting the value obtained from 100.

**** Rating 1-10; Perfect Score is 10.
Rating made on inspection of the markings by a panel of evaluators from the Owner.

ORGANIC SOLVENT BASED TRAFFIC PAINT DATA FORM

A. MANUFACTURER'S NAME _____
 ADDRESS _____

TELEPHONE NO. _____

B. SAMPLE IDENTIFICATION

Manufacturer's Code No. _____ Paint Batch No. _____
 Colour of Paint _____ Sample Date _____

C. TEST DATA

Density, kg/l	1-GP-71 M2.1	_____
Volatile Matter, %	1-GP-71 M17.1	_____
Water, %	1-GP-71 M24.1	_____
No Pickup Time, minutes	ASTM D711	_____
Hiding Power, m ² /l	Pfund Cryptometer	_____
	OPSS 1712 Table 1	_____
Bleeding, 1-10 rating	ASTM D868/D969	_____
Viscosity, KU	ASTM D562	_____
@ 7 °C		_____
@ 25 °C		_____

D. COMPOSITION OF PAINT

% by Mass

% by Volume

Pigment and Fillers	_____	_____
Non-Volatile	_____	_____
Volatile	_____	_____

Composition of Pigment and Fillers

% by Mass

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Type of Vehicle _____

Type of Thinner _____

Type of Driers _____

E. MATERIAL SAFETY DATA

F. APPLICATION PROCEDURES

Surface Preparation _____

Minimum Pavement Temperature _____

Paint Temperature _____ min °C _____ max °C

Mode of Application _____

Ambient Temperature _____ min °C Relative Humidity _____ max %

NOTE: Above form to be completed and forwarded with paint sample. Samples submitted without a completed Paint Data form will not be considered.



Note: The PROV implemented in July 2023 replaces OPSS 1713 COMMON, February 1991 with no technical content changes.

MATERIAL SPECIFICATION FOR THERMOPLASTIC PAVEMENT MARKING MATERIALS

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1713.07	PRODUCTION
1713.08	QUALITY ASSURANCE
1713.09	OWNER PURCHASE OF MATERIAL
1713.01	SCOPE

This specification covers the requirements for reflectorized thermoplastic pavement marking material that is suitable for application onto bituminous and concrete pavements.

1713.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1750 Traffic Paint Reflectorizing Glass Beads

Canadian General Standards Board

CGSB 1-GP-12C-1983 Standard Paint Colours

American Society for Testing and Materials

ASTM D256-1988 Impact Resistance of Plastics and Electrical Insulating Materials
ASTM D570-81 (1988) Water Absorption of Plastics

ASTM D713-87	Conducting Road Service Tests on Traffic Paint
ASTM D1415-88	Rubber Property - International Hardness
ASTM D2240-86	Rubber Property - Durometer Hardness
ASTM D2244-85	Calculation of Colour Differences from Instrumentally Measured Colour Coordinates
ASTM E28-67(1982)	Softening Point by Ring and Ball Apparatus
ASTM E97-82(1987)	Test Method for 45-deg., 0-deg. Directional Reflectance Factor of Opaque Specimens by Broad-Band Filter
ASTM E303-83	Measuring Surface Frictional Properties Using the British Pendulum Tester

British Standards Institution

BS 3262-1987 Hot-Applied Thermoplastic Road Marking Materials
Part 1, Specification for Constituent Materials and Mixtures
Part 2, Specification for Road Performance
Part 3, Specification for Application of Material to Road Surfaces

United States Federal Standard

U.S. FED-STD-595B, Dec. 15, 1989 Colours Used in Government Procurement

International Commission on Illumination

CIE 1976 L^*, a^*, b^* Uniform Colour Space and Colour Difference Equation

1713.03 DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

Compliance Certification means the procedure and requirements for establishing an approved source for materials.

Fingerprinting means the testing of thermoplastic pavement marking materials by gas chromatographic and infrared spectrosopic techniques for verification purposes.

Hot Applied Thermoplastic Pavement Marking Material means a thermoplastic material that is specifically formulated for hot spray or screed application onto bituminous or concrete pavements to delineate the vehicle operating limits.

No Tracking Time means the time required for a newly applied pavement marking line to show no visible deposition of the material to the pavement surface outside the line when viewed from a distance of 15 metres, as determined by passing over the applied line at 60 km per hour in a simulated passing maneuver with a passenger car.

Pavement Marking Material means a material formulated for application onto bituminous or concrete pavement in order to delineate vehicle operating limits.

Reflectorization means a material, treatment, or process to enable incident light to be returned in high proportions in the general direction of the light source.

Service Test means the evaluation of pavement marking materials on a test deck and performance rating prior to compliance certification.

Thermoplastics means a polymeric plastic material which softens, melts, and flows at elevated temperatures, but forms into a solid material at lower temperatures. This thermal behaviour being reversible is retained on repeated heating and cooling cycles.

1713.05 MATERIALS

1713.05.01 General

The thermoplastic pavement marking material shall not undergo any significant breakdown or deterioration when held at 170 °C for four hours or during four one-hour reheatings to the plastic temperature. The softening point and viscosity characteristics of the plastic material shall remain constant through four reheatings and should be the same from batch to batch.

There shall be no significant change in the colour of the material as the result of up to four reheatings of one hour each, up to a temperature of 170 °C. The material shall be environmentally safe during heating and application. The material shall not deteriorate by contact with sodium chloride, calcium chloride, or any other chemical used for ice control, or because of oil content of pavement materials or oil droppings from the traffic.

The ingredients used in the production of thermoplastic pavement marking materials shall be of high quality and consistency so that the appearance will not change in service to impair the colour or the visibility of the delineation.

1713.05.02 Colour

Thermoplastic pavement marking materials shall be according to the following colour requirements:

White Thermoplastic Pavement Marking Material - CGSB 1-GP-12C white 513-301

Yellow Thermoplastic Pavement marking Material shall match either the yellow colour chip of the Ministry of Transportation, Ontario or U.S. Federal 595B, Yellow 33538

The tolerance in colour allowed is as follows in the CIE L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation when calculated from instrumentally measured colour differences according to ASTM D2244.

White	$L^* = +2$ and -1.5 max
	$a^* = +1.5$ and -1 max
	$b^* = +4$ and -4 max

Yellow - MTO	$L^* = +2$ and -1.5 max
	$a^* = +3$ and -1.5 max
	$b^* = +7$ and -1.5 max

Yellow - U.S.	$L^* = -2$ and $+4$ max
	$a^* = -6$ and $+4$ max
	$b^* = -9$ and $+10$ max

1713.05.03 Chemical Composition

The chemical composition of the thermoplastic material shall be at the discretion of the manufacturer and shall be certified by the Owner.

1713.05.04 Reflectorization

Thermoplastic material for screed application and preformed thermoplastic pavement marking material shall contain premixed glass beads. Overlay glass beads shall also be applied at a rate recommended by the manufacturer for reflectorization. Thermoplastic materials recommended for spray application shall be used with overlay glass beads for reflectorization. These materials shall provide proper anchorage for the glass beads according to OPSS 1750, with the exception of the requirement of silicone coating.

Test samples of glass beads according to the above requirements may be obtained from the Owner upon request.

1713.05.05 Physical Property Requirements

Physical properties of thermoplastic pavement marking material submitted for compliance certification shall be according to Table 1.

Samples are required by the Owner for laboratory testing. The supplier shall submit with each test sample, complete data on physical properties, application procedure, and material safety for the thermoplastic pavement marking material.

1713.05.06 Service Test

Thermoplastic pavement marking material according to the qualifications of section 1713.05 and Table 1, shall be supplied for service test when requested by the Owner.

Thermoplastic pavement marking material shall be service tested according to the following:

- a) Test deck location and time for application shall be determined by the Owner.
- b) The test stripes shall be 10 cm in width and applied transversely across the lanes of the road. Thermoplastics shall be applied at a rate which results in a uniform thickness of $1.90 \text{ mm} \pm 0.40 \text{ mm}$ measured dry. The application shall be made by the supplier/manufacturer or their approved agent, using the pieces of equipment recommended by the manufacturer of thermoplastic pavement marking material.
- c) Application of test stripes of hot applied or preformed thermoplastic pavement marking material on a bituminous or concrete pavement with about 20,000 AADT.
- d) Ease of application and quality and nature of the stripes, shape of the edges, and uniformity in thickness will be evaluated.
- e) Thermoplastic pavement marking will be inspected periodically and its service performance will be rated by the Owner as specified in Table 2.
- f) Susceptibility to snow plow damage and chipping will be assessed.
- g) Approval will be given after two years of service rating, providing the material conforms to Table 2 and meets the conditions of subsection 1713.05.05.

1713.07 PRODUCTION

1713.07.01 General

In order to qualify as a supplier, a manufacturer must satisfy the following minimum requirements:

- a) Adequate production facilities.
- b) A laboratory sufficiently equipped and staffed to provide a quality control program which will ensure compliance with this specification.
- c) Properly documented production, sampling, and testing procedures and methods.

1713.07.02 Quality Control

A manufacturer shall be responsible for carrying out a quality control program to ensure that the thermoplastic pavement marking materials conform to this specification.

1713.08 QUALITY ASSURANCE

1713.08.01 Acceptance Criteria

The Owner may request samples to be taken from the shipments at any time for quality assurance testing. Samples shall be taken from each batch produced for delivery to the Owner. Criteria for acceptance shall include the following requirements and manufacturing tolerances:

- a) Composition shall not vary by more than $\pm 5\%$, based on fingerprinting and other tests of the values established for the reference sample.
- b) Softening point shall be within $\pm 3\text{ }^{\circ}\text{C}$ from the value established for the reference sample.
- c) Colour difference ' ΔE ' shall be less than ± 1.5 provided the colour conforms to this specification.
- d) Directional reflectance with:
 - i. Minimum value of 70% white.
 - ii. Minimum value of 45% yellow.

1713.08.02 Quality Control of Production Batches

A 500 g sample of hot applied thermoplastic pavement marking material or one section of the preformed thermoplastic pavement marking material from each production batch along with test results on softening point, hardness, and material composition shall be supplied to the Owner for laboratory testing.

Delivery records shall be kept by the supplier of the number of containers of each batch shipped to each delivery point and a list of such shipments shall be given to the Owner.

1713.08.03 Storage

Thermoplastic pavement marking materials shall conform to this specification after storage.

1713.09 OWNER PURCHASE OF MATERIAL

1713.09.01 Certificate of Compliance

The manufacturer shall submit a certificate of compliance with tenders indicating that the physical properties, material composition, and installation characteristics of all of the manufacturer's production batches of thermoplastic pavement marking materials for the Owner shall conform to this specification and shall not deviate from the allowable tolerances, unless approved by the Owner.

1713.09.02 Delivery and Packaging of Thermoplastic Pavement Marking Material

The delivery schedule, delivery location, colour, type, and quantity shall be as specified by the Owner. Thermoplastic pavement marking material supplied shall be packaged to commercially acceptable standards. Each package shall have a label or marking with the following information:

- a) Manufacturer's name and address.

- b) Type and colour of thermoplastic pavement marking material.
- c) Manufacturer's code and batch numbers.
- d) Net weight in kilograms or in metres for preformed material.
- e) Date of manufacture.

1713.09.03 Measurement and Payment

Measurement of thermoplastic pavement marking material shall be by metres.

Payment at the price specified in the purchasing order shall be for the supply of thermoplastic pavement marking material.

TABLE 1
PHYSICAL PROPERTY REQUIREMENTS FOR
THERMOPLASTIC PAVEMENT MARKING MATERIAL

Test and Property	Requirements		Test Methods ASTM
	Min.	Max.	
Directional Reflectance % White Yellow	70 45		E97
Softening Point °C	80		E28
Water Absorption %		0.5	D570
Impact Resistance Izod	**		D256*
Hardness at 25 °C IRHD	90	98	D1415
Skid Resistance BPN Units	**		E303

* Material is cast into 3" x 1" x 0.9" bars for this test.

** Values to be established.

TABLE 2
PERFORMANCE REQUIREMENTS FOR SERVICE TEST AT ABOUT 20,000 AADT
FOR THERMOPLASTIC PAVEMENT MARKING MATERIAL

Property	Performance Requirements for Test Stripes						Test Method
	Newly Installed Thermo-Plastics	Service Life Ratings of					
		1 yr	2 yrs	3 yrs	4 yrs	5 yrs	
Directional Reflectance % White Yellow	≥ 70 ≥ 45	≥ 50 ≥ 35	≥ 50 ≥ 35	≥ 50 ≥ 35	≥ 50 ≥ 35	≥ 50 ≥ 35	ASTM E97*
Retroreflectance mcd/m²/lux White Yellow	** **	** **	** **	** **	** **	** **	Instrument Mirolux 12
No Tracking Time, mins.	≤ 2						MTO
Durability		≥ 95	≥90	≥ 80	≥ 75	≥ 70	MTO***
Appearance	10	≥ 8	≥ 7	≥ 6	≥ 5	≥ 5	ASTM D713 & MTO***

* These values are based on markings placed on a typical asphalt surface.

** Values to be established.

*** Durability is calculated, first by estimating the % wear from the photographs/video images of stripes taken at test sites, and then deducting the value obtained from 100.

**** Rating 1-10; Perfect score is 10.
Rating made on inspection of the markings by a panel of evaluators from the Owner.

THERMOPLASTIC PAVEMENT MARKING MATERIAL DATA FORM

A. MANUFACTURER'S NAME _____
ADDRESS _____

TELEPHONE NO. _____

B. SAMPLE IDENTIFICATION

Commercial Trade Name of Sample _____
Manufacturer's Code No. _____
Batch No. _____
Colour _____
Date of Manufacture _____

C. MATERIAL COMPOSITION

Resins and Conditioners wt % _____
Pigments and Fillers wt % _____
Glass Beads wt, % _____
Gradation of Beads _____

D. TEST DATA

Softening Point °C	ASTM E28	_____
Water Absorption %	ASTM D570	_____
Impact Resistance	ASTM D256*	_____
Hardness**, IRHD	ASTM D1415	_____
Shore A° or D°	ASTM D2240	_____

E. MATERIAL SAFETY DATA

* Material is cast into 3" x 1" x 0.9" bars for this test.

** Hardness may also be measured according to ASTM D2240.

F. PROCEDURE FOR OVERLAY AND INLAY APPLICATION

1. Pavement Surface Preparation Procedure _____

2. Pavement Temperature Range for Installation
 Minimum °C _____
 Maximum °C _____
3. Air Temperature
 Minimum °C _____
4. Humidity Maximum % _____
5. Temperature Range of Hot Thermoplastic Material for Application
 Minimum °C _____
 Maximum °C _____
6. Types of Pavement *** where the application is not recommended.

7. Equipment for Application _____

8. Application Procedure for Glass Beads _____

9. Particulars regarding suitability of application onto partly worn existing pavement marking.
 - a. On solvent based traffic paint _____
 - b. On water-borne traffic paint _____
 - c. On thermoplastic pavement marking _____
 - d. On field reacted polymeric pavement marking _____
10. Any Other Relevant Information _____

*** Refers to the age of pavement, the surface texture (e.g., OFC, DFC etc.) and whether it is asphalt or concrete pavement.

Note: This form must be completed in full and forwarded with material sample. Samples submitted without a completed data form will not be considered.



Note: The PROV implemented in July 2023 replaces OPSS 1714 COMMON, February 1991 with no technical content changes.

MATERIAL SPECIFICATION FOR FIELD REACTED POLYMERIC PAVEMENT MARKING MATERIALS

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1714.01	SCOPE

This specification covers the requirements for field reacted, two component polymeric pavement marking materials which are suitable for application onto concrete and bituminous pavements.

1714.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1750 Traffic Paint ReflectORIZING Glass Beads

Canadian General Standards Board Specifications

CGSB 1-GP-12C-1983 Standard Paint Colours

American Society for Testing and Materials

ASTM D713-87	Conducting Road Service Tests on Traffic Paint
ASTM D868-85	Degree of Bleeding of Traffic Paint

ASTM D869-85	Degree of Settling of Traffic Paint
ASTM D1415-88	Rubber Property - International Hardness
ASTM D1644-88	Non-Volatile Content of Varnishes
ASTM D1652-88	Epoxy Content of Epoxy Resins
ASTM D2074-66 (1987)	Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D2240-86	Rubber Property - Durometer Hardness
ASTM D2244-85	Calculation of Colour Differences from Instrumentally Measured Colour Coordinates
ASTM D4060-84	Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM E97-82 (1987)	Test for 45-deg, 0-deg, Directional Reflectance Factor of Opaque Specimens by Broad Band Filter
ASTM E298-84	Assay of Organic Peroxides
ASTM E303-83	Measuring Surface Frictional Properties Using the British Pendulum Tester

United States Federal Standard

U.S.-FED-STD-595B-Dec. 15, 1989 Colours Used in Government Procurement

International Commission on Illumination

CIE 1976 - L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation

1714.03 DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

Compliance Certification means the procedure and requirements for establishing an approved source of materials.

Field Reacted Polymeric Pavement Marking Material means a pavement marking material consisting of two separate components, a polymerizable component and a curing agent or a polymerization catalyst. These two components are designed to be mixed at the site and applied during the pot life of the mixture.

Fingerprinting means the testing of field reacted polymeric pavement marking materials by infrared spectroscopy and other techniques for verification purposes.

No Tracking Time means the time required for a newly installed beaded line to show no visible deposition of the material to the pavement surface outside the line when viewed from a distance of 15 metres, as determined by passing over the applied pavement marking line at 60 km per hour in a simulated passing maneuver at about 60 km per hour with a passenger car.

Pavement Marking Material means a material formulated for application onto bituminous or concrete pavement in order to delineate vehicle operating limits.

Pot Life mean the length of time a material is usable after a curing agent or a polymerization catalyst has been mixed.

Reflectorization means a material, treatment, or process to enable incident light to be returned in high proportions in the general direction of the light source.

Service Test means the evaluation of pavement marking materials on a test deck and performance rating prior to compliance certification.

1714.05 MATERIALS

1714.05.01 General

The ingredients used in the production of the field reacted polymeric pavement marking materials shall be of high quality consistency such that the appearance will not change in service to impair the colour or visibility of the delineation.

1714.05.02 Colour

The field reacted polymeric pavement marking material shall be according to the following colour requirements after mixing at the recommended proportions and curing:

- White - CGSB 1-GP-12C white 513-301
- Yellow - Shall match either the yellow colour chip of the Ministry of Transportation, Ontario or U.S. Federal 595B, Yellow 33538
- Black - CGSB 1-GP-12C black 512-301

The tolerance in colour allowed is as follows in the CIE $L^*a^*b^*$ Uniform Colour Space and Colour Difference.

Equation when calculated from instrumentally measured colour differences according to ASTM D2244:

White	$L^* = +2$ and -1.5 max $a^* = +1.5$ and -1 max $b^* = +4$ and -4 max
Yellow - MTO	$L^* = +2$ and -1.5 max $a^* = +3$ and -1.5 max $b^* = +7$ and -1.5 max
Yellow - U.S.	$L^* = -2$ and $+4$ max $a^* = -6$ and $+4$ max $b^* = -9$ and $+10$ max

1714.05.03 Chemical Composition

The chemical composition of the field reacted polymeric pavement marking material shall be at the discretion of the manufacturer and shall be certified by the Owner.

1714.05.04 ReflectORIZATION

Field reacted polymeric pavement marking material recommended for screed application shall contain premixed glass beads and overlay glass beads shall also be applied at a rate recommended by the manufacturer for reflectORIZATION of the pavement markings. Field reacted polymeric pavement marking materials recommended for spray application shall be used with overlay glass beads for reflectORIZATION. These materials shall provide proper anchorage for the glass beads which shall be according to OPSS 1750, with the exception of the requirement of silicone coating.

Test samples of glass beads according to the above requirements may be obtained from the Owner.

1714.05.05 Physical Property Requirements

The physical properties of the field reacted polymeric pavement marking material submitted for compliance certification shall be according to Table 1.

Samples are required by the Owner for laboratory testing. The supplier shall submit with each test sample, complete data for both components and mixing ratios of the field reacted polymeric pavement marking material.

1714.05.06 Service Tests

Field reacted polymeric pavement marking materials according to the qualifications of section 1714.05 and Table 1 shall be submitted for service tests when requested by the Owner.

The field reacted polymeric pavement marking material shall be service tested according to the following:

- a) Test deck location and time for application shall be determined by the Owner.
- b) The test stripes shall be 10 cm in width and applied transversely across the lanes of the road. The application shall be made by the supplier or the manufacturer or his agent, as recommended by the manufacturer except that the thickness of screed applied material shall be $1.90 \text{ mm} \pm 0.40 \text{ mm}$.
- c) Application of test stripes of the field reacted polymeric material on a bituminous or concrete pavement with about 20,000 AADT.
- d) Ease of application, quality, and nature of the stripes, including the shape of the edges and uniformity in thickness will be assessed.
- e) The field reacted polymeric pavement marking will be inspected periodically and its service performance will be rated by the Owner as specified in Table 2.
- f) Approval will be given after two years of service rating, providing the material conforms to Table 2 and meets the conditions of subsection 1714.05.05.

1714.07 PRODUCTION

1714.07.01 General

In order to qualify as a supplier of field reacted polymeric pavement marking materials, a manufacturer must satisfy the following minimum requirements.

- a) Adequate production facilities.
- b) A laboratory sufficiently equipped and staffed to provide a quality control program which will ensure compliance with this specification.
- c) Properly documented production, sampling, and testing procedures and methods.

1714.07.02 Quality Control

A manufacturer shall be responsible for carrying out a quality control program to ensure that the field reacted polymeric pavement marking materials conform to this specification.

1714.08 QUALITY ASSURANCE

1714.08.01 Acceptance Criteria

The Owner may request samples to be taken from the shipments of field reacted polymeric pavement marking materials at any time for quality assurance testing. Samples shall be taken from each batch produced for delivery to the Owner. Criteria for accepting each production batch include the following requirements and manufacturing tolerances:

- a) Composition shall not vary by more than $\pm 5\%$ of the reference value, as determined by fingerprinting and other specific tests for the materials according to the applicable ASTM specification from ASTM D1644, ASTM D1652, ASTM D2074, and ASTM E298.
- b) Pot life shall not vary by more than ± 5 minutes of the value established for the reference sample, when tested at 25 °C and 50% relative humidity.
- c) Directional reflectance with:
 - i. Minimum value of 70% white.
 - ii. Minimum value of 45% yellow.

1714.08.02 Quality Control of Production Batches

A 500 g sample of the prepolymer or polymerizable component and an equivalent amount of curing agent or catalyst samples shall be supplied to the Owner for laboratory testing.

1714.08.03 Storage

The field reacted polymeric pavement marking materials shall be according to this specification after storage.

1714.09 OWNER PURCHASE OF MATERIAL

1714.09.01 Certificate of Compliance

The manufacturer shall submit a certificate of compliance with tenders indicating the physical properties, material composition, and installation characteristics of all of the manufacturer's production batches of the field reacted polymeric pavement marking materials for the Owner shall conform to this specification and shall not deviate from the allowable tolerances, unless approved by the Owner.

1714.09.02 Delivery and Packaging of the Field Reacted Polymeric Pavement Marking Material

The delivery schedule, delivery location, colour, type, and quantity shall be as specified by the Owner. Both components of the field reacted polymeric pavement marking material supplied shall be packaged to commercially acceptable standards. Each package shall have a label or marking with the following information:

- a) Manufacturer's name and address.
- b) Type and colour of the field reacted polymeric pavement marking material.
- c) Manufacturer's code and batch numbers.
- d) Net weight in kilograms.

e) Date of manufacture.

1714.09.03 Measurement and Payment

Measurement of field reacted polymeric pavement marking material shall be by kilograms.

Payment at the price specified in the purchasing order shall be for the supply of field reacted polymeric pavement marking material.

TABLE 1
PHYSICAL PROPERTY REQUIREMENTS FOR FIELD REACTED
POLYMERIC PAVEMENT MARKING MATERIALS

Test and Property	Requirements		Test Methods	
	Min.	Max.	ASTM	Other
Settling, 6 months Component A Component B	6 6		D869	MTO
Pot Life min. at 25 °C		20		
Bleeding	5		D868	
Directional Reflectance %			E97	
White Paint	70			
Yellow Paint	45			
Black		12		
Hardness IRHD	90	98	D1415	
Abrasion Resistance 1000 cycles/g	*		D4060 CS-17	
Skid Resistance BPN Units	*		E303	

* Values to be established.

TABLE 2
PERFORMANCE REQUIREMENTS FOR SERVICE TEST AT ABOUT 20,000 AADT
FOR FIELD REACTED POLYMERIC PAVEMENT MARKING MATERIALS

Property	Performance Requirements							
	Newly Installed Marking	Service Life Ratings of						Test Method
		3 mths	1 yr	2 yr	3 yrs	4 yrs	5 yrs	
Directional Reflectance %								
White	≥ 70		≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	ASTM E97*
Yellow	≥ 45		≥ 35	≥ 35	≥ 35	≥ 35	≥ 35	
Black	≤ 12	≤ 12						
Retroreflectance mcd/m²/lux								Instrument Mirolux
White	**		**	**	**	**	**	
Yellow	**		**	**	**	**	**	
Black	**	**						
No Tracking Time, mins.	≤ 15							
Durability								MTO***
White & Yellow			≥ 95	≥ 90	≥ 80	≥ 75	≥ 70	
Black		≥ 90						
Appearance	10	≥ 9	≥ 8	≥ 7	≥ 6	≥ 5	≥ 5	ASTM D713 & MTO****

* These values are based on markings placed on a typical asphalt surface.

** Values to be established.

*** Durability is calculated, first by estimating the % wear from the photographs/video images of stripes taken at test sites, and then deducting the value obtained from 100.

**** Rating 1 - 10; Perfect Score is 10. Rating made on inspection of the markings by a panel of evaluators from the Owner.

FIELD REACTED POLYMERIC PAVEMENT MARKING MATERIAL DATA FORM

A. MANUFACTURER'S NAME _____
 ADDRESS _____

 TELEPHONE NO. _____

B. SAMPLE IDENTIFICATION	COMPONENT A	COMPONENT B
Commercial, Trade Name of Sample	_____	_____
Manufacturer's Code No.	_____	_____
Batch No.	_____	_____
Colour	_____	_____
Date of Manufacture	_____	_____

C. MATERIAL COMPOSITION	COMPONENT A	COMPONENT B
Resins and Conditions, wt %	_____	_____
Pigments and Fillers, wt %	_____	_____
% Active Polymerization	_____	_____
Catalyst, Curing Agent	_____	_____
Glass Beads, wt %	_____	_____
Gradation of Glass Beads	_____	_____
	_____	_____
	_____	_____

D. TEST DATA

Settling, 6 months	ASTM D869	_____
Component A		_____
Component B		_____
Bleeding, mixed material	ASTM D868	_____
Pot Life at 25°C min.	MTO	_____

Hardness*, IRHD	ASTM D1415	_____
Shore A° or D°	ASTM D2240	_____

Abrasion Resistance	ASTM D4060	
1000 cycles/g	CS-17	_____

E. MATERIAL SAFETY DATA FOR BOTH COMPONENTS

F. PROCEDURE FOR OVERLAY AND INLAY APPLICATION

1. Pavement Surface Preparation Procedure

2. Pavement Temperature Range for Application

Minimum °C

Maximum °C

3. Air Temperature

Minimum °C

Maximum °C

4. Humidity Maximum %

5. Mix Ratio of Component A & B

Mixing Procedure Quantities

Pot Life min. at 25 °C

6. Types of Pavement ** where the application is not recommended

7. Equipment for Application

8. Application Procedure for Glass Beads Overlay

9. Particulars regarding suitability of application onto partly worn existing pavement marking.

a. on solvent based traffic paint

b. on water-borne traffic paint

c. on thermoplastic pavement marking

d. on field reacted polymeric pavement marking

10. Any Other Relevant Information

* Hardness may also be measured according to ASTM D2240.

** Refers to the age of pavement, the surface texture (e.g., OFC, DFC), and whether it is asphalt or concrete pavement.

NOTE: This form must be completed in full and forwarded with test sample. Samples submitted without a completed Data Form will not be considered.



Note: The PROV implemented in July 2023 replaces OPSS 1715 COMMON, February 1991 with no technical content changes.

MATERIAL SPECIFICATION FOR PREFORMED PLASTIC PAVEMENT MARKING TAPE

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1715.08	QUALITY ASSURANCE
1715.09	OWNER PURCHASE OF MATERIAL

1715.01 SCOPE

This specification covers the requirements for reflective and non-reflective preformed plastic pavement marking tapes which are suitable for use onto concrete and bituminous pavements.

1715.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Materials

OPSS 1750 Traffic Paint Reflectorizing Glass Beads

Canadian General Standards Board

CGSB 1-GP-12C-1983 Standard Paint Colours

American Society for Testing and Materials

ASTM D523-89 Method for Specular Gloss

ASTM D638-87b	Tensile Properties of Plastics
ASTM D713-87	Conducting Road Service Tests on Traffic Paint
ASTM D1000-88a	Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
ASTM D4505-85	Preformed Plastic Pavement Marking Tape for Extended Service Life
ASTM D4592-86	Preformed Plastic Pavement Marking Tape for Limited Service Life
ASTM E97-82(1987)	Method for 45-deg., 0-deg. Directional Reflectance Factor of Opaque Specimens by Broad-Band Filter
ASTM E303-83	Measuring Surface Frictional Properties Using the British Pendulum Tester

United States Federal Standard

U.S. FED-STD-595B Dec. 15, 1989 Colours Used in Government Procurement

International Commission on Illumination

CIE 1976 - L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation

1715.03

DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

Compliance Certification means the procedure and requirements for establishing an approved source of materials.

Durable Preformed Plastic Pavement Marking Tape means preformed plastic pavement marking tape with extended service life period with a minimum service period of two years when placed according to the manufacturer's recommended procedures on pavement surfaces with an annual average daily traffic, AADT of about 20,000.

Fingerprinting means the testing of preformed plastic pavement marking tape by gas chromatographic method and other techniques for verification purposes.

Preformed Plastic Pavement Marking Tape means plastic material specifically designed and preformed into pliable rolls or ribbons of various lengths and width or into symbols either white, yellow, or black for use as pavement marking on concrete or bituminous pavement.

Reflectorization means a material, treatment, or process to enable incident light to be returned in high proportions in the general direction of the light source.

Service Test means the evaluation of pavement marking materials on a test deck and performance rating prior to compliance certification.

Temporary Preformed Plastic Pavement Marking Tape means preformed plastic pavement marking tape with a limited service life and a minimum service period of three months when placed according to manufacturer's recommended procedures on pavement surfaces with an annual average daily traffic, AADT of about 20,000.

1715.05 MATERIALS

1715.05.01 General

Only material properties which are necessary for proper installation and satisfactory performance of preformed plastic pavement marking tape are specified here. The material as supplied shall be free of cracks and have edges true, straight, and unbroken according to ASTM D4505. Preformed plastic pavement marking tape of all types shall have a uniform width and thickness.

The material used in the manufacture of preformed plastic pavement marking tape shall be of high quality so that the appearance will not change in service to impair the colour or the visibility of the delineation.

1715.05.02 Colour

The preformed plastic pavement marking tape shall be according to the following colour requirements:

- White - CGSB 1-GP-12C white 513-301
- Yellow - Shall match either the yellow traffic paint chip of the Ministry of Transportation, Ontario or U.S. Federal 595B, Yellow 33538
- Black - CGSB 1-GP-12C black 512-301

The tolerance in colour allowed is as follows in CIE L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation when calculated from instrumentally measured colour differences according to ASTM D2244:

White	$L^* = +2$ and -1.5 max $a^* = +1.5$ and -1 max $b^* = +4$ and -4 max
Yellow - MTO	$L^* = +2$ and -1.5 max $a^* = +3$ and -1.5 max $b^* = +7$ and -1.5 max
Yellow - U.S.	$L^* = -2$ and $+4$ max $a^* = -6$ and $+4$ max $b^* = -9$ and $+10$ max

1715.05.03 Adhesive

The preformed plastic pavement marking tape shall be either precoated with a factory applied adhesive at the base or supplied with a suitable adhesive and any other material such as a primer that is necessary for installation of the tape onto the pavement.

1715.05.04 Material Composition

The material composition of the preformed plastic pavement marking tape shall be at the discretion of the manufacturer and shall be certified by the Owner.

1715.05.05 Physical Property Requirements

The physical properties of the preformed plastic pavement marking tape submitted for compliance certification shall be according to Table 1.

Samples are required by the Owner for laboratory testing. The supplier shall submit with each test sample, one complete set of data on physical properties, application procedure, and material safety for preformed plastic pavement marking tape.

1715.05.06 Service Test

Preformed plastic pavement marking tape according to subsection 1715.05.06 and Table 1 shall be submitted for service test when requested by the Owner.

Preformed plastic pavement marking tape for extended service, durable preformed plastic tape shall be service tested according to the following:

- a) Test deck location and time for installation shall be determined by the Owner.
- b) The test strips shall be 10 cm in width and installed transversely across the lanes of the road. The installation of the preformed plastic pavement marking tape shall be made by personnel from the supplier/manufacturer or his agent using the pieces of equipment recommended by the manufacturer for installation.
- c) A service test shall consist of installation of test stripes of pre-formed plastic pavement marking tapes, onto bituminous or a concrete pavement with about 20,000 AADT.
- d) Ease of application and quality and nature of the stripes will be assessed.
- e) The installed tape will be inspected periodically and its service performance will be rated by the Owner as specified in Table 2.
- f) Approval will be given after two years of service rating of durable preformed plastic pavement marking tape, providing the material conforms to Table 2 and meets the conditions of subsection 1715.05.05.

Temporary preformed plastic pavement marking tapes of removable type shall be according to this specification and also to ASTM D4592 except that the required minimum service life is three months at about 20,000 AADT.

1715.07 PRODUCTION

1715.07.01 General

In order to qualify as a supplier of preformed plastic marking tape, a manufacturer must satisfy the following minimum requirements:

- a) Adequate production facilities.
- b) A laboratory sufficiently equipped and staffed to provide a quality control program which will ensure compliance with this specification.
- c) Properly documented production, sampling, and testing procedures and methods.

1715.07.02 Quality Control

A manufacturer shall be responsible for carrying out a quality control program to ensure that the preformed plastic pavement marking tapes conform to this specification.

1715.08 QUALITY ASSURANCE

1715.08.01 Acceptance Criteria

The Owner may request samples to be taken from the shipments of preformed plastic pavement marking tape for quality assurance testing. Samples shall be taken from each batch produced for delivery to the Owner. Criteria for accepting the preformed tape include the following requirements and tolerances:

- a) Composition as determined by fingerprinting and other tests shall not vary by more than $\pm 5\%$ from that of the reference sample.
- b) Colour difference, ΔE shall be within ± 1.5 of the value established on the reference sample.
- c) Directional Reflectance, Y shall not vary by more than ± 3 and have a minimum value of 65 and 45 for white and yellow tapes respectively.
- d) Retroreflectance shall not vary by more than ± 10 mcd/m²/lux.

Viscosity and the infrared spectograph of any adhesive and/or primer shall match that obtained for the approved reference samples.

1715.08.02 Quality Control of Production Batches

- a) One metre sections of each type and colour of the tapes, and a section of legends and/or symbols shall be supplied to the Owner for laboratory testing from each production batch.
- b) 200 ml of primer or adhesive, if the use of such surface preparation material or adhesive is recommended by the manufacturer, from each production batch, to be supplied to the Owner.

1715.08.03 Storage

The preformed plastic pavement marking tape shall conform to this specification after storage.

1715.09 OWNER PURCHASE OF MATERIAL

1715.09.01 Certificate of Compliance

The manufacturer shall submit a certificate of compliance with tenders indicating that the physical properties, material composition, and installation characteristics of all of the manufacturer's production batches of preformed plastic pavement marking tapes for the Owner shall conform to this specification and shall not deviate from the allowable tolerances, unless approved by the Owner.

1715.09.02 Delivery and Packaging of Preformed Plastic Pavement Marking Tape

The delivery schedule, delivery location, colour, type, and quantity shall be as specified on the Owner's purchase order.

Each package of preformed plastic pavement marking tape shall be clearly identified with the following information:

- a) Manufacturer's name and address.
- b) Types and colour of preformed plastic pavement marking tape.
- c) Manufacturer's code and batch numbers.

d) Dimension and length or numbers of legends and symbols.

e) Date of manufacture.

1715.09.03 Measurement and Payment

Measurement of preformed plastic pavement marking tapes shall be by metres.

For measurement purposes, a count shall be made of the number of legends and symbols.

Payment at the price specified in the purchasing order shall be for the supply of preformed plastic pavement marking tape.

TABLE 1
PHYSICAL PROPERTY REQUIREMENTS FOR
PREFORMED PLASTIC PAVEMENT MARKING TAPE

Property	Durable Preformed Plastic Tape		Temp. Preformed Plastic Tape		Test Methods	
	Min.	Max.	Min.	Max.	ASTM	Others
Directional Reflectance %					E97	
White	65		65			
Yellow	45		45			
Black Temporary				12		
Retroreflectance mcd/m ² /lux						Instrument Mirolux 12
White	**		**			
Yellow	**		**			
Black Temporary				**		
Tensile Strength MPa			7.5*		D638	
Elongation at Break %		50		50	D638	
Adhesion at						
10 °C	500		500		D1000	
24 °C	500		500		D1000	
g/25.4 mm of width						
60° Gloss					D523	
White		10		10		
Yellow		10		10		
Black Temporary				5		
Skid Resistance BPN Units	**		**		E303	

* This requirement is applicable to temporary preformed tape of removable type.

** Values to be established.

TABLE 2
PERFORMANCE REQUIREMENTS FOR SERVICE TEST AT ABOUT 20,000 AADT
FOR PREFORMED PLASTIC PAVEMENT MARKING TAPE

Property	Performance Requirements						Test Method
	Temp. Tape 3 mths	Durable Tape					
		1 yr	2 yr	3 yr	4 yr	5 yr	
Directional Reflectance %							E97
White	≥ 65	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	
Yellow	≥ 45	≥ 35	≥ 35	≥ 35	≥ 35	≥ 35	
Black Temporary	≤ 12						
Retroreflectance							Instrument Mirolux 12
mcd/m²/lux							
White	*	*	*	*	*	*	
Yellow	*	*	*	*	*	*	
Black Temporary	*						
Durability %	≥ 95	≥ 95	≥ 90	≥ 80	≥ 75	≥ 70	MTO**
Appearance	≥ 8	≥ 8	≥ 7	≥ 6	≥ 5	≥ 5	D713 & MTO ***

* Values to be established.

** Durability is calculated, first by estimating the % wear from the photographs/video images of stripes taken at test sites, and then deducting the value obtained from 100.

*** Rating 1 - 10; Perfect Score is 10.
Rating made on inspection of the markings by a panel of evaluators from the Owner.

PREFORMED PLASTIC PAVEMENT MARKING TAPE MATERIAL DATA FORM

A. MANUFACTURER'S NAME _____
 ADDRESS _____

TELEPHONE NO. _____

B. SAMPLE IDENTIFICATION
 Commercial/Trade Name of Sample _____
 Manufacturer's Code No. _____
 Batch No. _____
 Colour _____
 Width _____
 Thickness _____
 Date of Manufacture _____

C. MATERIAL COMPOSITION
 Resins and Conditioners wt % _____
 Pigments and Fillers wt % _____
 Beads wt, % _____

D. TEST DATA
 1. Preformed Tape
 a. Tensile strength, Mpa ASTM D638 _____
 at 24 °C 0.6 cm/min
 b. Elongation and Break % ASTM D638 _____
 0.6 cm/min
 c. Adhesion at 10 °C ASTM D1000 _____
 g/25.4 mm at 24 °C _____
 Softening Point °C ASTM E28 _____

2. Adhesive and Primer, if used separately
 Viscosity 25 °C ASTM D562 _____
 Primer Adhesive

E. MATERIAL SAFETY DATA

F. PROCEDURE FOR OVERLAY AND INLAY APPLICATION/INSTALLATION

1. Pavement Surface Preparation Procedure _____

2. Pavement Temperature Range for Installation
Minimum °C _____
Maximum °C _____
3. Air Temperature
Minimum °C _____
4. Humidity Maximum % _____
5. Adhesive Application Procedure _____

6. Type of Pavement * where the application is recommended _____

7. Equipment for Installation _____

8. Any Other Relevant Information _____

* Refers to the age of the pavement, the surface texture, e.g. OFC, DFC, and whether it is asphalt or concrete.

NOTE: This form must be completed in full and forwarded with tape sample. Samples submitted without a completed Data Form will not be considered.



Note: The PROV implemented in July 2023 replaces OPSS 1716 COMMON, February 1991 with no technical content changes.

MATERIAL SPECIFICATIONS FOR WATER-BORNE TRAFFIC PAINT

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1716.08	QUALITY ASSURANCE
1716.09	OWNER PURCHASE OF MATERIAL

1716.01 SCOPE

This specification covers the requirements for water-borne traffic paint which is suitable for application onto concrete and bituminous pavements.

1716.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1750 Traffic Paint Reflectorizing Glass Beads

Canadian General Standards Board

CGSB-1-GP-12C-1983 Standard Paint Colours

CGSB-1-GP-71-1983 Testing Paints and Pigments:

California Department of Transportation

8010-61G-30 Water Borne Traffic Paint

American Society for Testing and Materials

ASTM D185-84	Coarse Particles in Pigments, Pastes and Paints
ASTM D562-81(1985)	Consistency of Paints Using the Stormer Viscometer.
ASTM D711-84	No Pick-Up Time of Traffic Paint
ASTM D713-87	Conducting Road Service Tests on Traffic Paint
ASTM D869-85	Evaluating Degree of Settling of Traffic Paint
ASTM D2205-85	Traffic Paints
ASTM D2243-82(1987)	Freeze-Thaw Resistance of Water-Borne Paints
ASTM D2244-85	Calculation of Colour Differences from Instrumentally Measured Colour Coordinates
ASTM D2369-87	Volatile Content of Coatings
ASTM D3168-85	Practice for Qualitative Identification of Polymers in Emulsion Paints
ASTM D3960-87	Determining Volatile Organic Content (VOC) of Paints and Related Coatings
ASTM E70-77(1986)	Test Method for pH of Aqueous Solutions With the Glass Electrode
ASTM E97-82(1987)	Test Method for 45-deg., 0-deg., Directional Reflectance Factor of Opaque Specimens by Broad-Band Filter
ASTM E303-83	Measuring Surface Frictional Properties Using the British Pendulum Tester

United States Federal Standard

U.S. FED-STD-595B Dec. 15, 1989 Colours Used in Government Procurement

International Commission on Illumination

CIE 1976 - L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation

1716.03 DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

Compliance Certification means the procedure and requirements for establishing an approved source for materials.

Fingerprinting means the testing of water-borne by gas chromatographic and infrared spectroscopic techniques for verification purposes.

No Tracking Time means the time required for a newly applied pavement marking line to show no visible deposition of the material to the pavement surface outside the line when viewed from a distance of 15 metres, as determined by passing over the applied line at 60 km per hour in a simulated passing maneuver with a passenger car.

Pavement Marking Material means a material formulated for application onto bituminous or concrete pavement in order to delineate vehicle operating limits.

Reflectorization means a material, treatment, or process to enable incident light to be returned in high proportions in the general direction of the light source.

Service Test means the evaluation of pavement marking materials on a test deck and performance rating prior to compliance certification.

Traffic Paint means a paint specifically formulated for use as a pavement marking to delineate vehicle operating limits.

Water-Borne Traffic Paint means traffic paint whose components are carried in water either as an emulsion or a dispersion and will form a solid paint film on deposition and evaporation of water and volatiles after application.

1716.05 MATERIALS

1716.05.01 General

Water-borne traffic paint shall be homogeneous and shall be well ground to a uniform smooth consistency. It shall be free from skin, dirt, and other foreign particles and shall be capable of being sprayed at the temperature intended for the paint. The water-borne traffic paint shall flow evenly and smoothly and cover solidly when applied to pavements.

The materials used in the manufacture of the water-borne traffic paint shall be of high quality and consistency such that the appearance will not change in service to impair the colour or visibility of the delineation. The water-borne traffic paint film shall be flat in finish, and the white and yellow markings shall be visible under daylight and artificial light after the addition of the overlay glass beads.

1716.05.02 Colour

The water-borne traffic paint shall conform to the following colour requirements:

White - CGSB 1-GP-12C white 513-301

Yellow - Shall match either the yellow traffic paint chip of the Ministry of Transportation, Ontario or U.S. Federal 595B, Yellow 33538

Black - CGSB 1-GP-12C Black 512-301

The tolerance in colour allowed is as follows in the CIE L^* , a^* , b^* Uniform Colour Space and Colour Difference Equation when calculated from instrumentally measured colour differences conforming to ASTM D 2244:

White $L^* = +2$ and -1.5 max
 $a^* = +1.5$ and -1 max
 $b^* = +4$ and -4 max

Yellow - MTO $L^* = +2$ and -1.5 max
 $a^* = +3$ and -1.5 max
 $b^* = +7$ and -1.5 max

Yellow - U.S. $L^* = -2$ and $+4$ max
 $a^* = -6$ and $+4$ max
 $b^* = -9$ and $+10$ max

1716.05.03 Chemical Composition

The chemical composition of the water-borne traffic paint shall be at the discretion of the paint manufacturer and shall be certified by the Owner.

1716.05.04 Reflectorization

The white and yellow paints shall be used with overlay glass beads which are applied uniformly after application of the paint at a rate as shown below. The white and yellow paints shall provide proper anchorage for overlay glass beads according to OPSS 1750.

Rate of application for overlay glass beads per litre of traffic paint.

% Volume Solids of Traffic Paint	Glass Beads Required in kg
40-56	0.7
57-70	0.8

Test samples of glass beads according to OPSS 1750 may be obtained from the Owner upon request.

1716.05.05 Physical Property Requirements

Water-borne traffic paints shall be supplied ready-mixed for use without any addition of water.

The handling and storage qualities must be acceptable with respect to degree of settling, uniform consistency, absence of skinning, and thixotropic properties. The water-borne traffic paint shall be capable of being sufficiently atomized to produce an uniformly applied paint stripe without side splatter and overspray within the limitation imposed by conventional striping equipment.

The physical properties of the water-borne traffic paints submitted for compliance certification shall conform to Table 1.

Samples are required by the Owner for laboratory testing. The supplier shall submit with each test sample, complete data on physical properties, application procedure, and material safety for the water-borne traffic paint.

1716.05.06 Service Test

Water-borne traffic paint, according to subsection 1716.05.05 and Table 1 shall be submitted for service test when requested by the Owner.

Water-borne traffic paints will be service tested according to the following:

- a) Test deck location, time, and procedure of application shall be as specified by the Owner.
- b) Test stripe shall be 10 cm in width and applied transversely by across the lanes of the road. Application of the traffic paint to a dry thickness of 230 microns $\pm$ 25 microns on bituminous or concrete pavement with about 20,000 AADT and application of overlay glass beads according to OPSS 1750 at the approved rate immediately over the white and yellow striped line.
- c) The ease and uniformity of application, severity of overspray, covering properties, and drying time will be evaluated during application.
- d) The applied water-borne traffic paint will be inspected periodically and its service performance will be rated by the Owner as specified in Table 2.
- e) Approval will be given after one year of service rating providing the material conforms to Table 2 and meets the conditions of subsection 1716.09.02.

1716.07 PRODUCTION

1716.07.01 Plant Inspection

In order to qualify as a supplier of water-borne traffic paints, a manufacturer must satisfy the following minimum requirements:

- a) Adequate facilities to produce minimum batches of 3000 litres.
- b) A laboratory sufficiently equipped and staffed to provide a quality control program which will ensure compliance with this specification.
- c) Properly documented production, sampling, and testing procedures and methods.

1716.07.02 Quality Control

A manufacturer shall be responsible for carrying out a quality control program to ensure that the water-borne traffic paints conform to this specification.

1716.08 QUALITY ASSURANCE

1716.08.01 Acceptance Criteria

The Owner may request samples to be taken from the shipments of water-borne traffic paints at any time for quality assurance testing. Samples shall be taken from each batch produced for delivery to the Owner. Criteria for accepting each production batch include the following requirements and manufacturing tolerances:

- a) Density shall be within 0.05 kg/l of the value established on the test sample according to CGSB-1-GP-71 - Method 2.1.
- b) Viscosity shall be within ± 5 KU of the reference value.
- c) Colour Difference ΔE shall be within ± 1.5 of the value established on the reference sample.
- d) Composition shall not vary by more than $\pm 5\%$, based on fingerprinting and other tests, ASTM D3168, of the value of the reference sample.
- e) Total solids shall not vary by more than $\pm 2\%$ from the value of the reference sample.
- f) pH of the sample shall not vary by more than one unit from that of the value established for the reference sample.
- g) No pickup time of each production batch sample shall be within ± 2.5 minutes of the value established for the test sample according to ASTM D711.
- h) Directional Reflectance with:
 - i. Minimum value of 70% white.
 - ii. Minimum value of 50% yellow.
- i) Hiding Power with minimum value of 8.4 m²/l.

1716.08.02 Quality Control of Production Batches

A one litre sample from each production batch of water-borne traffic paint along with test results on density, viscosity at 25 °C, pH, total solids, and no-pickup time shall be delivered to the Owner's laboratory within two days of manufacture of the respective batches.

Delivery records shall be kept by the supplier of the number of containers of each batch shipped to each delivery point and a list of such shipments during each calendar week shall be given to the Owner at the end of each week until the entire order is completed and shipped.

1716.08.03 Storage

The water-borne traffic paint shall conform to this specification after storage.

1716.09 OWNER PURCHASE OF MATERIAL

1716.09.01 Trial Batch Application

A trial batch of water-borne traffic paints conforming to this specification may be purchased by the Owner for evaluation of application properties using the Owner's painting equipment. The trial batch shall consist of a minimum quantity of 1,000 litres of traffic paint.

No-tracking time will also be determined.

Those water-borne traffic paint conforming to this specification which exhibit satisfactory loading and application properties when used with the Owner's traffic painting equipment will be considered for purchase.

1716.09.02 Certificate of Compliance

The manufacturer shall submit a certificate of compliance with tenders indicating that the physical properties and chemical composition of all of the manufacturer's production batches of traffic paint for the Owner shall conform to this specification and shall not deviate from the allowable tolerances, unless approved by the Purchaser.

1716.09.03 Delivery and Packaging of Water-Borne Traffic Paint

The delivery schedule, delivery location, colour, and quantity shall be as specified on the Owner's purchase order.

The water-borne traffic paint shall be furnished in returnable drums with airtight liners.

Each drum shall be clearly marked on the side and the top with weather resistant markings to show the following information:

- a) Manufacturer's name and address.
- b) Type of traffic paint.
- c) Colour.
- d) Manufacturer's code and batch numbers date of filling the drum.
- e) Volume of contents in litres.

A small portion of the water-borne traffic paint may be required in 20-litre containers. The quantity will be specified on the purchase order.

1716.09.04 Measurement and Payment

Measurement of water-borne traffic paint shall be by litres.

Payment at the price specified in the purchasing order shall be for the supply of water-borne traffic paint.

TABLE 1
PHYSICAL PROPERTY REQUIREMENTS FOR WATER-BORNE TRAFFIC PAINT

Test and Property	Requirements		Test Methods		
	Min.	Max.	CGSB 1-GP-71	ASTM	OTHER
Volatile Organic Content %		8.5		D3960	
Settling 6 months	8.0			D869	
Hiding Power m ² /l	8.4				Pfund cyptometer with #3.5 wedge
Skinning 48 hours	nil	nil	10.1		
Viscosity KU @ 7 °C @ 25 °C	85	135.0 110.0	4.5	D562	
Viscosity Change after Heat-Shear Stability Test at 25 °C KU		10.0			Caltrans 8010-61G-30
Freeze-Thaw Stability	Pass			D2243	
Coarse Particles # 60 sieve - 250 µm # 100 sieve - 150 µm	nil	nil 0.01		D185 & D2205	
No Pickup Time, mins.		8.0*		D711	
Directional Reflectance % White Paint Yellow Paint Black Paint	70.0 50.0	12		E97	
Skid Resistance BPN Units	**			E303	

* For coning type of traffic paints, this value can be higher.

** Values to be established.

TABLE 2
PERFORMANCE REQUIREMENTS FOR SERVICE TEST
AT ABOUT 20,000 AADT FOR WATER-BORNE TRAFFIC PAINT

Property	Performance Requirements					Test Method
	Newly Installed Paints	Service Life Ratings of				
		3 mths	1 yr	1.5 yrs	2 yrs	
Directional Reflectance %						ASTM E-97*
White	≥ 70	≥ 70	≥ 50	≥ 50	≥ 50	
Yellow	≥ 50	≥ 50	≥ 35	≥ 35	≥ 35	
Black	≤ 12	≤ 12				
Retroreflectance mcd/m ² /lux						Instrument Mirolux 12
White	**	**	**	**	**	
Yellow	**	**	**	**	**	
Black	**	**				
No Tracking Time, mins.	≤ 2					MTO
Durability						
White and Yellow		≥ 90	≥ 85	≥ 75	≥ 70	ASTM D913 & MTO***
Black		≥ 90				
Appearance	10	≥ 8	≥ 7	≥ 6	≥ 5	ASTM D713 & MTO****

* These values were obtained on a typical asphalt surface.

** Values to be established.

*** Durability is calculated, first by estimating the % wear from the photographs/video images of stripes taken at test sites, and then deducting the value obtained from 100.

**** Rating 1 - 10; perfect score is 10.

Rating made on inspection of the markings by a panel of evaluators from the Owner.

WATER-BORNE TRAFFIC PAINT DATA FORM

A. MANUFACTURER'S NAME _____
 ADDRESS _____

TELEPHONE NO. _____

B. SAMPLE IDENTIFICATION

Manufacturer's Code No. _____ Paint Batch No. _____
 Colour of Paint _____ Sample Date _____

C. TEST DATA

Density, kg/l	1-GP-71 M2.1	_____
Volatile Organic Content %	ASTM D 3960	_____
No Pickup Time, minutes	ASTM D711	_____
Hiding Power, m ² /l	Pfund Cryptometer	_____
	OPSS 1716, Table 1	_____
pH	ASTM E70	_____
Total Solids	ASTM D2369	_____
Freeze-Thaw Stability	ASTM D2243	_____
Viscosity Change after		_____
Heat-Shear Stability	OPSS 1716, Table 1	_____

D. COMPOSITION OF PAINT

	% by Mass	% by Volume
Pigment and Fillers	_____	_____
Binder	_____	_____
Water	_____	_____

Composition of Pigment and Fillers % by Mass

1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
8	_____

Type of Binder _____

VOC individual components mg/litre

_____	_____
_____	_____
_____	_____
_____	_____

Surface Preparation _____
 Minimum Pavement Temperature _____
 Paint Temperature _____ min °C _____ max °C
 Mode of Application _____
 Air Temperature _____ min °C Humidity _____ max %

OPSS.PROV 1716



Note: The PROV implemented in July 2023 replaces OPSS 1750 COMMON, December 1983 with no technical content changes.

MATERIAL SPECIFICATION FOR TRAFFIC PAINT REFLECTORIZING GLASS BEADS

TABLE OF CONTENTS

1750.01	SCOPE
1750.02	REFERENCES
1750.03	DEFINITIONS - Not Used
1750.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
1750.05	MATERIALS
1750.06	EQUIPMENT - Not Used
1750.07	PRODUCTION
1750.08	QUALITY ASSURANCE - Not Used
1750.09	OWNER PURCHASE OF MATERIAL

1750.01 SCOPE

This specification covers the requirements for glass beads for use with traffic paint and requirements for Owner purchase of reflectorizing glass beads.

1750.02 REFERENCES

This specification refers to the following standards, specifications or publications:

ASTM Specifications

D1155-53 (1975)	Standard Test Method for Roundness of Glass Spheres
D1214-58 (1975)	Standard Method of Sieve Analysis of Glass Spheres
E11-81	Wire Cloth Sieves for Testing purposes

1750.05 MATERIALS

1750.05.01 Durability

The beads shall be manufactured from glass of a composition designed to be highly resistant to the effects of traffic wear and weathering.

1750.05.02 Colour

The glass shall be colourless to a degree that the resulting beads, when added to white paint, do not impart a noticeable hue.

1750.05.03 Bead Type and Grade

Beads shall be supplied in the Overlay Type and Moisture Proof Grade. The beads shall be treated in such a manner as to overcome the effects of water, as vapour or liquid, on the beads before the beads are added to the paint stripe.

1750.07 PRODUCTION

1750.07.01 Roundness

At least 70% by mass of the glass beads shall be true spheres.

1750.07.02 Gradation

The glass beads shall meet the following gradation requirements when tested according to ASTM D1214.

US Standard ASTM E11 Sieve Series	Opening μm	Percentage Passing by Dry Mass
		Overlay Type
No. 20	850	100
No. 30	600	95 - 100
No. 40	425	45 - 70
No. 50	300	20 - 40
No. 70	212	5 - 20
No. 100	150	0 - 3

1750.07.03 Refractive Index

The index of refraction of the glass beads, when tested by the immersion method at 25 °C under tungsten light, shall not be less than 1.50.

1750.07.04 Imperfections

The surface of the beads shall be smooth, lustrous, and free from film, scratches, and pits.

Not more than 25% by mass of the true spheres shall have imperfections such as milkiness, dark specks, incipient fractures, and air inclusions in the form of bubbles greater than 10% of the volume of the spheres.

1750.09 OWNER PURCHASE OF MATERIAL

1750.09.01 Sampling and Testing

1750.09.01.01 General

A maximum of 10% but no less than 1% of the total number of packages in each batch will be taken at random for test purposes by the Owner. The contents of each random package will be riffled until a representative sample of approximately 1000 g (or 500 ml) of beads is obtained. The 1,000 g samples will be combined to form a composite sample of about 4 kg (about 4 L in volume) representing a batch of 25,000 kg of beads. The composite sample will be riffled in the laboratory until about a 150 g sample is obtained for the following testing.

1750.09.01.02 Roundness Testing

The percentage true spheres shall be determined by one of the following methods:

- a) By counting the beads under 50X and 100X magnification as follows:
 - i. Glass beads larger than #50 sieve size inclusive, shall be counted under 50X magnification (see gradation requirements).
 - ii. Glass beads smaller than #50 sieve size shall be counted under 100X magnification.
 - iii. Approximately 1,000 beads contained loosely in a culture dish shall be counted under reflected light for each sieve specified to determine the percentage by mass of perfectly round spheres.
- b) By ASTM D1155.

1750.09.01.03 Imperfections Testing

Imperfections shall be evaluated by observation under 50X and 100X magnification.

1750.09.01.04 Water Resistance Test

One hundred grams of glass beads will be placed in a 500 ml beaker and an equivalent volume of distilled water will be flowed into the beaker on top of the glass beads. The beaker will be permitted to stand for 5 minutes. At the end of this period, the water shall be poured off and the glass beads will be transferred to a clean, dry beaker and permitted to stand for 5 minutes. The spheres will then be introduced into a standard 125 mm diameter glass funnel having a stem of 125 mm length. The beads shall flow through the funnel without stoppage. Slight initial agitation to start the flow through the funnel at the beginning of the test will be permissible.

1750.09.02 Packaging

Beads in bags shall be free of clusters, lumps, moisture, and foreign matter.

Glass beads shall be packaged in bags of 25 kg net capacity and each bag shall be marked to show clearly the following information:

- a) Overlay Type Glass Beads
- b) Moisture Proof Grade
- c) MTC
- d) Batch number
- e) Manufacturer's name (marked in 25 mm high letters)

Bags shall be paper-lined burlap with 50 µm polyethylene inserts. The burlap liner, all seams and top closures shall be waterproof and leakproof and shall be capable of maintaining these properties during transportation and numerous handlings.

Bags shall be approximately 0.35 x 0.66 m with the 50 µm polyethylene insert being 0.35 x 0.96 m.

All bags shall be subject to prior approval by the Owner and shall be or be equal in quality to either:

- a) A Bemis Waterproof, Standard Type, single paper lined, cemented centre seam, taped bottom bag, produced by Bemis Bros. Bag Company, St. Louis, Missouri, U.S.A., or
- b) A Lloyd jute bag with polyethylene liner, Code #1010, produced by Lloyd Bag Company Limited, 114, St. Clair Street, Chatham, Ontario.

1750.09.03 Delivery

Delivery details and scheduling shall be as stipulated on the Owner's purchase order.

1750.09.04 Quality Assurance

Any shipment or shipments of this material supplied to the Owner shall be sampled and tested within a 30 Day period immediately following the date of the delivery. Failure to meet the requirements of this specification shall constitute cause for rejection of the shipment. Upon rejection of the shipment, the letters "MTC" shall be made permanently illegible on each bag of the shipment. Rejected materials shall be expeditiously removed and replaced with acceptable materials at no additional cost to the Owner.

1750.09.05 Measurement and Payment

Measurement of beads shall be by kilograms.

Payment at the price specified in the purchasing order shall be for the supply of beads.



Note: The PROV published in April 2018 replaces OPSS 1801 COMMON, November 2014 with no technical content changes.

MATERIAL SPECIFICATION FOR CORRUGATED STEEL PIPE (CSP) PRODUCTS

TABLE OF CONTENTS

1801.01	SCOPE
1801.02	REFERENCES
1801.03	DEFINITIONS
1801.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
1801.05	MATERIALS
1801.06	EQUIPMENT - Not Used
1801.07	PRODUCTION
1801.08	QUALITY ASSURANCE

1801.01 SCOPE

This specification covers the requirements for all corrugated steel pipe products to be used for storm sewers, pipe culverts, and subdrains.

1801.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

G401-14 Corrugated Steel Pipe Products

1801.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Certification Body means an independent 3rd party agency accredited by the Standards Council of Canada that has the qualifications, skills, and expertise required to confirm that a pipe manufacturer

produces pipe products to the quality and requirements of an accepted standard and that has the mandate to certify the pipe products produced.

Certified means pipe products that have been marked with a certification body's logo confirming that the production of the pipe product is in accordance with the quality and requirements of CSA G401.

Corrugated Steel Pipe Products means any one or any combination of the following products:

- round corrugated steel pipe with an end finish
- corrugated steel pipe arch with an end finish
- round structural plate corrugated steel pipe with an end finish
- structural plate corrugated steel pipe arch with an end finish
- round spiral rib pipe with an end finish
- spiral rib steel pipe arch with an end finish
- perforated corrugated steel pipe
- corrugated steel pipe coupler bands with or without gasket
- corrugated steel pipe end sections
- corrugated steel pipe safety slope end treatments
- corrugated steel pipe saddle branches

Delivered Quality means the pipe products' physical condition upon arrival at the construction site in terms of the extent and degree of dents, scratches, cracks, pipe coating integrity, etc., that appear on the pipe products delivered.

1801.05 MATERIALS

1801.05.01 Corrugated Steel Pipe Products

Corrugated steel pipe products shall be according to CSA G401 and Appendix A of the same standard. Coating shall be galvanized, aluminized Type 2, thermoplastic polymer, or polymer laminated as specified in the Contract Documents.

1801.07 PRODUCTION

1801.07.01 Fabrication

The pipe diameter, wall thickness, coating, and type of all corrugated steel pipe products shall be as specified in the Contract Documents.

All corrugated steel pipe products used on the Contract shall be certified and supplied from a manufacturer that produces the corrugated steel pipe products according to CSA G401.

When the delivered quality of certified corrugated steel pipe products is deemed to be unacceptable by the Contract Administrator, the products shall be rejected.

1801.08 QUALITY ASSURANCE

1801.08.01 Inspection, Testing, and Record Keeping

Inspection, testing, and record keeping for corrugated steel pipe products shall be according to CSA G401.

1801.08.02 Markings

Certified corrugated steel round pipe and pipe arch and certified spiral rib round pipe and pipe arch shall be marked according to CSA G401, along with the logo of the certification body and name of the pipe manufacturer.

Certified structural plate corrugated steel pipe plate shall be marked according to CSA G401, along with the logo of the certification body and name of the pipe manufacturer.

Accepted certification body logos confirming certified corrugated steel pipe products shall be as shown in Figures 1 and 2.

1801.08.03 Certificate of Compliance

When requested by the Owner, the Contractor shall provide a certificate of compliance for subdrains and the corrugated steel pipe products used for eccentric loader assemblies to indicate that the product was produced and tested according to the appropriate specification requirements.

When requested by the Owner, the Contractor shall provide a copy of the certificate of compliance from the manufacturer for storm sewers and pipe culverts. The manufacturer's certificate of compliance shall be issued by the certification body confirming that the manufacturer produces certified corrugated steel pipe products in accordance with CSA G401.



FIGURE 1
CSA Standards Certification Logo



FIGURE 2
Canadian Welding Bureau Certification Logo



**ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION**

OPSS.PROV 1802
APRIL 2018
(Formerly OPSS 1802, November 2015)

Note: The PROV published in April 2018 replaces OPSS 1802 COMMON, November 2015 with no technical content changes.

**MATERIAL SPECIFICATION FOR
SMOOTH WALLED STEEL PIPE**

TABLE OF CONTENTS

1802.01	SCOPE
1802.02	REFERENCES
1802.03	DEFINITIONS - Not Used
1802.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
1802.05	MATERIAL - Not Used
1802.06	EQUIPMENT - Not Used
1802.07	PRODUCTION
1802.08	QUALITY ASSURANCE

1802.01 SCOPE

This specification covers the requirements for smooth walled steel pipe to be used for the installation of pipes or casings.

1802.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

Z662-11 Package Consists of Z662-11, Oil and Gas Pipeline Systems, and Z662.1-07, Commentary on CSA Z662-11, Oil and Gas Pipeline Systems

ASTM International

A 252-98e1 Welded and Seamless Steel Pipe Piles

American Water Works Association (AWWA)

C200-05 Steel Water Pipe-6 in. (150 mm) and Larger

1802.07 PRODUCTION

1802.07.01 Requirements

All pipe shall be new and manufactured from steel according to ASTM A 252, Grade 2, with a minimum yield strength of 240 MPa.

Production welding shall be according to AWWA C200.

Pipe ends shall be bevel edged on the outside to an angle of 30°.

Pipe wall thickness shall be according to Table 1, except as amended below:

- a) The least nominal wall thickness for pipe with outside diameters from 88.9 to 141.3 mm shall be 4.8 mm.
- b) When protective coating or cathodic protection for steel casing or carrier pipe is not specified in the Contract Documents, the pipe wall thickness shall be increased to the nearest standard size that is a minimum of 1.6 mm greater than the least nominal wall thickness shown.

1802.07.02 Identification

The following information shall be clearly marked by stencilling, stamping, or painting of each section of pipe:

- a) Name or trademark of the manufacturer.
- b) Heat number.
- c) Outside diameter.
- d) Nominal wall thickness.
- e) Length of pipe.
- f) Weight per unit length.
- g) Standard designation.
- h) Grade of steel.

1802.08 QUALITY ASSURANCE

1802.08.01 Certificate

Upon request, suppliers shall provide a certificate to indicate that the product was produced and tested according to the appropriate standard requirements.

1802.08.02**Inspection and Testing**

The Owner reserves the right to make inspections and tests at such time as the Owner considers necessary to ensure the materials supplied are according to this specification. All materials failing to comply with the requirements of this specification shall be rejected.

TABLE 1
Least Nominal Wall Thickness for Steel Casing Pipe
in Cased Crossings and Carrier Pipe in Uncased Crossings

Pipe Outside Diameter mm	Least Nominal Wall Thickness mm	
	Roads	Railways
88.9	3.2	3.2
101.6	3.2	3.2
114.3	3.2	3.2
141.3	4.0	4.0
168.3	4.8	4.8
219.1	4.8	4.8
273.1	4.8	4.8
323.9	4.8	4.8
355.6	4.8	5.6
406.4	4.8	5.6
457.0	4.8	6.4
508.0	4.8	7.1
559.0	5.6	7.9
610.0	6.4	8.7
660.0	6.4	9.5
711.0	6.4	10.3
762.0	6.4	10.3
813.0	6.4	11.1
864.0	6.4	11.9
914.0	6.4	11.9
965.0	7.9	12.7
1016.0	7.9	12.7
1067.0	7.9	12.7
1118.0	7.9	14.3
1168.0	7.9	15.9
1219.0	8.3	15.9
1270.0	8.7	15.9
1321.0	9.5	19.1
1372.0	9.5	19.1
1422.0	9.5	19.1
1524.0	10.3	20.6

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MATERIAL SPECIFICATION FOR CIRCULAR AND ELLIPTICAL CONCRETE PIPE

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APPENDICES

1820-A	Commentary

1820.01 SCOPE

This specification covers the requirements for reinforced and non-reinforced non-pressure circular concrete pipe with rubber gasket joints, and for non-gasketed reinforced elliptical concrete pipe.

1820.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

1820.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1820.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

A257.1-09	Non-Reinforced Circular Concrete Culvert, Storm Drain, Sewer Pipe, and Fittings [Part of A257 Series-09, Standards for Concrete Pipe and Manhole Sections]
A257.2-09	Reinforced Circular Concrete Culvert, Storm Drain, Sewer Pipe, and Fittings [Part of A257 Series-09, Standards for Concrete Pipe and Manhole Sections]
A257.3-09	Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections, and Fittings Using Rubber Gaskets [Part of A257 Series-09, Standards for Concrete Pipe and Manhole Sections]
A3000-08	Cementitious Materials Compendium

ASTM International

C 507M-11	Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric)

Plant Prequalification Program Publication

Prequalification Requirements for Precast Concrete Drainage Products

1820.04 DESIGN AND SUBMISSION REQUIREMENTS

1820.04.01 Design Requirements

1820.04.01.01 Concrete Pipe

Non-reinforced circular concrete pipe shall be according to CAN/CSA A257.1.

Reinforced circular concrete pipe shall be according to CAN/CSA A257.2.

Reinforced elliptical concrete pipe shall be according to ASTM C 507M.

1820.04.01.02 Joints and Gaskets

Joints and gaskets for circular concrete pipe shall be according to CAN/CSA A257.3.

Joints for elliptical concrete pipe shall be according to ASTM C 507M, and according to the requirements outlined in the publication, Prequalification Requirements for Precast Concrete Drainage Products.

Elliptical concrete pipe produced with non-gasketed joints shall be used for storm pipe sewers only.

1820.04.01.03 Jacking Pipe

Jacking pipe shall be according to CAN/CSA A257.2 with a minimum class of 65-D and a minimum concrete strength of 40MPa.

1820.04.01.04 Elliptical Reinforcing

Elliptical reinforcing for circular concrete pipe is not permitted for pipes up to and including 900 mm nominal internal diameter.

1820.04.01.05 Lift Holes and Anchors

Lift holes are not permitted for pipes. Lift anchors are not permitted for pipes up to and including 900 mm nominal internal diameter.

1820.05 MATERIALS

1820.05.01 Cement

Cement shall be Portland cement or a commercial blend of Portland cement and blast-furnace slag or fly ash, or both. Ground granulated blast-furnace slag or fly ash may also be added separately to Portland cement. Whether added separately or in the form of blended cement, ground granulated blast-furnace slag shall constitute not more than 70% by mass of the total cementing materials and fly ash shall constitute not more than 40% by mass of the total cementing materials. The total amount of supplementary cementing materials in the cement for concrete pipe shall not exceed 70% by mass of the total cementing materials.

Portland cement, blended cement, ground granulated blast-furnace slag, and fly ash shall be according to CAN/CSA A3000.

1820.07 PRODUCTION

1820.07.01 General

A manufacturer producing circular concrete pipe or elliptical concrete pipe or both shall possess a current Prequalification Certificate, issued under the Plant Prequalification Program as outlined in the publication, Prequalification Requirements for Precast Concrete Drainage Products.

1820.07.02 Markings

Markings for circular concrete pipe shall be according to CAN/CSA A257.2.

Markings for elliptical concrete pipe shall be according to ASTM C 507M.

In addition, all pipe shall be marked with the Prequalification Stamp shown in Figure 1 and as outlined in the publication, Prequalification Requirements for Precast Concrete Drainage Products.



Figure 1
Prequalification Stamp

Appendix 1820-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



MATERIAL SPECIFICATION FOR PRECAST REINFORCED CONCRETE BOX CULVERTS WITH SPAN 3m OR LESS

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1821.09	OWNER PURCHASE OF MATERIAL - Not Used
1821.01	SCOPE

This specification covers the material and fabrication requirements of single-cell precast reinforced concrete box culverts with span 3 m or less (including imperial sized spans of 3.048 m).

1821.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete
OPSS 909	Prestressed Concrete - Precast Concrete
OPSS 919	Formwork and Falsework

Ontario Provincial Standard Specifications, Material

OPSS 1002	Aggregates - Concrete
OPSS 1302	Water
OPSS 1306	Burlap
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications

Structural Manual

MTO Laboratory Testing Manual:

- LS-410 Method of Test for Compressive Strength of Concrete Cores
- LS-412 Method of Test for Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals
- LS-432 Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
- LS-433 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

MTO Forms:

- PH-CC-433A Concrete Mix Design Form A
- PH-CC-701 Request to Proceed
- PH-CC-702 Notice to Proceed

CSA Standards

- A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*
* [Part of A23.1-19/A23.2-19 – Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]
- A23.4-16 Precast Concrete Materials and Construction
- S6-19 Canadian Highway Bridge Design Code
- W47.1-09 (R2019) Certification of companies for fusion welding of steel
- W59-18 Welded steel construction (metal arc welding)
- W186 Welding of Reinforcing Bars Company Certification

ASTM International

- A153/A153M-16a Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- A240/A240M-22 Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

1821.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Box Culvert means a box culvert constructed of precast reinforced concrete box units rectangular in cross-section, with a span 3 m or less and includes imperial sized spans of 3.048 m.

Box Unit means a single precast reinforced concrete box unit of a box culvert.

Concrete Appurtenances means as defined in OPSS 422.

Dry Cast Concrete means concrete with a slump of 0 mm at the time of placing, that is consolidated in the form using low-frequency high-amplitude vibration.

Height of Fill means the smallest elevation difference, between the top surface of box culvert and the top of pavement or finished grade, from edge of shoulder to edge of shoulder.

Honeycombing means rough and stony concrete surface with voids where the mortar did not fill the spaces between the coarse aggregate particles.

Longitudinal Steel Reinforcement means steel reinforcement aligned parallel to the longitudinal axis of the box unit.

Perimeter Steel Reinforcement means perimeter steel reinforcing bars or perimeter wires reinforcement aligned perpendicular to the longitudinal axis of the box unit.

Wet Cast Concrete means concrete with a measurable slump at the time of placing, that is typically consolidated by vibration.

1821.04 DESIGN AND SUBMISSION REQUIREMENTS

1821.04.01 Design Requirements

All box units shall be designed according to CSA S6, the Structural Manual, Division 1, Table 1 and as specified the Contract Documents.

1821.04.02 Submission Requirements

1821.04.02.01 Working Drawings

The box unit manufacturer's Working Drawings, including supporting documentation, shall be submitted to the Contract Administrator at least 7 Days prior to fabrication of the box units. All Working Drawings shall bear the seal and signature of an Engineer certifying they are as specified in the Contract Documents.

1821.04.02.02 Concrete Mix Designs

The concrete mix shall be designed to provide adequate strength and durability for the intended use and to meet the requirements as specified in the Contract Documents. The concrete mix design shall be submitted according to the Mix Design clause in OPSS 1350.

1821.04.02.03 Salt Scaling Resistance in Dry Cast Concrete

Salt scaling results obtained by the manufacturer shall be submitted to the Contract Administrator within 14 weeks of casting the box unit. Salt scaling results shall be current within 3 months at the time of submission. The results shall demonstrate the concrete meets the requirements of this specification.

For evaluation of the salt scaling resistance of dry cast concrete, a set of two specimens shall be cast and tested using the same mix design and production procedures as will be used for the work. The specimens shall be 300 x 300 x 75 mm and shall be tested according to LS-412.

The salt scaling resistance test shall be carried out by a laboratory from MTO's list of qualified laboratories for scaling resistance of concrete surfaces. The salt scaling result shall be the average of a set.

1821.04.02.04 Precast Plant Certification Submissions

The certificate, verifying that the precast plant is certified according to the Precast Plant Certification clause, shall be submitted with the concrete mix design submission.

Copies of precast plant certification audit reports of the Canadian Precast Concrete Quality Assurance Program (CPCQA), Canadian Standards Association (CSA), or both as applicable, and related documentation, shall be submitted to the Owner upon request.

If concrete is supplied by a ready-mix concrete supplier, a currently valid certificate of ready mixed concrete production facilities as issued by the Ready Mixed Concrete Association of Ontario (RMCAO), shall be submitted with the concrete mix design submission.

For multi-year Contracts, for all plants supplying the work, documentation verifying that the precast plant, and ready-mix plant(s) if used, continue to hold valid certification shall be submitted annually.

1821.04.02.05 Manufacturer's Certificate of Conformance and Precast Report

A Manufacturer's Certificate of Conformance and a precast report shall be submitted to the Contract Administrator for each shipment of box units at least 5 Business Days prior to shipping from the precast plant.

The precast report shall contain the following information:

- a) List of box units in the shipment, including their ID number, lot number, and description.
- b) Mill certificates for the steel reinforcement used in the box units.
- c) Summary of material test results for plastic concrete. For wet cast concrete, test results for air content, slump, and concrete temperature shall be submitted. For dry cast concrete, test results for concrete temperature shall be submitted.
- d) Covermeter and dimensional check report.
- e) Summary of material test results for hardened concrete: stripping strength (for wet cast concrete only), confirmation of the projected 28-Day compressive strength. If test results are not available at the time of shipping, they may be submitted within 4 Business Days following completion of testing.
- f) Sampling records for compressive strength, air void system (for wet cast), rapid chloride permeability and scaling resistance (for dry cast).

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator before the delivery of each shipment of box units to the Working Area.

The box units shall not be delivered to the Working Area until the Contract Administrator has issued a MTO form PH-CC-702, Notice to Proceed.

1821.05 MATERIALS

1821.05.01 Associated Hardware

All associated hardware shall be according to OPSS 905, except that all exposed and embedded hardware within 35 mm of exposed faces, including spacers and support devices, shall be non-corroding, non-metallic, or be galvanized according to ASTM A153M, or be stainless steel according to ASTM 240M Type 304.

1821.05.02 Burlap

Burlap shall be according to OPSS 1306.

1821.05.03 Concrete

Concrete materials for precast components shall be according to the Materials section in OPSS 1350 with the following additions and amendments:

- a) The minimum specified 28-Day compressive strength shall be 35 MPa, unless otherwise specified in the Contract Documents.
- b) For wet cast concrete, the minimum specified stripping strength shall be 20 MPa, unless otherwise specified in the Contract Documents.

- c) For wet cast concrete, the air void system spacing factor, when tested according to LS-432, shall be 0.200 mm maximum.
- d) For dry cast concrete, the salt scaling resistance when tested according to LS-412 and this specification shall have a mass loss of not more than 0.8 kg/m².
- e) Aggregates shall be according to OPSS 1002.
- f) The allowable proportion of cementing material of ground granulated blast furnace slag in dry cast concrete shall be limited to a maximum of 40% by mass of total cementing materials.

1821.05.04 Formwork

All formwork shall be according to OPSS 919 and CSA A23.4. Formwork shall be fabricated to meet the dimensional tolerances and finishes specified in the Contract Documents. Textile form liners shall not be permitted.

1821.05.05 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

1821.05.06 Water

Water used for curing, including steam curing and pre-soaking of burlap, and water used in proprietary patching materials shall be according to OPSS 1302.

1821.06 EQUIPMENT

1821.06.01 General

Equipment made of aluminum, including tools, shall not come in contact with the plastic concrete.

1821.07 PRODUCTION

1821.07.01 Precast Plant Certification

Box units shall be fabricated by a plant certified according to one of the following:

- a) CPCQA certification program, precast concrete drainage products, or
- b) CSA precast concrete products certification program, group D, drainage products (D1 minimum).

If concrete is supplied by a ready-mix concrete plant, the concrete production facility shall be certified by the RMCAO.

1821.07.02 Markings

As a minimum, the following information shall be lettered with waterproof paint on an upper top haunch of each box unit in the following order, and readily visible for inspection:

- a) Prequalification stamp according to the CPCQA or CSA certification program.
- b) Name or trademark of the manufacturer.

- c) Identification of plant if manufacturer has more than one plant.
- d) Date of manufacture (yyyy-mm-dd).
- e) Unique number.
- f) Specification designation.
- g) MTO site number, when specified in the Contract Documents.
- h) Minimum and maximum height of fill over box units.

In addition, the word "TOP" shall be lettered with waterproof paint on the top surface of each box unit. This requirement shall be waived if the manufacturer installs lift holes in the top slab only.

1821.07.03 Steel Reinforcement

1821.07.03.01 General

The placement of steel reinforcement shall be according to OPSS 905.

Under no circumstance shall reinforcement be inserted into plastic concrete.

1821.07.03.02 Area of Steel Reinforcement

The box unit steel reinforcement area shall be according to Table 1 for the box unit dimensions, wall thickness, and height of fill specified in the Contract Document.

1821.07.03.03 Placement of Steel Reinforcement

The concrete cover shall be according to Table 2.

The clear distance of the end perimeter steel reinforcement shall be not less than 35 mm or greater than 50 mm from the ends of the box unit. Box units may be assembled utilizing any combination of single or double layers of the steel welded wire reinforcement (WWR) or reinforcing steel bars.

The areas of steel reinforcement shall be the steel reinforcement areas as shown in Table 1. Steel reinforcement areas greater than those required shall not be cause for rejection.

1821.07.04 Laps, Welds, and Spacing of Steel Reinforcement

Splices in the perimeter steel reinforcement shall be made by lapping and only at locations specified in the Contract Documents. Sheets of the WWR shall be welded at lap locations using the provisions for non-load-bearing joints according to CSA W186. WWR sheets shall not be welded elsewhere. The welding shall be performed by a welder qualified by the Canadian Welding Bureau (CWB) working for a company certified according to CSA W186. The overlap measured between the outermost longitudinal wires of each WWR sheet shall not be less than the spacing of the longitudinal wires plus 50 mm, or 250 mm, whichever is greater. Lap splices for reinforcing steel bars including longitudinal steel reinforcement, shall be Class B splices according to CSA S6.

The spacing center to center of the perimeter wires shall not be less than 50 mm or greater than 105 mm. The spacing center to center of the longitudinal wires shall not be greater than 205 mm.

Welding of steel hardware shall be according to CSA W59 and shall be performed by a welder qualified by the CWB working for a company certified according to CSA W47.1, Division 1 or 2.

Welding of steel reinforcement shall be according to OPSS 905.

1821.07.05 Joints

The box units shall be produced with bell and spigot ends. The ends shall be of such design that when the boxes are laid together, they will make a continuous box culvert with a smooth interior free of irregularities in the flow line.

1821.07.06 Production of Concrete

1821.07.06.01 General

Production of concrete shall be according to the General, Temperature Control, Mixing Time and Mixing Rate, and Discharge Time subsections in OPSS 1350.

1821.07.06.02 Sampling and Testing of Plastic Concrete for Wet Cast Concrete

For wet cast concrete, sampling and testing of the plastic concrete for slump, air content, and temperature shall be according to OPSS 1350. The results of these tests shall be recorded and submitted in the precast report. The minimum frequency of testing shall be as follows:

- a) For concrete supplied by an external concrete supplier and delivered by a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.
- b) For batches of concrete produced at the precast plant and transported by a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.
- c) For batches of concrete produced at the precast plant, and not delivered by a ready-mix truck, once for each of the first five batches of concrete, until satisfactory control is established, and then once every fifth batch.

Satisfactory control is established when three or five consecutive tests of concrete, as specified above, are within the specified requirements, without adjustments. If any adjustments are required or conducted, testing shall continue until three or five consecutive tests, as specified above, meet the requirements with no adjustments. Satisfactory control shall be established each Day or when there is a break in production longer than 1.5 hours.

Testing of plastic concrete shall be carried out as close as possible to the location of discharge of concrete into the formwork.

Sampling and testing of slump, air content, and temperature of plastic concrete shall be carried out by a person holding either of the following certifications:

- a) CCIL Certified Concrete Testing Technician;
- b) ACI Concrete Field Testing Technician, Grade 1; or
- c) CSA Standards Concrete Field Testing Technician.

The person shall have a valid original card issued by the certifying agency in their possession at all times.

1821.07.06.03 Testing of Plastic Concrete for Dry Cast Concrete

For dry cast concrete, the concrete shall be tested for temperature. Temperature shall be measured according OPSS 1350. The minimum frequency of testing shall be once for each Day of production.

1821.07.07 Placing of Concrete

1821.07.07.01 General

The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation.

For wet cast concrete, concrete shall be deposited within 0.5 m of the top of the steel reinforcement and 1.5 m horizontally of its final position.

Concrete shall be placed at a steady rate, such that a monolithic concrete is obtained without the formation of cold joints or pour lines.

1821.07.07.02 Concrete Placing Restrictions

All surfaces against which concrete is to be placed shall be free of standing water.

All debris shall be removed from the area where concrete is to be placed.

Any surface against which concrete is placed, including any existing concrete, steel reinforcement, structural steel, forms, or other surfaces shall be at a minimum temperature of 5.0 °C immediately prior to commencement of placing concrete. The temperature of the formwork, steel reinforcement or any other material against which concrete is to be placed shall not exceed 30.0 °C.

1821.07.07.03 Consolidation

Internal or external vibrators or both shall be used to thoroughly consolidate concrete.

Vibration shall not be used to make the concrete flow or to spread the concrete more than 1.5 m from the point of deposit.

The requirements of this clause do not apply to self-consolidating concrete, where accepted for use by the Owner.

1821.07.07.04 Concrete Finishing

For wet cast concrete, finishing of the concrete surface shall be done immediately following placement.

No material shall be applied to the concrete surface or the finishing tools to aid in the finishing.

1821.07.08 Curing

1821.07.08.01 General

Box units shall be moist cured until a minimum compressive strength of 25 MPa is achieved or for 4 Days, whichever occurs first.

Except for exposed surfaces, wet cast box units may be cured by leaving the box units in the form.

Dry cast box units and the exposed surfaces of the wet cast box units shall be moist cured using one or a combination of the methods in the Moist Curing clause of this specification.

1821.07.08.02 Moist Curing

Moist curing shall be sufficient to keep all surfaces of the concrete in a continuously wet condition, with no dry areas, by applying one or a combination of the following methods:

- a) Curing according to the Curing with Burlap and Water clause.
- b) Curing by means of continuous water application, e.g. mist.
- c) Curing according to the Steam Curing and Other Application of Heat clause.
- d) Curing by means of immersion in water.

Records of moist curing shall be maintained and submitted according to the requirements of this specification.

Formwork shall be removed within 4 Days of concrete placement and the concrete shall be moist cured for the remainder of the minimum curing period and no less than 24 hours.

1821.07.08.03 Curing with Burlap and Water

Curing with burlap and water shall be according to the Curing with Burlap and Water clause in OPSS 909 with the addition of the following:

- a) Burlap shall be held in place without marring the surface of the concrete.

1821.07.08.04 Steam Curing and Other Application of Heat

Steam curing and application of heat, if used, shall be according to the requirements of the Steam Curing and Other Application of Heat section in OPSS 909.

1821.07.09 Surface Finish

The surface finish shall be according to the Surface Finish subsection in OPSS 904.

1821.07.10 Concrete Cover Measurement

The Contractor shall carry out, at the precast facility, a covermeter survey on two box units, selected at random, per group of 15 consecutively produced box units.

Measurement shall be obtained on a 1 metre grid on all interior and exterior surfaces of the box unit, including the ends of the units.

Cover measurements shall be carried out by a method acceptable to the Contract Administrator and shall be reported in writing to the Contract Administrator prior to delivery of the box units.

1821.07.11 Dimensional Tolerances

The Contractor shall carry out dimension measurements on two box units, selected at random, per group of 15 consecutively produced box units.

Box units shall meet the tolerances according to Table 2 and as specified in the Contract Documents.

For dimensional tolerances not specified, the maximum allowable dimensional variation shall be 1:800 or +/- 5mm, whichever is greater.

1821.07.12 Material Sampling for Acceptance Testing

1821.07.12.01 Sampling of Steel Reinforcement

When requested by the Contract Administrator, samples of steel reinforcement shall be provided to the Owner according to OPSS 905.

1821.07.12.02 Sampling of Water, Admixtures and Cementing Materials

When requested by the Contract Administrator, samples of all cementing materials, admixtures, and water shall be obtained for testing by the Owner.

1821.07.12.03 Sampling of Hardened Concrete for Acceptance Testing

1821.07.12.03.01 General

Test specimens shall consist of cores removed from box units.

Cores shall be removed at the plant or on site when the box unit is between 7 to 10 Days of age, and prior to application of any sealer. Cores and slabs shall be removed in the presence of the Contract Administrator or Owner's representative.

The box units and the location of the cores shall be randomly selected by the Contract Administrator.

1821.07.12.03.02 Notification

A list of box units and their identification numbers shall be submitted to the Contract Administrator within 24 hours of the completion of a lot.

1821.07.12.03.03 Coring

One set of cores shall be obtained from each lot for quality assurance testing as directed by the Contract Administrator.

For dry cast concrete, a set of cores shall consist of five 100 mm diameter and 200 mm long cores.

For wet cast concrete, a set of cores shall consist of six 100 mm diameter and 200 mm long cores.

If the box unit is less than 200 mm thick, the full depth of the box unit shall be cored such that the core has a length to diameter ratio of at least 1.5.

The box unit from which the cores and samples are taken shall be clearly labelled and shall be retained until Contract Completion.

Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain steel reinforcement or other embedded material. A covermeter capable of detecting the type(s) of steel reinforcing materials in the box unit shall be used to establish the location of steel reinforcement and other embedded material prior to coring.

The Contract number, lot number, and unique box unit number shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag, sealed to prevent loss of moisture and placed into clear polyethylene security bags supplied by the Owner when instructed by the Contract Administrator. The specimens shall be accompanied by a transmittal form and MTO form PH-CC-433A, Concrete Mix Design Form A of the concrete mix design for the box unit. At this point, the Contract Administrator shall take possession of, and assume responsibility for the samples. The Contract Administrator or his representative may apply security seals.

The core holes and lift holes shall be filled, within 3 Days, according to the Filling of Core Holes subsection in OPSS 1350, with concrete or a proprietary patching material from the Owner's pre-qualified products list. Concrete used to patch holes shall have comparable properties to that of the concrete used in the box unit.

1821.07.12.04 Access for Quality Assurance

Unhindered access for inspection and testing of all the work shall be provided to the Contract Administrator or Owner's representative.

Any debris and obstructions shall be removed to allow access for the purposes of covermeter and dimensional measurements or inspection.

1821.07.13 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

1821.08 QUALITY ASSURANCE

1821.08.01 General

The acceptance of box units shall be according to the requirements of this specification.

Acceptance for compressive strength, rapid chloride permeability, concrete cover and dimensional measurements of dry cast concrete shall be on a lot basis.

Lots not meeting the requirements of the Contract Documents shall be deemed rejectable.

1821.08.02 Lot Size

The Contract Administrator shall determine the limits of each lot prior to commencing production and shall confirm the specific box units to be included in each lot prior to commencing production of that lot. A lot generally consists of all the box units of the same span and concrete mix design produced during 7 consecutive Days.

1821.08.03 Acceptance of Concrete Compressive Strength

1821.08.03.01 General

Compressive strength shall be determined according to LS-410.

Three cores shall be tested to determine the acceptability of compressive strength of the lot. 28-Day concrete compressive strength of a lot shall be considered acceptable when the average of the three individual compressive strength cores is equal to or greater than the specified strength and no individual core result is more than 10.0% below the specified 28-Day compressive strength.

Test results shall be forwarded to the Contractor as they become available.

1821.08.03.02 Referee Testing of Compressive Strength

Referee testing of compressive strength may only be invoked by the Contractor within 5 Business Days of receipt of the acceptance test result.

Referee testing of compressive strength shall be carried out on a set of three cores taken by the Contractor from the box unit which the acceptance cores were taken from. The cores shall be removed in the presence of the Contract Administrator. Coring shall be according to the Coring clause. Referee cores shall be obtained within 3 Business Days of invoking referee testing.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to LS-410.

Referee test results shall be forwarded to the Contractor as they become available.

The confirmation value for confirming the acceptance test result shall be the greater of 10.0% of the specified strength or 10.0% of the strength of the acceptance cores, expressed to one decimal place.

If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is confirmed, and the acceptance test result shall be used in the determination of acceptance of the lot. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed, and the acceptance test result shall be disregarded and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The cost of referee testing of compressive strength shall be according to OPSS 1350.

1821.08.04 Acceptance of Air Void System in Hardened Concrete

1821.08.04.01 General

For wet cast concrete, one core per lot shall be tested for air void system parameters. Acceptance of air void system shall be based on the result obtained on the core representing the lot.

Testing of air void system shall be according to LS-432. One half of the sample shall be tested to determine the acceptability of the lot. The other half of the sample shall be retained by the Owner for audit purposes.

Test results shall be forwarded to the Contractor as they become available.

For a lot to be considered acceptable, the sample shall have a minimum air content of 3.0% and a spacing factor of 0.200 mm or less. Acceptable lots shall be subject to full payment.

Lots with samples having a spacing factor between 0.200 mm and 0.250 mm shall be considered unacceptable. Unacceptable lots shall be rejected and replaced, except where the Owner permits an unacceptable lot to remain in place. When the Owner permits an unacceptable lot to remain in place it shall be subject to a payment adjustment, calculated according to the Payment Adjustment for Air Void System in Hardened Concrete clause in OPSS 422.

Lots with samples having air content less than 3.0%, a spacing factor more than 0.250 mm or both shall be deemed rejectable.

1821.08.04.02 Referee Testing of Air Void System in Hardened Concrete

Referee testing of air void system in hardened concrete shall be according to OPSS 1350.

The cost of air void system referee testing shall be according to OPSS 1350.

1821.08.05 Acceptance of Rapid Chloride Permeability

1821.08.05.01 General

Acceptance of rapid chloride permeability shall be based on the result obtained on the core representing the lot.

One core per lot shall be tested according to LS-433. Acceptance testing shall be carried out at 28 to 32 Days. Two samples 50 mm long shall be cut from the core representing a lot, tested, and averaged to determine the acceptance of the lot. Another core shall be retained for referee testing.

Test results shall be forwarded to the Contractor as they become available.

1821.08.05.02 Concrete Without Silica Fume

Lots with rapid chloride permeability less than or equal to 2,500 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

Lots with a rapid chloride permeability result greater than 2,500 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 2,500 coulombs and less than 3,500 coulombs shall be subject to a payment adjustment calculated according to the Basis of Payment section in OPSS 422.

Lots with rapid chloride permeability results exceeding 3,500 coulombs shall be deemed rejectable.

1821.08.05.03 Concrete Containing Silica Fume

Lots with rapid chloride permeability less than or equal to 1,000 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

Lots with a rapid chloride permeability result greater than 1,000 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 1,000 coulombs and less than 2,000 coulombs shall be subject to a payment adjustment calculated according to the Basis of Payment section in OPSS 422.

Lots with rapid chloride permeability results exceeding 2,000 coulombs shall be deemed rejectable.

Test results shall be forwarded to the Contractor as they become available.

1821.08.05.04 Referee Testing of Rapid Chloride Permeability

1821.08.05.04.01 General

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 5 Business Days of receipt of the acceptance test result.

Referee testing shall be carried out on two 50 mm samples obtained from the reserved core representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.

Cores shall be tested according to LS-433.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested by that laboratory.

Referee test results shall be forwarded to the Contractor as they become available.

The cost of referee testing of rapid chloride permeability for all concrete shall be according to OPSS 1350.

1821.08.05.04.02 Concrete Without Silica Fume

When the referee result is greater than the acceptance test result or no more than 500 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 500 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

1821.08.05.04.03 Concrete Containing Silica Fume

When the referee result is greater than the acceptance test result or no more than 300 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 300 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall be used for determining acceptability of the lot.

1821.08.06 Acceptance of Water, Admixtures, and Cementing Materials

Acceptance of water, admixtures and cementing materials shall be according to OPSS 1350.

1821.08.07 Dimensional Verification and Concrete Cover Measurements

The Contract Administrator shall carry out measurements on interior and exterior surfaces on at least one box unit per lot to confirm compliance with the requirements of Table 2 and the Contract Documents. The Contract Administrator shall be notified in writing when the test area is ready for the concrete covermeter survey and dimensional verification.

If a box unit fails to meet the dimensional or cover tolerances specified in Table 2 and the Contract Documents:

- a) It shall be deemed rejectable; and
- b) A consultant shall be retained by the Owner, at the Contractor's expense, to verify that all the other box units in the lot are within the tolerances of Table 2 and as specified in the Contract Documents.

1821.08.08 Defects and Deficiencies Causing Rejection

An individual box unit having one or more of the following defects and deficiencies shall be deemed rejectable:

- a) Inadequate area of steel reinforcement or cover to steel reinforcement;
- b) Dimensions outside of the tolerances specified in Table 2 and the Contract Documents;
- c) Defects resulting from incorrect proportioning, mixing, and forming;
- d) Cracks greater than 0.3 mm in width or full-depth cracks;
- e) Honeycombed or broken surface texture; and
- f) Spalls and damaged ends.

TABLE 1 (1.1 to 1.9)
Steel Reinforcement Areas

Table 1.1: 1.8 m span by 0.9 m rise. 200 mm wall thickness. As4=400							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	520	415	400	400	425	510	600
As2	1010	410	400	420	525	635	810
As3	480	425	400	435	540	650	865
As5	300	140	140	140	140	140	140

Table 1.2: 1.8 m span by 1.2 m rise. 200 mm wall thickness. As4=400							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	470	400	400	400	400	465	545
As2	1085	440	400	445	555	670	865
As3	480	460	400	465	575	695	950
As5	300	140	140	140	140	140	140

Table 1.3: 2.4 m span by 1.2 m rise. 200 mm wall thickness. As4=400							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	790	725	545	645	755	920	1085
As2	1350	700	565	715	905	1400	2480
As3	565	730	590	745	930	1560	2750
As5	300	140	140	140	140	140	140

Table 1.4: 2.4 m span by 1.5 m rise. 200 mm wall thickness. As4=400							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	730	685	515	605	705	855	1010
As2	1385	790	630	800	1010	1430	2500
As3	630	825	665	835	1045	1600	2850
As5	300	140	140	140	140	140	140

Table 1.5: 2.4 m span by 1.8 m rise. 200 mm wall thickness. As4=400							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	675	650	490	570	665	800	945
As2	1445	830	660	830	1045	1510	2670
As3	675	875	705	880	1095	1740	3060
As5	300	140	140	140	140	140	140

Table 1.6: 3.0 m span by 1.5 m rise. 250 mm wall thickness. As4=500							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	850	875	660	775	905	1090	1290
As2	1260	835	675	855	1070	1680	2910
As3	620	875	715	895	1110	1910	3310
As5	300	140	140	140	140	140	140

Table 1.7: 3.0 m span by 1.8 m rise. 250 mm wall thickness. As4=500							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	800	835	630	740	855	1035	1215
As2	1290	930	750	945	1185	1685	2950
As3	660	985	800	995	1240	1950	3380
As5	300	140	140	140	140	140	140

Table 1.8: 3.0 m span by 2.1 m rise. 250 mm wall thickness. As4=500							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	750	805	610	710	820	985	1155
As2	1340	970	775	980	1225	1780	3080
As3	700	1035	835	1040	1290	2080	3610
As5	300	140	140	140	140	140	140

Table 1.9: 3.0 m span by 2.4 m rise. 250 mm wall thickness. As4=500							
	Fill <0.6 m	Fill = 0.6 m	Fill = 2.0 m	Fill = 3.0 m	Fill = 4.0 m	Fill = 5.0 m	Fill = 6.0 m
As1	770	740	565	650	750	900	1055
As2	1380	1010	800	1010	1260	1860	3220
As3	745	1080	875	1080	1335	2220	3850
As5	300	140	140	140	140	140	140

Notes Table 1 (1.1 to 1.9):

- a) All metric or all imperial dimensions may be used for span, height, and wall thickness unless specified in the Contract Documents.
- b) Specified yield strength of welded WWR $F_y = 500$ MPa. Reinforcing steel bar, if used, shall be grade 500W.
- c) Area of steel reinforcement given is mm^2 per metre length of box unit. In Table 1.1 through Table 1.9:
 - i. As1 shall be the area of steel of the C-shaped bars on the outside face of the box culvert.
 - ii. As2 shall be the area of steel on the bottom face of top slab.
 - iii. As3 shall be the area of steel on the top face of the bottom slab.
 - iv. As4 shall be the area of steel on the inside face of the walls.
 - v. As5 shall be the area of steel in the longitudinal direction on each face of all slabs and walls.
 - vi. As6 = 525 shall be the longitudinal steel reinforcement required on the bottom face of the top slab, in lieu of As5, only when depth of fill is <0.6 m.
 - vii. The extent and details of the steel reinforcement shall be as specified in the Contract Documents.

- d) The area of steel reinforcement for As1 through As3, shall be determined from Table 1 for height of fill at both edges of pavement and at the crown. The largest steel reinforcement area for each of As1 through As3 shall be used for each one of these points. Interpolation shall be used for values of height of fill between those tabulated. As4 through As6 shall be taken as applicable on each box culvert size mentioned in their respective in Table 1.1 through Table 1.9
- e) As6 is only required for height of fill <0.6 m. As6 may be added to the area of As5 of the bottom mat of steel reinforcement in the top slab or as a second layer of steel reinforcement on top of the bottom mat of steel reinforcement in the top slab.
- f) Where some reinforcing steel bar is used instead of fully using WWR, or where steel reinforcement is comprised of second layer of steel reinforcement, the effective area of steel reinforcement (A_{se}), calculated as $A_{se} = ASL1 \times \eta_f + ASL2 \times \eta_s$, shall be greater than the tabulated value of As. ASL1 is the Area of steel in the first layer, ASL2 is the Area of steel in the second layer, and η_f and η_s are the efficiency factors obtained from Table 3. The second layer of steel reinforcement shall be placed against the first layer such that the clear spacing of reinforcing steel bar in all layers shall permit proper consolidation of the concrete. (For example, if 1000 mm² of reinforcing steel bar is provided in the first layer of steel reinforcement, and 2000 mm² of WWR is provided in the second layer, and the slab is 200 mm thick, the effective area of steel reinforcement shall be $1000 \times 88\% + 2000 \times 75\% = 2380 \text{ mm}^2$, which must be greater than the value from Table 3).

TABLE 2
Tolerances

Item	Tolerances
Span (Straight-line measurement taken horizontally at the mid-height of box unit perpendicular to the centre line of the culvert.)	± 15 mm from Working Drawings
Height	± 15 mm from Working Drawings
Length	+15/-5 mm
Wall and Slab Thickness	+10 mm, -5 mm
Haunch	± 10 mm
End Squareness or Skew (Note 1)	< 15 mm along its length
Plumbness	1 in 300 maximum
Location of Blockouts	± 15 mm
Location of Inserts	± 10 mm
Concrete Cover	Cover shall be 40 mm, ± 5 mm for WWR and 50 mm ± 15 mm to reinforcing steel bars.
Notes: 1. Variations in the lengths of two opposite surfaces of the box unit. The ends of the box unit shall be normal to the wall and centreline of the box unit within the tolerances specified elsewhere in this Table except where concrete appurtenances are specified in the Contract Documents.	

TABLE 3
Steel Reinforcement Efficiency Factors, η_f and η_s

	First Layer WWR		First Layer Reinforcement Bar	
Section Thickness	(η_f)	(η_s)	(η_f)	(η_s)
200	100%	86%	88%	75%
250	100%	90%	91%	82%



**ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION**

**OPSS.PROV 1840
NOVEMBER 2018**
(Formerly OPSS 1840, November 2015)

Note: The PROV published in November 2018 replaces OPSS 1840 COMMON, November 2015 with no technical content changes.

**MATERIAL SPECIFICATION FOR
NON-PRESSURE POLYETHYLENE PLASTIC PIPE PRODUCTS**

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1840.01 SCOPE

This specification covers the requirements for non-pressure polyethylene (PE) plastic pipe products to be used for sanitary or storm sewers, pipe culverts, and subdrains.

1840.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

B182.6-11	Profile Polyethylene (PE) Sewer Pipe and Fittings for Leak-Proof Sewer Applications [Part of B1800-11, Thermoplastic Nonpressure Pipe Compendium]
B182.8-11	Profile Polyethylene (PE) Storm Sewer and Drainage Pipe and Fittings [Part of B1800-11, Thermoplastic Nonpressure Pipe Compendium]

ASTM International

F 405-13	Corrugated Polyethylene (PE) Pipe and Fittings
F 667-12	3 Through 24 in. Corrugated Polyethylene Pipe and Fittings
F 714-13	Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
F 894-13	Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe

American Association of State Highway and Transportation Officials (AASHTO)

M252-09	Corrugated Polyethylene Drainage Pipe
M294-13	Corrugated Polyethylene Plastic Pipe, 300 to 1,500 mm Diameter

Bureau De Normalisation Du Quebec (BNQ)

3624-115 (2007)	Polyethylene (PE) Pipe and Fittings - Flexible Corrugated Pipes for Drainage - Characteristics and Test Methods.

1840.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Certification Body means an independent 3rd party agency, accredited by the Standards Council of Canada that has the qualifications, skills, and expertise required to confirm that a pipe manufacturer produces pipe products to the quality and requirements of an accepted standard and that has the mandate to certify the pipe products produced.

Certified means pipe products that have been marked with a certification body's logo confirming that the production of the pipe product is in accordance with the quality and requirements of CSA B182.6, CSA B182.8, AASHTO M294 Type S, or ASTM F 894.

Closed Profile Pipe means a pipe product that has a hydraulically smooth waterway reinforced circumferentially or spirally with corrugations that are joined integrally by an essentially smooth outer wall.

Corrugated Pipe means a single-walled pipe where the wall is formed into a series of alternating crests and valleys.

Delivered Quality means the pipe products' physical condition upon arrival at the construction site in terms of the extent and degree of dents, scratches, cracks, pipe coating integrity, etc., that appear on the pipe products delivered.

Open Profile Pipe means a pipe product that has a hydraulically smooth waterway reinforced circumferentially or spirally with outside corrugations.

Polyethylene Plastic means plastics based on virgin polymers made with ethylene as essentially the sole monomer.

Profile means a pipe wall construction that presents an essentially smooth surface in the waterway but includes ribs or other shapes, which can be either solid or hollow that helps brace the pipe against diametrical deformation.

1840.05 MATERIALS

1840.05.01 Polyethylene Plastic Pipe Products

The moulding and extrusion material shall be polyethylene plastic according to:

- a) ASTM F 405, ASTM F 667, or BNQ 3624-115 for corrugated sub-drainage tubing.
- b) AASHTO M252 for corrugated interior flexible culvert pipe.

- c) CSA B182.6, CSA B182.8, or AASHTO M294 Type S for open profile sewer and drainage pipe.
- d) ASTM F 714 or ASTM F 894 for closed profile sewer and drainage pipe.

1840.07 PRODUCTION

1840.07.01 Requirements

The pipe diameter, stiffness, material, and type for all polyethylene plastic pipe products shall be as specified in the Contract Documents.

Polyethylene plastic pipe products shall be produced according to the following:

- a) ASTM F 405, ASTM F 667, or BNQ 3624-115 for corrugated sub-drainage tubing and fittings.
- b) AASHTO M252 for corrugated interior flexible culvert pipe.
- c) CSA B182.6, CSA B182.8, or AASHTO M294 Type S for open profile sewer and drainage pipe and fittings.
- d) ASTM F 714 or ASTM F 894 for closed profile sewer and drainage pipe.

All polyethylene plastic pipe products used on the Contract for sewers and culverts shall be certified and supplied from a manufacturer that produces the polyethylene plastic pipe products according to CSA B182.6, CSA B182.8, AASHTO M294 Type S, ASTM F 894 or ASTM F 714.

When the delivered quality of certified polyethylene plastic pipe products is deemed to be unacceptable by the Contract Administrator, the products shall be rejected.

1840.08 QUALITY ASSURANCE

1840.08.01 Testing

Test methods for corrugated polyethylene plastic pipe products shall be according to ASTM F 405, ASTM F 667, BNQ 3624-115 or AASHTO M252, as applicable.

Test methods for open and closed profile polyethylene plastic pipe products shall be according to CSA B182.6, CSA B182.8, AASHTO M294 Type S, ASTM F 894, or ASTM F 714 as applicable.

1840.08.02 Markings

Markings for certified polyethylene plastic pipe products shall be according to CSA B182.6, CSA B182.8, AASHTO M294 Type S, ASTM F 894, or ASTM F 714 as applicable.

As a minimum, the following markings shall be placed, notwithstanding any other required markings, in accordance with the applicable standard:

- a) Pipe nominal size.
- b) Pipe or ring stiffness.
- c) Standard designation (e.g., CSA B182.6).
- d) Manufacturer.

e) Accredited certification body's logo.

Accepted certification body logos confirming certified polyethylene plastic pipe products shall be as shown in Figures 1, 2, and 3.

1840.08.03 Certificate of Compliance

When requested by the Owner, the Contractor shall provide a certificate of compliance for subdrains to indicate that the product was produced and tested according to the appropriate specification requirements.

When requested by the Owner, the Contractor shall provide a copy of the certificate of compliance from the manufacturer for storm sewers and pipe culverts. The manufacturer's certificate of compliance shall be issued by the certification body confirming that the manufacturer produces certified polyethylene plastic pipe products.



FIGURE 1
CSA Standards Certification Logo



FIGURE 2
Warnock Hersey - Intertek Certification Logo



FIGURE 3
NSF International Certification Logo
(Note: Different variations of the NSF logo will also be accepted)



Note: The PROV published in November 2018 replaces OPSS 1841 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR NON-PRESSURE POLYVINYL CHLORIDE PIPE PRODUCTS

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1841.07	PRODUCTION
1841.08	QUALITY ASSURANCE
1841.01	SCOPE

This specification covers the requirements for non-pressure polyvinyl chloride (PVC) plastic pipe products to be used for sanitary and storm sewers, service connections, and pipe culverts.

1841.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

B182.1-11	Plastic Drain and Sewer Pipe and Pipe Fittings [Part of B1800-11, Plastic Nonpressure Pipe Compendium]
B182.2-11	PSM Type Polyvinylchloride (PVC) Sewer Pipe and Fittings [Part of B1800-11, Plastic Nonpressure Pipe Compendium]
B182.4-11	Profile Polyvinylchloride (PVC) Sewer Pipe and Fittings [Part of B1800-11, Plastic Nonpressure Pipe Compendium]

ASTM International

D 3034-14	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
F 679-13a	Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings

F 794-03 (2009)	Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
F 949-10	Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
F 1760-01(2011)	Coextruded Poly (Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
F 1803-06	Poly (Vinyl Chloride) (PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter

Uni-Bell PVC Pipe Association

UNI-B-9-90	Polyvinyl Chloride (PVC) Profile Wall Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter (Nominal Pipe Sizes 4 - 48-inch)

1841.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Certification Body means an independent 3rd party agency, accredited by the Standards Council of Canada that has the qualifications, skills, and expertise required to confirm that a pipe manufacturer produces pipe products to the quality and requirements of an accepted standard and that has the mandate to certify the pipe products produced.

Certified means pipe products that have been marked with a certification body's logo confirming that the production of the pipe product is in accordance with the quality and requirements of CSA B182.1, CSA B182.2, or CSA B182.4.

Delivered Quality means the pipe products' physical condition upon arrival at the construction site in terms of the extent and degree of dents, scratches, cracks, pipe coating integrity, etc., that appear on the pipe products delivered.

Pipe Products means pipe lengths and associated pipe fittings that are needed to construct a pipe sewer run or a pipe culvert.

1841.05 MATERIAL

1841.05.01 Polyvinyl Chloride Pipe Products

The extruded, moulded, and fabricated material shall be polyvinyl chloride plastic according to CSA B182.1, CSA B182.2, CSA B182.4, ASTM D 3034, ASTM F 679, ASTM F 794, ASTM F 949, ASTM F 1760, ASTM F 1803, or UNI-B-9, as applicable, for the appropriate type of polyvinyl chloride plastic pipe products.

1841.07 PRODUCTION

1841.07.01 Requirements

The pipe diameter, stiffness, material, and type of all polyvinyl chloride plastic pipe products shall be as specified in the Contract Documents.

The requirements for profile polyvinyl chloride plastic pipes and associated fittings shall be according to CSA B182.4, ASTM F 794, ASTM F 949, ASTM F 1803, or UNI-B-9, as applicable.

The requirements for smooth interior and exterior walled polyvinyl chloride plastic pipe and associated fittings shall be according to either:

- a) ASTM D 3034 or ASTM F 679 for pipes manufactured without reprocessed-recycled material.
- b) CSA B182.2 for pipes manufactured that may have multilayer construction and the middle layer may have reprocessed-recycled material.
- c) CSA B182.2 or ASTM F 1760 for pipes manufactured having reprocessed-recycled material.

Polyvinyl chloride service connection pipe shall be according to CSA B182.1 and have bell and spigot joints with elastomeric gaskets.

All polyvinyl chloride plastic pipe products used on the Contract shall be certified and supplied from a manufacturer that produces the polyvinyl chloride plastic pipe products according to CSA B182.1, CSA B182.2, CSA B182.4, ASTM D 3034, ASTM F 679, ASTM F 794, ASTM F 949, ASTM F 1760, ASTM F 1803, or UNI-B-9, as applicable, for the appropriate type of polyvinyl chloride plastic pipe products.

1841.07.02 Testing

Testing of polyvinyl chloride plastic pipe products shall be according to the appropriate standard for which the product was produced.

1841.08 QUALITY ASSURANCE

1841.08.01 Inspection and Testing

The Owner reserves the right to make inspections and tests at such times as the Owner may consider necessary to ensure that the materials supplied are in accordance with this specification.

All materials failing to comply with the requirements of this specification shall be rejected.

1841.08.02 Markings

Markings for certified polyvinyl chloride plastic pipe products shall be according to the appropriate standard for which the product was produced.

As a minimum, the following markings shall be placed, notwithstanding any other required markings, in accordance with the applicable standard:

- a) Pipe diameter.
- b) Pipe stiffness.
- c) Standard designation (e.g., CSA B182.2).
- d) Manufacturer.
- e) Accredited certification body's logo.

Accepted certification body logos confirming certified polyvinyl chloride plastic pipe products shall be as shown in Figures 1, 2 and 3.

1841.08.03**Certificate of Compliance**

When requested by the Owner, the Contractor shall provide a copy of the certificate of compliance from the manufacturer for sanitary and storm sewers, service connections, and pipe culverts. The manufacturer's certificate of compliance shall be issued by the certification body confirming that the manufacturer produces certified polyvinyl chloride plastic pipe products.



FIGURE 1
CSA Standards Certification Logo



FIGURE 2
Warnock Hersey - Intertek Certification Logo



FIGURE 3
NSF International Certification Logo
(Note: Different variations of the NSF logo will also be accepted)



Note: The PROV published in November 2018 replaces OPSS 1842 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR PRESSURE POLYETHYLENE PIPE PRODUCTS

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1842.08	QUALITY ASSURANCE

1842.01 SCOPE

This specification covers the requirements for pressure polyethylene pipe products to be used for sewage forcemains, watermains, and associated service connections.

1842.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

B137.1-13 Polyethylene (PE) Pipe, Tubing, and Fittings for Cold Water Pressure Services
[Part of B137 Series-05, Thermoplastic Pressure Piping Compendium]

American Water Works Association (AWWA)

C901-08 Polyethylene (PE) Pressure Pipe and Tubing, ½ In. (13 mm) Through 3 In. (76 mm), for Water Service
C906-15 Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission

1842.05 MATERIALS

1842.05.01 Polyethylene Pipe Products

The moulding and extrusion material used to manufacture polyethylene pipe shall be polyethylene according to the requirements of AWWA C901 or AWWA C906.

The moulding and extrusion material used to manufacture polyethylene fittings shall be polyethylene according to the requirements of AWWA C906 for fittings 100 mm through 1,600 mm and CSA B137.1 for fittings less than 100 mm diameter.

1842.07 PRODUCTION

1842.07.01 Requirements

The requirements for the production of polyethylene pipe and tubing shall be according AWWA C901 or AWWA C906.

The requirements for the production of polyethylene pipe fittings shall be according to AWWA C906 for fittings 100 mm through 1,600 mm diameter and CSA B137.1 for fittings less than 100 mm diameter.

1842.07.02 Markings

Markings for polyethylene pipe and tubing shall be placed so that the intervals between markings are no greater than 1.5 m.

For polyethylene pipe and tubing according to AWWA C901, minimum markings shall be as follows:

- a) Nominal size.
- b) Standard material code designation (e.g., PE 2406).
- c) On pipe, the dimension ratio and diameter base (e.g., DR 11).
- d) On tubing, the word "Tubing" and dimension ratio.
- e) Pressure class (e.g., PC 160).
- f) Standard designation (e.g., AWWA C901).
- g) Manufacturer's name or trademark.
- h) Production record code.

For polyethylene pipe according to AWWA C906, minimum markings shall be as follows:

- a) Nominal size and OD base.
- b) Standard material code designation (e.g., PE 3408).
- c) Dimension ratio (e.g., DR 17).
- d) Pressure class (e.g., PC 100).

- e) Standard designation (e.g., AWWA C906).
- f) Manufacturer's name or trademark.
- g) Production record code.

Markings shall be applied in a manner that will not reduce the strength or damage the pipe and shall remain legible during normal handling and storage.

1842.08 QUALITY ASSURANCE

1842.08.01 Certificate

Upon request, suppliers shall provide a certificate to indicate that the product was produced and tested according to the appropriate specification requirements.

1842.08.02 Inspection and Testing

The Owner may make inspections and tests at such times as considered necessary to ensure that the material supplied is according to this specification.

All materials failing to comply with the requirements of this specification shall be rejected.



Note: The PROV published in April 2018 replaces OPSS 1843 COMMON, November 2013 with no technical content changes.

MATERIAL SPECIFICATION FOR NON-PRESSURE POLYPROPYLENE (PP) PLASTIC PIPE PRODUCTS

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1843.06	EQUIPMENT - Not Used
1843.07	PRODUCTION
1843.08	QUALITY ASSURANCE

1843.01 SCOPE

This specification covers the requirements for non-pressure polypropylene (PP) plastic pipe products to be used for sanitary or storm sewers and pipe culverts.

1843.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

B182.13-11 Profile Polypropylene (PP) Sewer Pipe and Fittings for Leak-Proof Sewer Applications
[Part of B1800-11, Thermoplastic Non-Pressure Pipe Compendium]

1843.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Certification Body means an independent 3rd party agency, accredited by the Standards Council of Canada that has the qualifications, skills, and expertise required to confirm that a pipe manufacturer

produces pipe products to the quality and requirements of an accepted standard and that has the mandate to certify the pipe products produced.

Certified means pipe products that have been marked with a certification body's logo confirming that the production of the pipe product is in accordance with the quality and requirements of CSA B182.13.

Delivered Quality means the pipe products' physical condition upon arrival at the construction site in terms of the extent and degree of dents, scratches, cracks, pipe coating integrity, etc., that appear on the pipe products delivered.

Polypropylene Plastic means a material made with virgin polymers in which propylene is essentially the sole monomer.

Profile means a pipe wall construction that presents an essentially smooth surface in the waterway but includes ribs or other shapes, which can be either solid or hollow that helps brace the pipe against diametrical deformation.

1843.05 MATERIALS

1843.05.01 Polypropylene Plastic Pipe Products

The moulding and extrusion material shall be polypropylene plastic according to CSA B182.13 for profile sewer and drainage pipe.

1843.07 PRODUCTION

1843.07.01 Requirements

The pipe diameter, stiffness, material, and type for all polypropylene plastic pipe products shall be as specified in the Contract Documents.

Polypropylene plastic pipe products shall be produced according to CSA B182.13 for profile sewer and drainage pipe and fittings.

All polypropylene plastic pipe products used on the Contract for sewers and culverts shall be certified and supplied from a manufacturer that produces the polypropylene plastic pipe products according to CSA B182.13.

When the delivered quality of certified polypropylene plastic pipe products is deemed to be unacceptable by the Contract Administrator, the products shall be rejected.

1843.08 QUALITY ASSURANCE

1843.08.01 Testing

Test methods for profile polypropylene plastic pipe products shall be according to CSA B182.13.

1843.08.02 Markings

Markings for certified polypropylene plastic pipe products shall be according to CSA B182.13.

As a minimum, the following markings shall be placed, notwithstanding any other required markings, in accordance with the applicable standard:

- a) Pipe nominal size.
- b) Standard designation (e.g., CSA B182.13).
- c) Manufacturer.
- d) Accredited certification body's logo.

Accepted certification body logo confirming certified polypropylene plastic pipe products shall be as shown in Figure 1.

1843.08.03 Certificate of Compliance

When requested by the Owner, the Contractor shall provide a copy of the certificate of compliance from the manufacturer for storm sewers and pipe culverts. The manufacturer's certificate of compliance shall be issued by the certification body confirming that the manufacturer produces certified polypropylene plastic pipe products.



FIGURE 1
Warnock Hersey - Intertek Certification Logo



Note: The PROV published in April 2018 replaces OPSS 1850 COMMON, April 2013 with no technical content changes.

MATERIAL SPECIFICATION FOR FRAMES, GRATES, COVERS, AND GRATINGS

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1850.07	PRODUCTION
1850.08	QUALITY ASSURANCE

1850.01 SCOPE

This specification covers the requirements for frames with grates or covers for catch basins, maintenance holes, and valve chambers, ditch inlet gratings and locking devices.

1850.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

G164-M92 (R2003) Hot Dip Galvanizing of Irregularly Shaped Articles
W59-03 Welded Steel Construction (Metal Arc Welding)
CAN/CSA-S6-14 Canadian Highway Bridge Design Code

ASTM International

A 36/A 36M-08 Carbon Structural Steel

A 48/A 48M-03	Gray Iron Castings
A 536-84 (2009)	Ductile Iron Castings
F 738M-02 (2008)	Stainless Steel Metric Bolts, Screws, and Studs
F 836M-02 (2010)	Style 1 Stainless Steel Metric Nuts

Society of Automotive Engineers (SAE)

J403-01 Chemical Compositions of SAE Carbon Steels

National Association of Architectural Metal Manufacturers (NAAMM)

Metal Bar Grating Manual

1850.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Cover means a cast iron or ductile iron casting to allow access into a maintenance hole or valve chamber.

Frame means a cast iron or ductile iron casting to support a cover or grate.

Grate means a cast iron or ductile iron casting with parallel or lattice of cross bars to allow water flow and access into a catch basin or ditch inlet.

Grating means a fabricated lattice of steel bars covering a drain, ditch inlet, or pipe outlet.

Locking Device means a device consisting of a cast iron or ductile iron-locking lug and stainless steel bolt, nut, and washer to secure a cover to a frame.

Reticuline Bar means a sinuously bent connecting bar extending between two adjacent bearing bars, alternately contacting and being riveted to each other.

1850.04 DESIGN AND SUBMISSION REQUIREMENTS

1850.04.01 Design Requirements

Frames, grates, covers, and gratings shall be designed to an ultimate limit state of 166.6 kN wheel load. This load includes a live load factor and a dynamic load allowance specified in CAN/CSA-S6. The load application shall be distributed over an area of 250 x 250 mm.

1850.05 MATERIALS

1850.05.01 Frames With Grates or Covers

1850.05.01.01 Castings

Castings shall be according to ASTM A 48M, Class No. 30B, or ASTM A 536, Grade 65-45-12.

1850.05.01.02 Bolts and Nuts

All bolts, nuts, and washers shall consist of stainless steel Type 304. Bolts shall be according to ASTM F 738M and nuts shall be according to ASTM F 836M.

1850.05.01.03 Locking Devices

All components shall be manufactured from material compatible with the associated frame and cover.

Locking lugs shall be cast according to ASTM A 48M, Class No. 30B, or ASTM A 536, Grade 65-45-12.

1850.05.01.04 Hinge Pins

Steel for hinge pins shall be according to ASTM A 36M.

Steel pins shall be cast into the grate during the pouring and filling operation. Pins shall not be added after the grate is cast.

1850.05.02 Gratings

1850.05.02.01 Welded Steel Gratings

Steel for bearing bars and cross bars shall be according to ASTM A 36M.

1850.05.02.02 Riveted Steel Gratings

Steel for bearing bars shall be according to ASTM A 36M.

Steel for reticuline bars shall be according to ASTM A 36M.

Rivets shall be flat-headed according to SAE J403, Grade No. 1015.

1850.05.02.03 Fasteners

Fasteners, except for the bolts, shall be hot dipped galvanized according to CSA G164-M. The bolt thread shall be coated with white non-staining grease after galvanizing.

1850.07 PRODUCTION

1850.07.01 Frames, Grates, and Covers

The castings shall be produced as specified in the Contract Documents.

The castings shall be sound, free from pouring faults, sponginess, cracks, blowholes, and other defects.

Circular frames, covers, and grates shall be furnished with machined horizontal bearing surfaces as specified in the Contract Documents. All square and rectangular frames and grates shall be furnished with an as-cast bearing surface.

1850.07.01.01 Tolerances

- a) For the rectangular frame with two piece cover for meter and valve chambers, tolerances shall be as specified in the Contract Documents.
- b) For all other castings, the overall casting dimensions shall conform to the following tolerances:
 - i. 300 mm or less, ± 3 mm
 - ii. Up to and including 900 mm, ± 6 mm

1850.07.01.02 Markings

The initials or trademark of the manufacturer, product code, year of manufacture, and additional lettering, logos, or markings as specified in the Contract Documents shall be distinctly cast in raised letters on the top side of the frame and the grate or cover.

The word DANGER shall be distinctly cast in the centre portion of the top side of all maintenance hole covers and shall be a minimum of 50 mm in height and a minimum of 6 mm in depth.

If iron for the casting is melted and poured at one foundry and labelled with the name of another organization, manufacturer, or foundry, the castings shall include both the name of the producing foundry and the organization for which the casting is produced. This lettering shall be cast so that the producing foundry and the organization for which the casting is produced can be easily identified on the same side of the casting.

The initials or trademark of the manufacturer, country of manufacture, and date of manufacture (yyyy/mm/dd) shall be cast on the underside of the grate or cover, and as well, on either the top side of the frame flange or on the inside of the frame.

1850.07.01.03 Finish

All surfaces shall be bare, without any coating. The surfaces of castings shall be uniform and free of flaking rust or mounds of rust or debris.

When specified in the Contract Documents, all surfaces shall be painted in the shop with one coat of asphalt or tar base black paint having a minimum softening point of 71 °C. All joints shall be thoroughly coated.

1850.07.02 Gratings

Gratings shall be produced as specified in the Contract Documents.

1850.07.02.01 Welded Gratings

The end bearing bars shall be welded to the angle bars along both legs with a 5 mm fillet weld. Other bearing bars shall be spot welded on each end to the angle bar. Crossbars shall be spot welded at each point of contact with the bearing bars. Welding shall be according to CSA W59.

1850.07.02.02 Reticuline Bars

The section of reticuline bar parallel to the bearing bar at each rivet shall not exceed 40 mm.

1850.07.02.03 Tolerances

All tolerances shall be within the limits specified in the NAAMM Metal Bar Grating Manual.

1850.07.02.04 Finish

Gratings shall be hot dipped galvanized according to CSA G164-M.

1850.07.03 Locking Devices

Locking devices shall be produced as specified in the Contract Documents.

1850.08 **QUALITY ASSURANCE**

1850.08.01 **Certificate**

When requested by the Owner, the Contractor shall provide a certificate from the manufacturer to indicate that the product was produced and tested according to the appropriate specification requirements. The certificate shall be from an independent testing laboratory currently accredited by the Standards Council of Canada.

1850.08.02 **Inspection and Testing**

When requested by the Owner, 2 Type B test bars for each lot of castings as described in ASTM A 48M shall be supplied for tension testing. Test results for the test bars shall be reported within 2 weeks from receipt of the test bars. Testing shall be completed by an independent testing laboratory currently accredited by the Standards Council of Canada.

Additionally, when requested by the Owner, an independent testing laboratory currently accredited by the Standards Council of Canada shall perform load testing and dimensioning of sample castings.

The Owner reserves the right to make inspections and tests at such time as the Owner may consider necessary to ensure the materials are in accordance with this specification. All materials failing to comply with the requirements of this specification shall be rejected.



**MATERIAL SPECIFICATION FOR
RUBBER ADJUSTMENT UNITS FOR MAINTENANCE HOLES,
CATCH BASINS, AND VALVE CHAMBERS**

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1853.08	QUALITY ASSURANCE
1853.09	OWNER PURCHASE OF MATERIAL - Not Used

1853.01 SCOPE

This specification covers the material and performance requirements for rubber adjustment units for maintenance holes, catch basins, and valve chambers.

1853.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

S6-19 Canadian Highway Bridge Design Code

ASTM International

D412-16(2021)	Test Method for Vulcanized Rubber and Thermoplastic Elastomers-Tension
D573-04(2019)	Test Method for Rubber-Deterioration in an Air Oven
D2240-15(2021)	Test Method for Rubber Property-Durometer Hardness
D3574-17	Test Methods for Flexible Cellular Materials-Slab, Bonded, and Molded Urethane Foams

1853.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Flat Profile means not having more than 0.25 mm deviation lineally in 305 mm.

1853.04 DESIGN AND SUBMISSION REQUIREMENTS

1853.04.01 Design Requirements

The maximum thickness of any rubber adjustment unit shall not be greater than 75 mm, and stack height to be in accordance with manufacturer's recommendations.

Rubber adjustment units shall not be adversely affected by exposure to salt, gasoline, antifreeze, or motor oil when tested for resistance to chemical agents.

Thickness of the rubber adjustment units shall be within 3 mm of the manufacturer's stated dimension. All other dimensions shall be within 5 mm of manufacturer's stated dimensions.

1853.05 MATERIALS

1853.05.01 Rubber

Rubber adjustment units shall be made of recycled or virgin rubber - most preferably Styrene-Butadiene Rubber (SBR).

1853.07 PRODUCTION

1853.07.01 Requirements

Adjustment units shall be manufactured using production compression moulding, tooling, and manufacturing practices to be consistent with current technology used for that type of material.

Manufactured rings shall be compressed to a minimum of 300 psi / 20.68 bar.

Adjustment units to be supplied in round, square, and rectangular shapes, and in flat and tapered profiles up to a maximum of 75 mm (3") per ring. Stacking height per manufacturer's recommendation.

1853.07.02 Quality Control

The manufacturing process shall be such that individual units will be consistent in quality and appearance. All rough edges shall be trimmed of excess flash, each ring to be checked for thickness, and flatness.

1853.07.02.01 General

Testing shall be conducted on production run rubber adjustment units not less than 24 hours old and not more than 60 Days old. The temperature of the test specimens shall be maintained at $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for at least 12 hours prior to and during the test period.

1853.07.02.02 Hardness

The moulded surface and interior hardness measurements of the adjustment unit material shall not vary more than 15 points Shore A for any single unit when measured according to ASTM D2240. The readings shall be taken within 1 second after the presser foot is in firm contact with the specimen, unless the durometer has a maximum indicator, in which case the maximum indicated reading shall be recorded within 1 second of the cessation of the indenter travel.

1853.07.02.02.01 Moulded Surface Hardness

A minimum of six measurements for hardness shall be taken on each moulded surface of the adjustment unit. Each measurement shall be at different positions evenly spaced along the adjustment unit surfaces and shall be at least 12 mm from any edge of the adjustment unit.

1853.07.02.02.02 Interior Hardness

The adjustment units selected for testing shall be cut into a minimum of three equal size pieces providing a minimum of six cut surfaces. A total of 15 evenly spaced interior hardness measurements shall be taken of each cut surface. Each measurement shall be at least 6 mm apart and shall be at least 12 mm from any edge of the specimen.

1853.07.02.03 Tensile Strength

A minimum of three test specimens shall be cut from each adjustment unit selected for testing. The tensile strength of each specimen shall be a minimum of 1 MPa when tested according to ASTM D412, Test Method A, using straight specimens.

1853.07.02.04 Compression Deformation and Compression Set

1853.07.02.04.01 Specimens

A minimum of three test specimens shall be cut from each adjustment unit selected for testing. The same samples shall be used for the compression deformation and compression set testing. Each specimen shall have a minimum thickness of 25 mm and a minimum top and bottom surface area of 2,500 mm². The top and bottom surfaces shall not be larger than the plates of the compression equipment.

1853.07.02.04.02 Testing Procedure

Each specimen shall be tested for initial compression deformation, final compression deformation, and compression set.

1853.07.02.04.03 Initial Compression Deformation

The initial compression deformation for each specimen shall be 6% ± 2% when tested in the following manner:

- a) The dimensions of each specimen shall be recorded to the nearest 0.02 mm prior to being subjected to any testing.
- b) Place the specimen in the compression equipment, using extreme care to place it exactly in the centre between the plates to avoid tilting. Apply an initial constant load to achieve 0.05 MPa stress to the specimen. Immediately determine the thickness of the specimen by measuring the distance between the top and bottom plates. This value will represent the initial thickness of the specimen prior to compression.

- c) Over a period of 30 seconds or less, apply and maintain a constant load to achieve 1 MPa stress to the specimen.
- d) Immediately after the required load has been achieved, determine the initial compression deformation thickness of the specimen by measuring the distance between the top and bottom plates and calculate the percentage of compression as follows:

$$C_{d1} = [(D_1 - D_2) / D_1] \times 100$$

where:

C_{d1} = initial compression deformation as a percentage of the initial thickness
 D_1 = initial thickness
 D_2 = initial compression deformation thickness

1853.07.02.04.04 Final Compression Deformation

The final compression deformation for each specimen shall be $6\% \pm 2\%$ when tested in the following manner:

- a) Maintain the load required to achieve the 1 MPa stress for a period of 30 minutes.
- b) At the end of the 30-minute period, determine the final compression deformation thickness of the specimen by measuring the distance between the top and bottom plates and calculate the percentage of compression as follows:

$$C_{d2} = [(D_1 - D_3) / D_1] \times 100$$

where:

C_{d2} = final compression deformation as a percentage of the initial thickness
 D_1 = initial thickness, as derived during the initial compression deformation testing
 D_3 = final compression deformation thickness

1853.07.02.04.05 Compression Set

The maximum compression set for each specimen shall be 4% when tested in the following manner:

- a) Remove the load on the specimen and allow it to rest undisturbed for a period of 30 minutes.
- b) At the end of the 30-minute period, apply a constant load to achieve 0.05 MPa stress to the specimen. Immediately determine the compression set thickness of the specimen by measuring the distance between the top and bottom plates and calculate the percentage of compression set as follows:

$$C_s = [(D_1 - D_4) / D_1] \times 100$$

where:

C_s = compression set as a percentage of the initial thickness
 D_1 = initial thickness
 D_4 = compression set thickness

1853.07.03 Tolerances

The thickness of the adjustment unit shall be within 3 mm of manufacturer's stated dimensions. All other dimensions shall be within 5 mm.

Except for shim or wedge units, the deviation from a plane parallel to theoretical surface shall not be greater than 1 in 500.

1853.07.04 Minimum Physical Requirements

Minimum physical requirements shall be according to Table 1.

1853.07.05 Markings

Each adjustment unit shall be clearly marked on the inside or top surface with the following information:

- a) Manufacturer's name.
- b) Product trade name/catalogue number, if applicable.
- c) Origin of manufacture.
- d) Dimensions of the adjustment unit including:
 - i. thickness,
 - ii. inside dimensions, and
 - iii. outside dimensions.

1853.08 QUALITY ASSURANCE

1853.08.01 Certificate of Conformance

A certificate of compliance from the manufacturer indicating that the physical properties of the material supplied complies with the requirements of this specification shall be submitted to the Contract Administrator prior to installation.

TABLE 1
Minimum Physical Requirements

TEST / STANDARD	PROPERTIES
Hardness - ASTM D2240	Maximum 15 Shore A variance
Tensile Strength - ASTM D412	220 psi 1.5 Mpa 1 Mpa minimum (145 psi)
Compression Deformation - OPSS 1853	6% $\pm$ 2%
Compression Set - OPSS 1853	4% maximum
Density - ASTM D3574 Test A	64.214 Lbs./Cu. Ft. $\pm$ 3%
Thermal Aging Properties - ASTM D573 Tensile, Hardness, Compression Deformation	3Hrs. @ 148• C (300• F) 100% Retained
Low Temperature Brittleness - 24 Hrs. @ -40 C	No signs of cracks, ruptures, or degradation



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MATERIAL SPECIFICATION FOR HIGH DENSITY POLYETHYLENE (HDPE) AND EXPANDED POLYSTYRENE (EPS) ADJUSTMENT UNITS FOR MAINTENANCE HOLES, CATCH BASINS, AND VALVE CHAMBERS

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1854.06	EQUIPMENT - Not Used
1854.07	PRODUCTION
1854.08	QUALITY ASSURANCE

1854.01 SCOPE

This specification covers the material and performance requirements for high density polyethylene (HDPE) and expanded polystyrene (EPS) adjustment units used for maintenance holes, catch basins, and valve chambers.

1854.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

S6-14 Canadian Highway Bridge Design Code

ASTM International

D 543-06	Evaluating the Resistance of Plastics to Chemical Reagents
D 1308-02 (2013)	Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes

1854.03 DEFINITIONS

For the purpose of this specification, the following definition applies:

Flat Surface means a surface not having more than 0.25 mm deviation lineally in 305 mm.

1854.04 DESIGN AND SUBMISSION REQUIREMENTS**1854.04.01 Design Requirements**

Both high density polyethylene (HDPE) and expanded polystyrene (EPS) adjustment units shall meet the following requirements, unless otherwise specified.

Adjustment rings shall not be adversely affected by exposure to salt, gasoline, antifreeze, or motor oil when tested for resistance to chemical reagents.

The maximum allowable deviation from dishing or bowling, as measured at the outer edge with the adjustment ring turned top down on a known flat surface shall be 6 mm.

The thickness of the adjustment units shall be within 3 mm of the manufacturer's stated dimension. All other dimensions shall be within 5 mm of manufacturer's specified dimension.

The appearance of the adjustment units shall be such that it shall have no voided areas, cracks, separations, or protrusions. Ripples or sags on vertical walls shall not cover more than 10% of the surface area. The colour of the adjustment ring shall be consistent.

1854.05 MATERIALS**1854.05.01 High Density Polyethylene (HDPE)**

The injection molding material shall be either recycled or virgin high density polyethylene or a combination of both. The properties of the injection molding material shall be according to ASTM D 1248, Type III, Class B, Category 3.

Adjustment units shall be manufactured from injection molding material that is recyclable as a high density polyethylene product.

The maximum allowable bulging between webs as measured around the largest outside diameter and the points where the outer wall intersects the web sections shall be 3 mm.

The HDPE material shall be tested for resistance to chemical reagents according to ASTM D 543, Practice A.

1854.05.02 Expanded Polystyrene (EPS)

EPS adjustment units shall be manufactured using high density expanded polystyrene with minimum density of 80.1 kg/m³. Core material of both round and square adjustment units shall be made of virgin expanded polystyrene that is polymerized during pre-expansion and aging. Recycled EPS material shall not be used.

EPS adjustment units shall be coated with a highly cross linked plural component polyurea sprayable system. The coating shall be 0.0762 to 0.127 mm thick.

The polyurea coating shall be tested for resistance to chemical reagents according to ASTM D 1308.

1854.07 PRODUCTION

1854.07.01 General

Adjustment units shall be manufactured using production type injection moulding, tooling, and manufacturing practices consistent with current technology being used for the type of material.

All rough edges shall be trimmed prior to shipping.

1854.07.02 Testing During Production

Testing shall be conducted on production run units not less than 24 hours old and not more than 60 Days old.

For each production run, the tests to confirm dimensions, flatness, and to ensure consistent appearance shall occur at a minimum rate of once every 500 adjustment units with the first test being conducted between the 5th and 10th adjustment ring.

1854.07.03 Markings

Each adjustment ring shall be clearly marked on the inside or top surface with the following information:

- a) Manufacturer's name or logo
- b) Product trade name or catalogue number, if applicable
- c) Location of manufacture
- d) Date of manufacture (i.e., yyyy-mm-dd)
- e) Dimensions of the adjustment units, including:
 - i. Thickness
 - ii. Inside dimensions
 - iii. Outside dimensions
- f) If the top and bottom surfaces are different, the side that is to be installed upwards.

1854.07.04 Proof Testing Procedures

1854.07.04.01 General

The adjustment ring shall meet or exceed the design load requirements as specified in CAN/CSA S6, for a CL-625-ONT Truck.

This testing procedure is intended to determine if a product line of similar material strength and structural design meets the performance requirements of Ontario Provincial Standards for Roads and Public Works (OPS) by testing the catch basin units, which are usually one of the smallest adjustment units and therefore under the greatest stress. If the catch basin ring passes, it can then be assumed that larger maintenance hole units of equal material strength and structural design shall also pass. If there are

material or structural differences between the sizes, separate tests shall then need to be conducted for the different materials and types.

Proof testing shall be conducted on production run units not less than 24 hours old and not more than 60 Days old.

1854.07.04.02 Sample Sizes

The manufacturer shall have the option of conducting tests on either a full size 50 mm high catch basin adjustment units for a 600 x 600 mm precast concrete catch basin or 50 mm high mini specimens cut from these units.

When mini specimens are used, the stress that would have been applied to the full size ring shall be the same as applied to the mini specimen.

1854.07.04.03 Maximum Bearing Surface Area

For the purpose of determining the maximum bearing surface area, only the area of the catch basin adjustment ring in contact with the top of a 600 x 600 mm precast concrete catch basin shall be used. Any excess material not in contact shall be removed.

The area of the full size catch basin adjustment ring in contact with the top of a 600 x 600 mm precast concrete catch basin box after removal of excess shall not exceed 0.28 m², which is the calculated area of the top of the catch basin box.

1854.07.04.04 Static Design Full Load Testing Procedure

The static design full load shall be the design load requirements as specified in CAN/CSA S6, determined to be 166.6 kN. This load shall be used for full size testing or the steps for equivalent stress for specimens shall be followed.

1854.07.04.04.01 Specimens

For testing, a minimum of 9 full size 50 mm catch basin adjustment units for specimens or a minimum of 9 mini test specimens cut from a 50 mm catch basin adjustment ring shall be selected. These specimens shall be the same size and be divided into 3 specimens for each of the 3 temperature groupings. The same samples for each temperature groupings shall be used for the compression deformation and compression set testing. For adjustment units using a web design, each mini specimen shall be cut as close to opposing sides of adjacent webs as possible without removing mass from those webs and shall be full thickness of the adjustment ring. The top and bottom surfaces shall not be larger than the plates of the compression equipment.

1854.07.04.04.02 Equivalent Stress and Design Load for Mini Specimens

A_f = the area of the full size catch basin adjustment unit in contact with the top of the catch basin.

A_{ms} = load bearing surface area of the mini specimens

S_i = initial stress on the adjustment ring = 14 kN / A_f

S_f = final stress on the adjustment ring = 166.6 kN / A_f

L_{mi} = initial load on the mini specimens = $S_i \times A_{ms}$

L_{mf} = final load on the mini specimens = $S_f \times A_{ms}$

1854.07.04.04.03 Testing Procedure

Compression deformation and compression set testing shall be as shown in Table 1.

All specimens shall be tested for initial compression deformation, final compression deformation, and compression set. Three samples shall be tested for each of the 3 temperature groupings: -20 °C, +23 °C, and +30 °C.

The specimens shall be maintained at the specified test temperatures for a minimum of 2 hours, immediately prior to the test period.

1854.07.04.04.04 Initial Compression Deformation

The initial compression deformation for each specimen shall be tested in the following manner:

- a) The thickness of each specimen in 4 equally spaced locations around the frame shall be recorded to the nearest 0.02 mm prior to being subjected to any testing. The average of these values shall be recorded as average thickness prior to test (D_0). If D_0 is not between 47 and 53 mm, the specimen shall be replaced.
- b) The specimen shall be placed in the compression equipment using care to place it exactly in the centre between the plates to avoid tilting.
- c) An initial constant load of 14 kN shall be applied on the full size specimens or initial load (L_{mi}) on the mini specimens. Immediately, determine the thickness of the specimen by measuring the distance between the frame and bottom plate in the same 4 equally spaced locations around the frame. The average of these values (D_1) represents the initial thickness of the specimen prior to compression.
- d) Over a period of 30 seconds or less, apply and maintain a constant load of 166.6 kN on the full size specimen or final load (L_{mf}) on a mini specimen.
- e) Immediately after the required load has been achieved, determine the initial compression deformation thickness of the specimen by measuring the distance between the frame and bottom plate in the same 4 locations. Using the average of these measurements (D_2) calculate the average initial compression deformation as follows:

$$C_{d1} = D_1 - D_2$$

Where:

C_{d1} = average initial compression deformation

D_1 = average initial thickness

D_2 = average initial compression deformation thickness

1854.07.04.04.05 Final Compression Deformation

The final compression deformation for each specimen shall be tested in the following manner:

- a) Maintain the load of 166.6 kN in step d) of the Initial Compression Deformation clause for a period of 30 minutes.
- b) At the end of the 30-minute period, determine the final compression deformation thickness of the specimen by measuring the distance between the top and bottom plates at the same 4 locations, average the measurements, and calculate the average final compression deformation as follows:

$$C_{d2} = D_1 - D_3$$

Where:

C_{d2} = average final compression deformation

D_1 = average initial thickness, as determined in step c) of the Initial Compression Deformation clause

D_3 = average final compression deformation thickness

1854.07.04.04.06 Compression Set

The average compression set for each specimen shall be tested in the following manner:

- a) Remove the load on the specimen and allow it to rest undisturbed for a period of 30 minutes.
- b) At the end of the 30-minute rest period, apply a constant 14 kN load to the specimen. Immediately determine the compression set thickness of the specimen by measuring the distance between the frame and bottom plates at the same 4 locations, average the measurements, and calculate the average compression set as follows:

$$C_s = D_1 - D_4$$

Where:

C_s = average compression set

D_1 = average initial thickness, as determined in step c) of the Initial Compression Deformation clause

D_4 = average compression set thickness

1854.07.04.05 Fatigue Load Test

A single full size catch basin ring of area A_f shall be tested to 1,000,000 cycles of 1 second duration for the fatigue load requirements as specified in CAN/CSA-S6, determined to be 98 kN at 23 °C.

At the end of the fatigue testing, the adjustment ring shall perform without failure. Failure of this test is defined as deformation or cracking that would compromise the structural integrity or water tightness of the installation when it is subjected to the specified loads, seasonal temperatures, and placement of hot mix asphalt.

1854.08 QUALITY ASSURANCE

1854.08.01 Certificate

Suppliers shall provide a certificate upon request to indicate that the product was produced and tested in accordance with this specification. Included with the certificate shall be reports from qualified independent third party laboratories proving that the product meets the requirements of this specification.

1854.08.02 Inspection and Testing

The Owner may make inspections and tests at such times as considered necessary to ensure that the material supplied is according to this specification.

All material failing to comply with the requirements of this specification shall be rejected.

TABLE 1
Maximum Allowable Percentage Compression Deformation and Compression Set
For a Single 50 mm Thick Adjustment Unit or Equivalent Sample

Temperature of Adjustment Ring °C	Maximum Average Initial Compression Deformation (C_{d1} / D_1)*100% %	Maximum Average Final Compression Deformation (C_{d2} / D_1)*100% %	Maximum Allowable Average Compression Set (C_s / D_1)*100% %
30	3.3	7.4	1.3
23	1.9	3.0	0.8
-20	1.1	0.8	0.5



MATERIAL SPECIFICATION FOR GEOTEXTILES

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1860.01 SCOPE

This specification covers the requirements for geotextiles.

1860.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

ASTM International

D 4354-12	Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
D 4355/D 4355M-14	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
D 4491/D 4491M-17	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
D 4533/D 4533M-15	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
D 4873-16	Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
D 4632/D 4632M-15a	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

D 6241-14 Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50 mm Probe

Canadian General Standards Board (CGSB)

148.1 No. 10-94 Methods of Testing Geosynthetics - Geotextiles - Filtration Opening Size

Bureau de normalisation du Québec (BNQ)

BNQ 7009-910 Geotextiles - Quality of Geotextiles Used in Road Engineering - Certification Protocol

1860.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Duplicate Samples means two samples taken at the same time and location, one to be used for quality assurance testing and the other for referee testing.

Filtration Opening Size (FOS) means the opening size of a geotextile in microns corresponding to 95% by mass particle diameter passing through the geotextile in the hydrodynamic sieving test CGSB 148.1, Method No. 10.

Geosynthetic means a synthetic material used in geotechnical engineering applications. Geosynthetics may include such items as geotextiles, geomembranes, geocells, geogrids, geonets, and geocomposites.

Geotextile means a permeable synthetic textile material that is used in association with foundation, soil, rock, earth, or other geotechnical related material for one or more of the following functions: separation, filtration, drainage, or protection. They may be woven, non-woven, or knitted.

Lat means a length equal to the circumference of a full geotextile roll provided by the manufacturer.

Minimum Average Roll Value (MARV) means the average value minus two standard deviations of a given property established by the manufacturer during production. The average roll value for a given property must meet or exceed this value.

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that materials received from the Contractor meet the specified requirements.

Quality Control (QC) means a system or series of activities carried out by the Contractor, Subcontractor, supplier, and manufacturer to ensure that materials supplied to the Owner meet the specified requirements.

Referee Testing means testing of a material attribute for the purpose of resolving acceptance issues at the request of the Contractor or the Owner.

1860.04 DESIGN AND SUBMISSION REQUIREMENTS

1860.04.01 Submission Requirements

Prior to the use of a geotextile in the Work, a certificate from the manufacturer stating the name of the manufacturer, product name, style number, chemical composition, and other pertinent information required to fully describe the geotextile as evaluated under the manufacturer's QC program, shall be submitted to the Contract Administrator. The certificate shall identify the name of the supplier of the geotextile covered pipe or tubing. A person having legal authority to bind the manufacturer or supplier shall attest to this certificate.

Upon request, documentation describing the manufacturer's QC program shall be made available to the Contract Administrator.

The requirements stated above shall be waived for geotextiles certified according to BNQ 7009-910.

1860.05 MATERIALS

Geotextile fibre or yarn shall be composed of at least 95% by mass of polypropylene, polyethylene, polyester, or other synthetic polymers, excluding polyamides.

Geotextiles shall contain stabilizers or inhibitors if necessary, to make the filaments resistant to deterioration by excessive ultraviolet (UV) light and heat exposure. Geotextiles shall be resistant to acid and alkali action and shall be unaffected by micro-organisms and insects.

1860.07 PRODUCTION

1860.07.01 Woven Geotextiles

Woven geotextiles shall be produced by interlacing two or more sets of filaments, yarns, fibres, film, tape, or other elements in such a way that the elements pass each other, essentially at right angles and with one set of elements parallel to the fabric axis. The edge of woven geotextiles shall be finished to prevent the outer yarn from pulling away.

1860.07.02 Non-Woven Geotextiles

Non-woven geotextiles shall consist of a manufactured sheet, web, or batt of directionally or randomly-oriented fibres, filaments, or other elements produced by bonding or interlocking the elements by mechanical, thermal, or chemical means.

1860.07.03 Knitted Sock Geotextiles

Knitted sock geotextiles shall be produced by interlooping one or more yarns, fibres, or filaments in a continuous tube. Knitted sock geotextiles are suitable only for wrapping of subdrain pipe.

1860.07.04 Seams

When sections of geotextile are joined by sewing, the seam strength shall be at least 90% of the minimum grab tensile strength requirement for the class of geotextile specified in the Contract Documents.

Seams joining two sections of geotextile shall be sewn with thread meeting the material requirements for the geotextile or, shall be bonded by thermal or chemical means.

1860.07.05 Physical Requirements

1860.07.05.01 Woven and Non-Woven Geotextiles

Woven and non-woven geotextiles are classified as either Class I or Class II and shall meet the physical property requirements shown in Table 1.

1860.07.05.02 Knitted Sock Geotextiles

Knitted sock geotextiles shall meet the physical property requirements shown in Table 2.

1860.07.05.03 Temporary Silt Fence

Geotextiles for temporary silt fence shall be woven or non-woven and shall meet the physical property requirements shown in Table 3.

1860.07.06 Protection during Shipment and Storage

Geotextiles shall be protected against excessive UV exposure and contamination from dirt, dust, moisture, and any other deleterious materials, until they are installed. All geotextiles shall be wrapped in an opaque protective covering from the time of manufacture to the time of installation. The geotextiles and protective wrapping shall be free of tears and punctures, upon delivery to the work.

Geotextiles intended to be covered by soil, rock, earth, or other materials shall not be exposed to direct sunlight for more than 72 hours following the removal of the protective wrap.

Geotextiles shall be protected from temperatures greater than 60 °C.

1860.07.07 Identification

Each roll of geotextile or geotextile-covered pipe or tubing shall be clearly marked according to ASTM D 4873 with a permanent, legible identification tag or label either on the protective wrap or the inner core as applicable, or affixed to a geotextile-covered pipe or tubing. Product labels shall show the name of the manufacturer or supplier, product number, type, Class, roll number, and date of manufacture.

For Class I and Class II geotextiles, the product label requirements stated in the paragraph above, shall be waived for geotextiles certified by the BNQ according to BNQ 7009-910 for the requirements specified in the Materials and Production sections. BNQ-certified geotextiles shall bear the "BNQ" mark of conformity, the BNQ Product Designation, as specified in Table 1, as well as all other identification marks specified by BNQ.

1860.08 QUALITY ASSURANCE

1860.08.01 General

When the Owner has elected to carry out QA testing to ensure that material used in the Work is according to the requirements of this specification, applicable geotextiles shall be sampled and tested according to the methods identified in Tables 1, 2, or 3, at the following rates:

- a) For Class I or II geotextile, one sample per 10,000 m² of installed product.
- b) For knitted sock geotextile, one sample per 10,000 m of installed subdrain pipe wrapped with knitted sock geotextile.
- c) For temporary silt fence geotextile, one sample per 10,000 m of silt fence barrier installed.

When the quantity of a geotextile is less than the lot size specified above, a minimum of one QA sample per each geotextile type shall be tested to verify that the material meets the requirements of this specification.

Testing shall be carried out at a laboratory designated by the Owner. The Owner shall be responsible for all costs associated with QA testing.

1860.08.02 Sampling

1860.08.02.01 General

QA sampling shall be carried out by the Contractor, in the presence of the Contract Administrator.

Sampling shall be according to ASTM D4354 and as specified in the Contract Documents.

All QA samples shall be duplicate samples with both samples taken side-by-side.

Each sample shall be rolled and placed into separate UV-protective containers (e.g., sealed cardboard box or opaque plastic bag). If a rolled sample is too large to fit within a UV-protective container, it may be folded in a manner that minimizes the number of folds required to fit the sample into the container.

Each sample shall be accompanied with a copy of the roll label or identification tag, as well as the appropriate contract-related information and testing requirements, as specified in the Contract Documents. All such information shall be placed in a moisture-proof envelope directly attached to each UV-protective container.

1860.08.02.02 Sample Size, Preparation, and Marking

Samples of Class I and Class II geotextiles shall be the full width of the roll and at least 2.0 meters in length in the machine direction.

Samples of temporary silt fence geotextile and knitted socks shall be a minimum of 3.0 m² in area.

When samples are taken from a roll of material for testing, at least one full lat of the material from that roll shall be discarded prior to sampling.

All samples shall be completely dry, free of damage, dust, or other contamination, at all times. Any samples that have been allowed to become moist or wet shall be air-dried in a protected place, away from direct sunlight until they are completely dry prior to packaging.

All samples shall be permanently marked with the machine direction.

For temporary silt fence geotextile that is attached to wooden stakes, the wooden stakes shall be carefully removed to avoid any tearing of the geotextile and the stakes discarded. The area within 150 mm of each of the stakes that were removed, shall then be permanently marked by crosshatching, to ensure that such areas are not used for testing.

1860.08.03 Acceptance

When QA testing has been carried out, QA test results shall be used for acceptance purposes.

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator, within five Business Days following notification that a sample representing a lot of geotextile does not meet the requirements of this specification. The notification shall include the type and, where applicable, the class of geotextile, as well as the specific attribute or attributes for which the referee testing is being requested.

The retained duplicate QA samples shall be used for referee testing.

Referee testing shall be carried out, as specified herein and elsewhere in the Contract Documents.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

When a referee test result shows that the materials are in accordance with the physical property requirements of this specification, then the material represented by that test result shall be accepted.

When a referee test result shows that the material does not meet the physical property requirements of this specification, then the material represented by that test result, including any material already in the Work, shall be considered rejectable. Rejected material shall be replaced at no additional cost to the Owner.

If a lot is considered rejectable based on the referee test results, then the Contractor shall also be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates specified in the Contract Documents. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

TABLE 1
Physical Property Requirements for Woven and Non-Woven Geotextiles

Property	Test Method	Unit	Geotextile Class			
			Class I		Class II*	
			Woven	Non-Woven	Woven	Non-Woven
			BNQ Product Designation			
			OPSS 1860-I-W	OPSS 1860-I-N	OPSS 1860-II-W	OPSS 1860-II-N
Tensile strength, MARV, minimum	ASTM D 4632/D 4632M	N	800	350	1100	700
Tear strength, MARV, minimum	ASTM D 4533/D 4533M	N	300	180	400	250
Puncture strength, MARV, minimum	ASTM D 6241	N	1650	990	2200	1375
Permittivity, minimum	ASTM D 4491/D 4491M, Method A	s ⁻¹	0.05			
Filtration opening size (FOS), typical	CGSB 148.1, Method No. 10	µm	As specified in the Contract Documents			
Ultraviolet stability, minimum	ASTM D 4355/4355M	%	50% retained tensile strength at 500 hours			

**Note: A Class II Woven geotextile may be used to replace a Class I Woven geotextile or a Class II Non-Woven geotextile may be used to replace a Class I Non-Woven geotextile, as long as the geotextile being proposed for use meets the requirements for Filtration Opening Size (FOS), according to CGSB 148.1, Method No. 10, as specified in the Contract Documents.*

TABLE 2
Physical Property Requirements for Knitted Sock Geotextiles

Property	Test Method	Acceptance Requirements
Puncture resistance, N	ASTM D6241	800
FOS, maximum, µm	CGSB 148.1, Method No. 10	As specified in the Contract Documents
Permittivity, minimum, s ⁻¹	ASTM D 4491/D 4491M, Method A	1.0

TABLE 3
Physical Property Requirements for Temporary Silt Fence Geotextiles

Property	Test Method	Unit	Supported Silt Fence	Unsupported Silt Fence	
				Woven	Non-Woven
Maximum post spacing	-	m	1.2	2.0	1.2
Tensile strength, MARV, minimum	ASTM D 4632/ D 4632M	N	400	550	
Permittivity, minimum	ASTM D 4491/ D 4491M	s ⁻¹	0.05		
Filtration Opening Size (FOS), maximum	CGSB 148.1, Method No. 10	µm	As specified in the Contract Documents		
Ultraviolet stability, minimum	ASTM D 4355/ D 4355M	%	70% retained tensile strength at 500 hours		



ONTARIO PROVINCIAL STANDARD SPECIFICATION

**OPSS.PROV 2001
APRIL 2021**
(Formerly OPSS 2001 November 2014)

Note: The PROV implemented in April 2021 replaces OPSS 2001 COMMON, November 2014 with no technical content changes.

MATERIAL SPECIFICATION FOR SIGNS

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2001.07	PRODUCTION
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2001.09	OWNER PURCHASE OF MATERIAL

2001.01 SCOPE

This specification covers the requirements for signs.

2001.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Ontario Traffic Manual (OTM):
Book 2 - Sign Design, Fabrication & Patterns

CSA Standards

O121-08 (R2013) Douglas Fir Plywood

ASTM International

A4956 - 13 Retroreflective Sheeting for Traffic Control

A653 / A653M - 11	Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
A792 / A792M - 10	Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
B209 - 10	Aluminum and Aluminum-Alloy Sheet and Plate

2001.05 MATERIALS

2001.05.01 General

Signs shall be fabricated according to OTM Book 2. Sign dimensions, patterns, colour, minimum reflective sheeting, and sign blank number shall be according to OTM Book 2, Master Sign Library, Sign Pattern Template.

Sign blank material type shall be selected in accordance with OTM Book 2.

2001.05.02 Aluminum Sign Blanks

Aluminum sign blanks shall be fabricated from aluminum sheeting according to ASTM B209, Alloy 6061-T6 or Alloy 5052-H38. The aluminum shall be 2.1 mm thick.

Sign blanks shall not deviate more than 3 mm from the specified size in any dimension, except thickness.

2001.05.03 Steel Sign Blanks

Steel sign blanks shall be fabricated from galvanized, galvannealed, or galvalume steel made from sheets or coils. Coated steel shall be 1.6 mm thick.

Galvanized and galvannealed steel shall be according to ASTM A653M, regular type, coating designation Z275.

Galvalume steel shall be according to ASTM A792M, coating designation AZM180.

Sign blanks shall not deviate more than 3 mm from the specified size in any dimension, except thickness.

2001.05.04 Plywood Sign Blanks

Plywood sign blanks shall be 19 mm thick, Douglas Fir Medium Density Overlaid Two Sides (MDO 2S) according to CSA O121. The front face and back face overlay shall be 60/60. Inner plies shall be Douglas Fir.

Sign blanks shall not deviate more than 4 mm from the specified size in any dimension, except thickness.

2001.05.05 Retroreflective Sheeting

Retroreflective sheeting shall be according to ASTM D4956.

2001.07 PRODUCTION

2001.07.01 Aluminum and Steel Sign Blanks

2001.07.01.01 General

Sign blanks shall be flat. Raised edges and burrs shall be removed.

2001.07.01.02 Cleaning and Coating

Sign blanks shall be degreased.

Sign blanks shall be prepared ready to accept overlay sheetings and paints according to the manufacturer's specifications.

2001.07.02 Plywood Sign Blanks

2001.07.02.01 Sign Faces

Surfaces shall be smooth, impermeable, and weatherproof.

One coat of primer or appropriate sealer shall be applied to the back face of the sign.

The front face of the sign shall be primed and painted according to the sheeting manufacturer's specifications and instructions.

2001.07.02.02 Sign Edges

All voids in the sign edges shall be filled with plastic wood. One coat of primer or appropriate sealer shall be applied.

2001.07.03 Markings

The month, year of manufacture, and the name of the supplier shall be printed clearly on each sign with a weatherproof marking.

2001.08 QUALITY ASSURANCE

2001.08.01 Inspection and Testing

The quality of the finished product may be subject to inspection and approval by the Owner. The Owner may make tests to govern the acceptance or rejection of the materials.

2001.09 OWNER PURCHASE OF MATERIAL

2001.09.01 Measurement and Payment

For measurement purposes, a count shall be made of the number of signs delivered and accepted.

Payment at the price specified in the purchasing order shall be for the supply of signs delivered to the destination on the date and time specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.



MATERIAL SPECIFICATION FOR IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR BRIDGE STRUCTURES

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APPENDICES

2301-A	Commentary

2301.01 SCOPE

This specification covers the material requirements for impressed current cathodic protection systems for highway bridge structures.

2301.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2301.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2301.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 603	Installation of Ducts
OPSS 609	Grounding
OPSS 935	Impressed Current Cathodic Protection System for Bridge Structures

Ontario Provincial Standard Specifications, Material

OPSS 1350	Concrete - Materials and Production
OPSS 2410	Extra Low Voltage Cables

CSA Standards

C22.2 No. 0.4-M1982 (R1993)	Bonding and Grounding of Electrical Equipment, Protective Grounding
C22.2 No. 5.1-M91	Molded Case Circuit Breakers
C22.2 No. 38-95	Thermosetting Insulated Wires and Cables
C22.2 No. 41-M1987 (R1993)	Grounding and Bonding Equipment
C22.2 No. 56-77 (R1992)	Flexible Metal Conduit and Liquid Tight Flexible Metal Conduit
C22.2 No. 65-93	Wire Connectors
C22.2 No. 85-M89	Rigid PVC Boxes and Fittings
C22.2 No. 158-1987 (R1995)	Terminal Blocks
C233.1-87 (R1995)	Gapless Oxide Surge Arrester for Alternating Current Systems
C57-1966 (R1994)	Electrical Power Connectors for Use in Overhead Line Conductors

ASTM International

B 265-95	Titanium and Titanium Alloy Strip, Sheet and Plate
A 666-94	Specification for Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar for Structural Applications

Others

Ontario Traffic Signal Control Equipment Specification (OTSCES)
Ontario Electrical Safety Code

2301.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Constant Current means an operating mode in a rectifier in which the current is set at a fixed level and the voltage varies according to the anode-to-concrete resistance.

Constant Voltage means an operating mode in a rectifier in which the voltage is set at a fixed level and the current varies according to the anode-to-concrete resistance.

Equipment Assembly means a cabinet containing the assembled and wired cathodic protection control and monitoring equipment.

Spacer Grid means a grid of cross-laid glass fibre reinforced polymer bars (GFRP) used to isolate the anode mesh and distribution bars from the reinforcing steel in order to prevent contact and subsequent shorts.

Instant-Off means as defined in OPSS 935.

Interruption means switching on and off the rectifier output.

Rectifier means a device used to convert alternating current to direct current. In a cathodic protection system, the rectifier is used to regulate the voltage and current output to each zone.

Remote Monitoring and Control Unit (RMU) means a device used to control the operating parameters of a rectifier, collect and transfer operating data of the rectifier and embedded instrumentation to a remote computer, and performs depolarization tests.

Zone means as defined in OPSS 935.

2301.04 DESIGN AND SUBMISSION REQUIREMENTS

2301.04.01 Design Requirements

2301.04.01.01 Cathodic Protection Rectifier

2301.04.01.01.01 General

A rectifier shall be provided for each zone as specified in the Contract Documents. Each rectifier circuit shall be individually controlled and shall be capable of operating in constant current or constant voltage.

Each rectifier circuit shall be able to operate separately. Adjustment of the output of any rectifier circuit shall not affect the preset output of any other rectifier circuit.

The rectifier shall not exceed 970 mm high x 450 mm wide x 320 mm deep. The rectifier shall be enclosed with access openings for the display, control, and external terminal blocks. The rectifier shall be equipped for mounting on a rack in the cathodic protection cabinet.

2301.04.01.01.02 AC Input

The rectifier shall operate on a nominal line voltage of 120 Volts AC, 60 Hz. The rectifier shall be equipped with a 3-wire cord with a 3 prong plug for AC power supply. The rectifier shall accept an AC voltage input range of 95 to 135 VAC.

2301.04.01.01.03 DC Output

The DC output of each rectifier circuit shall have two modes of operation; constant current or constant voltage. The circuit shall provide a visual indication of the mode of operation. The rated DC output of the rectifier circuit shall be 25 volts, 2 amperes. Each rectifier circuit shall be capable of operating from 0 to 100% of the rated amperage and voltage output. The output of each circuit shall be filtered with full wave rectification and shall be electrically isolated from the line input. The output ripple shall not exceed 5% of output voltage when measured at the rated output voltage and current.

Each rectifier circuit shall be equipped with a 0.1 ohm current shunt, precise to 1%, and connected in series with the rectifier output circuitry. The wattage shall be compatible with the rectifier output.

2301.04.01.01.04 DC Panel Meters

Each rectifier circuit shall have a digital DC panel meter for measuring voltage and current.

The meter shall have an accuracy of $\pm 0.5\%$. The operating temperature of the meter shall be from -30 to +60 °C. The input impedance shall be at least 10 Mega ohms.

2301.04.01.01.05 Interruption Capability

The rectifier shall be designed with devices to allow manual interruption and remote electronic interruption for the purpose of instant-off measurements and depolarization testing.

A secondary switch for manual interruption shall be incorporated into the wiring and supplied on the cathodic protection terminal block assembly.

2301.04.01.01.06 Remote Monitoring and Control of Output Current, Voltage and Potential

The rectifier shall be designed with devices so that the output current and voltage of each rectifier circuit can be monitored and the output current and voltage controlled remotely from zero to full rated DC output, with infinite resolution.

2301.04.01.01.07 Operating Temperature and Humidity

The rectifier shall be capable of operating when the ambient temperature is between -30 to +60 °C and the relative humidity is between 10 to 100%. The rectifier shall shutdown automatically on thermal fault above +60 °C and shall be capable of restarting automatically on cooling.

2301.04.01.01.08 Protection Devices

Each rectifier circuit shall be designed with an in-line breaker or other means to protect against overloads and short circuits.

2301.04.01.01.09 Lightning and Surge Protection

The rectifier shall be designed with lightning and voltage surge protection for the AC input and the DC output according to CAN/CSA-C233.1.

2301.04.01.02 Cathodic Protection Remote Monitoring and Control Unit

2301.04.01.02.01 Operational Requirements

The remote monitoring and control unit (RMU) shall be capable of monitoring the "on", "off", and "instant-off" readings of the embedded instrumentation, and the output voltage and current of the rectifier for each zone. The RMU shall be capable of controlling the output current and voltage and be capable of performing depolarization tests.

2301.04.01.02.02 Physical Requirements

The RMU shall not exceed 200 mm high x 450 mm wide x 500 mm deep. The RMU shall be enclosed with stainless steel panels, with access openings for the display, control, and external terminal blocks. The RMU shall be equipped for mounting on a rack in the cathodic protection cabinet.

2301.04.01.02.03 Hardware Requirements

2301.04.01.02.03.01 General

The RMU shall be equipped with a real time clock, a modem, and operating software.

The RMU shall operate on a nominal line voltage of 120 Volts AC, 60 Hz. The RMU shall be equipped with a 3-wire cord with a 3 prong plug for AC power supply. The RMU shall accept an AC voltage input range of 95 to 135 VAC.

The RMU shall be capable of measuring a minimum of 16 analog input parameters for each zone as specified in the Contract Documents.

A switch shall be provided on the front panel of the RMU to bypass the remote control of the current and voltage to allow on-site adjustment of the DC output.

The RMU shall be designed with a current limiting device that can be manually adjusted so that malfunction of the RMU will not result in excessive rectifier current output.

The RMU shall be equipped with a device that will automatically reset the RMU if the program does not operate properly.

2301.04.01.02.03.02 Interrupter

An on/off interrupt device shall be provided for conducting depolarization tests for each zone. The interrupt device shall be capable of opening the circuit within 50 milliseconds after the interrupt signal is given. The output current interrupt signal shall not interfere with normal operation of the rectifier when the RMU malfunctions.

2301.04.01.02.03.03 Communication

The RMU shall be equipped with two RS232 ports for local accessing the system running parameters. All functions provided by the RMU software including the downloading of the stored data shall be available through these ports.

The communication shall be performed via one RS232 port using a wireless data modem. The RMU shall be capable of connecting directly to a portable computer in the field via the other RS232 port. The cable for connecting the RMU and the portable computer shall be supplied with the RMU and the connections shall be made via two part plug-in connectors.

The RMU shall communicate to the remote rectifier system using a wireless data communication system using the following networking technologies: HSPA+ with fallback to HSUPA; HSDPA; UMTS; EDGE; GPRS; or EV-DO, revision A, with fallback to CDMA EV-DO, revision 0, CDMA1xRTT, comprising of an RS232 Serial Port HOST interface. A transparent point to point or point to multipoint link should be implemented between the RMU and the remote system, containing RS232 links as communication input/output terminals.

2301.04.01.02.03.04 Data Storage

The program shall operate so that recorded data is preserved in the event of a power failure to the unit.

The RMU shall have a minimum of 32 GB battery backed data storage.

2301.04.01.02.03.05 Real-Time Clock

The RMU shall be designed with a real time clock to time stamp recorded data, to indicate occurrence of and duration of, and power failures to the unit. The clock shall have a minimum resolution of one second and shall compensate for leap years and days of the month.

2301.04.01.02.03.06 Operating Temperature and Humidity

The RMU shall operate when the ambient temperature is between -30 to +60 °C and relative humidity is in the range of 10 to 100%. The RMU shall shutdown automatically on thermal fault when the ambient temperature is above +60 °C and shall restart automatically on cooling.

2301.04.01.02.03.07 Protection Devices

The RMU circuit shall be protected against current overloading and short circuit using an inline fuse or other means.

2301.04.01.02.03.08 Lightning and Surge Protection

The RMU shall have lightning and surge protection according to CAN/CSA-C233.1 for the AC input and DC output.

2301.04.01.02.03.09 System Operating Indicator

The RMU shall be designed with a system operating indicator located on the front panel.

2301.04.01.02.04 Software Requirements

2301.04.01.02.04.01 General

The software program shall be manually driven and shall include a help menu.

The RMU software shall be compatible with Microsoft Windows 7 Professional for desktop and laptop computer applications.

2301.04.01.02.04.02 Screen Display at Connection

The software shall present the user with a request for a password upon connection of the RMU either by a portable computer via one of the RS232 ports or a remote computer via a modem.

Two password security levels shall be provided:

- a) The OPERATOR password shall be alpha numeric with a minimum of 4 characters and a maximum of 12. The operator function shall be designed to permit the user to monitor the cathodic protection system, perform depolarization testing, and permit the user to change the parameters in the program.

When a password is entered, the program shall display a message to acknowledge the entered password as correct or not. The user shall have three opportunities to enter the correct password.

If the entered password is still incorrect after three attempts, the program shall terminate further communications for 30 minutes.

- b) The MONITOR password shall be alpha numeric with a minimum of 4 characters and a maximum of 12.

The monitor function shall be designed to permit the user to monitor the cathodic protection system and perform depolarization testing, but shall not permit the user to alter any parameters in the program.

2301.04.01.02.04.03 Screen Display with OPERATOR Password

When the OPERATOR password is entered, the OPERATOR menu shall be displayed on the screen providing the options as shown in Table 1.

2301.04.01.02.04.04 Screen Display with Monitor Password

When the MONITOR password is entered, a MONITOR menu providing the options as shown in Table 2 shall be displayed on the screen.

The options specified are selected options from the OPERATOR menu as shown in Table 1.

2301.04.01.03 Cathodic Protection Terminal Block Assembly

The design shall be according to CSA C22.2 No. 158.

The rail shall be designed to accommodate two terminal block zone assemblies.

2301.05 MATERIALS

2301.05.01 General

All electrical materials, equipment, components, or completed assemblies of components shall be approved according to the Ontario Electrical Safety Code.

2301.05.02 Cathodic Protection Equipment Assembly

2301.05.02.01 Fan and Thermostat

The fan and thermostat shall be according to the OSTCES.

2301.05.02.02 Wireless Modem Antenna

The wireless modem antenna shall be a 1/4 wave rod, weatherproof and waterproof, and shall be supplied ready for installation as a unit.

2301.05.02.03 Wire Connections

All wire connectors shall be according to CSA C22.2 No. 65.

2301.05.02.04 Grounding and Bonding Equipment

All equipment used for grounding and bonding shall be according to CSA C22.2 No. 0.4 and No. 41.

2301.05.02.05 Thermoset Wires and Cables

All interconnecting cables shall be according to CSA C22.2 No. 38, shall be at least 19 strand copper, type RWU90 cross link, -40 °C. The AC wiring shall be #14 AWG. The wires in the cables connecting the remote monitoring unit, the rectifier, and the terminal block assembly shall be #22 AWG.

The wire for the rectifier output DC current shall be #12 AWG. The bonding wire to the ground bar shall be No. 6 AWG.

2301.05.02.06 Lightning and Surge Protection

Lightning arresters shall be according to CAN/CSA-C233.1 and meet low voltage applications therein. The protection device shall be rated at a minimum of 650V.

AC surge and lightning protection shall be installed inside the 401C cathodic protection cabinet. The protection shall be used on the AC input side of both the rectifiers and RMU.

DC surge and lightning protection shall be installed inside the 401C cathodic protection cabinet. The protection shall be used on the DC power output side for rectifiers.

The AC and DC surge and lightning protection shall be supplied as specified in the Contract Documents.

2301.05.02.07 Fasteners

All fasteners shall be Type 304 stainless steel according to ASTM A666.

2301.05.02.08 Cable Separation

AC, DC and signal wires shall be shielded electrically from each other to prevent electrical interference.

2301.05.03 Cathodic Protection Cabinet

The cathodic protection cabinet shall be Model 401C according to the OTSCES.

The pedestal and all other associated components shall be according to the OTSCES.

2301.05.04 Cathodic Protection Rectifier

The rectifier shall be supplied by sources as specified in the Contract Documents.

The rectifier and RMU shall be fully compatible in operation. The rectifier and the RMU shall be supplied by the same supplier.

2301.05.04.01 Thermoset Wires and Cables

Wire shall be according to CSA C22.2 No. 38.

2301.05.05 Cathodic Protection Remote Monitoring and Control Unit

The RMU shall be supplied by sources as specified in the Contract Documents.

The rectifier and RMU shall be fully compatible in operation. The rectifier and the RMU shall be supplied by the same supplier.

2301.05.05.01 Wiring

All wiring used in the RMU shall be PVC insulated with a temperature range of -40 to +60 °C at 150V. Cables providing AC power to the RMU shall be according to CSA C22.2 No. 38.

2301.05.06 Cathodic Protection Terminal Block Assembly

The cathodic protection terminal block assembly, including fasteners, shall be manufactured from corrosion resistant materials so that exposure to moisture will not impair the effectiveness of the assembly. The assembly shall be mounted on a DIN rail according to the requirements for mounting on an OTSCES rack.

Each terminal block zone assembly shall have a design specific number of terminal points as shown in Table 3.

Each terminal point shall be capable of accommodating all wire sizes from #6 AWG to #14 AWG.

Terminals 1 to 4, anodes, shall be interconnected with a jumper.

Terminals 5 to 8, cathode structure (CS), shall be interconnected with a jumper.

The assembly shall be equipped with a simple 15 ampere on/off switch, single pole, double throw switch manufactured according to CSA C22.2 No. 5.1 to provide a secondary manual interrupt for the rectifier.

Electrical materials shall be according to CSA C22.2 No. 158.

Extra low voltage cable shall be according to CSA C22.2 No. 38 and shall be at least 7 strand type RWU90 cross link, -40°C.

2301.05.07 Cathodic Protection AC Power Distribution Assembly

The AC power distribution assembly, including the enclosure, circuit breakers, wire connectors, grounding and bonding equipment and thermoset wires shall be supplied as per the OTSCES.

2301.05.08 Identification Marking

The identification marking for the cabinet, rectifier and remote monitoring, and control unit shall be weather resistant on a corrosion resistant metal plate.

2301.05.09 Extra Low Voltage Cables for Cathodic Protection

All extra low voltage cable shall be according to OPSS 2410 or shall be type RWU90, cross link, -40°C, minimum 7-strand copper according to CSA C22.2 No. 38.

2301.05.09.01 Anode Bus Cables

The anode bus cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #6 AWG with black insulation, without splicing.

2301.05.09.02 Cathode Connection Cables

The cathode CS bus cable from the junction box to the rectifier of the cathodic protection cabinet shall be extra low voltage cable #6 AWG with white insulation, without splicing.

The cathode CM extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with red insulation, without splicing.

2301.05.09.03 Reference Cell Cables

2301.05.09.03.01 Graphite Reference Cell Cables

The reference cell extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with green insulation, without splicing.

2301.05.09.03.02 Silver-Silver Chloride Reference Cell Cables

The reference cell extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with blue insulation, without splicing.

2301.05.09.04 Grounding Materials

The ground wire, ground electrodes, and connectors shall be according to OPSS 609.

2301.05.09.05 Connectors

The cable connectors shall be according to CSA C22.2 No. 65 and CSA C57.

2301.05.10 Rigid Ducts and Junction Boxes for Cathodic Protection

2301.05.10.01 Ducts and Fittings

The ducts and fittings shall be rigid RE/PVC watertight and shall be according to OPSS 603.

The flexible liquid tight ducts and fittings shall be according to CSA C22.2 No. 56.

2301.05.10.02 Junction Boxes

The junction boxes shall be rigid PVC as specified in the Contract Documents and according to CAN/CSA C22.2 No. 85.

The boxes shall be supplied with predrilled holes for connectors and two 6 mm diameter drain holes. The drain holes shall be located with a minimum separation of 250 mm at the lowest point in the box where water may collect.

2301.05.11 Anode Mesh

The anode mesh material shall be high purity titanium Grade 1, according to ASTM B265, and coated with a mixed metal oxide catalyst. The diamond dimensions for the anode mesh shall be 80 x 40 mm maximum. The anode mesh shall be supplied in minimum widths of 1 m and as specified in the Contract Documents.

2301.05.11.01 Distribution Bars

The distribution bars shall be titanium Grade 1, according to ASTM B265. The bars shall be 12 mm wide x 1 mm thick and shall be supplied in lengths at least 3 m long.

The surfaces of the bar shall be free of oxides, grease, and other contaminants.

The bars shall be supplied as specified in the Contract Documents.

2301.05.11.02 Anode Mesh Fasteners

The fasteners shall be fabricated from nylon 6/6 grade plastic suitable for long term embedment in concrete, shall be resistant to acid, and shall be capable of securing the mesh anodes in place on concrete surfaces.

The portion of the fastener embedded in the concrete shall be no larger than 8 mm diameter and no more than 33 mm in length.

The fasteners shall be supplied as specified in the Contract Documents.

2301.05.11.03 Spacer Grid

The spacer grid shall consist of 12 mm glass fibre reinforcing polymer bars (GFRP) in each direction with a bar spacing of not more than 200 mm.

2301.05.12 Reference Cells

2301.05.12.01 Graphite Reference Cell

Graphite reference cells shall be 40 x 40 x 150 mm graphite bars, grade SR-45 or equivalent.

Cables for graphite reference cells shall be extra low voltage cables according to OPSS 2410 or shall be #10 AWG RWU90 with green insulation, type RWU90, cross link, -40°C, and minimum 7-strand copper according to CSA C22.2 No. 38.

The 40 x 40 x 150 mm graphite reference cell shall be fitted with a length of extra low voltage cable #10 AWG RWU90 with green insulation. The extra low voltage cable shall be sufficiently long to extend from the point of embedment to the splice in the junction box, without splicing.

The extra low voltage cable shall be securely attached to the graphite bar by means of a threaded brass connector. The cable shall be soldered in a hole in the centre of the brass connector. The brass connector shall be fitted into a drilled and tapped hole in the graphite bar. The brass connector shall be recessed at least 15 mm and shall have side clearances of 15 mm. After soldering, the recess shall be filled to fully seal out water from soldered area. The supplier shall install the cable prior to delivery of the reference cells to the site. The resistance between the end of the cable and the end of the graphite block shall not exceed 1 ohm.

The graphite reference cells shall be supplied as specified in the Contract Documents.

2301.05.12.02 Silver-Silver Chloride Reference Cell

Cables for silver-silver chloride reference cells shall be extra low voltage cables according to OPSS 2410 or shall be #10 AWG with blue insulation, type RWU90, cross link, -40°C, and minimum 7-strand copper according to CSA C22.2 No. 38.

The silver-silver chloride reference cell shall be fitted with a length of extra low voltage cable #10 AWG with blue insulation. The extra low voltage cable shall be sufficiently long to extend from the point of embedment to the splice in the junction box, without splicing.

The silver-silver chloride reference cells shall be supplied as specified in the Contract Documents.

2301.05.13 Cathode Connections

Cables for cathode connections shall be extra low voltage cables according to OPSS 2410 or shall be type RWU90, cross link, -40°C, and minimum 7 strand copper according to CSA C22.2 No. 38.

The cathode CS cable from the point of connection of the reinforcing steel to the junction box shall be extra low voltage #10 AWG RWU90 with white insulation, without splicing.

The cathode CM cable from the point of connection of the reinforcing steel to the junction box shall be extra low voltage #10 AWG RWU90 with red insulation, without splicing.

2301.05.14 Silicone Seal

The silicone seal shall be suitable for electrical applications and burial in concrete.

2301.05.15 Heat Shrink Tubing and Splice Kits

The heat shrink tubing and splice kit shall fully insulate and seal out water from the connection area of the splice and shall be suitable for burial applications.

Heat shrink tubing and splice kits shall be supplied as specified in the Contract Documents.

2301.05.16 Heat Shrink Tape

The heat shrink tape shall fully insulate and seal out water from the connection area of the splice.

2301.05.17 Epoxy

The epoxy shall be non-conductive low viscosity type and suitable for burial in concrete.

Epoxy shall be supplied as specified in the Contract Documents.

2301.05.18 Thermite Weld

Cathode connections to the reinforcing steel shall be made by thermite weld.

2301.05.19 Thread Locking Compound

The thread locking compound shall be a removable anaerobic setting liquid compound that when used in metal to metal contact positively locks and seals the threaded fastener to prevent corrosion and loosening.

2301.07 PRODUCTION

2301.07.01 Cathodic Protection System Equipment Assembly

Assembly of the cathodic protection system shall consist of the following equipment:

- a) Cathodic protection cabinet.
- b) Cathodic protection remote monitoring and control unit.
- c) Cathodic protection rectifier.
- d) Cathodic protection terminal assembly.
- e) Cathodic protection AC power distribution assembly.
- f) Fan with thermostat.
- g) Wireless modem.

The cathodic protection remote monitoring and control unit equipment shall be installed and wired in the cathodic protection cabinet according to the details on the Working Drawings and according to OPSS 935.

The wireless modem antenna shall be installed according to the antenna manufacturer's requirements.

All connections to ground shall extend to the ground bar.

All cables shall be bundled and held in place with nylon cable ties or shall be installed in wiring ducts or raceways.

2301.07.02 Identification Marking

Each of the following cathodic protection system components shall have identification markings showing the manufacturer's name or trade mark; serial number, if available; and the date of manufacture permanently attached with adhesive to the assembly in a highly visible location.

- a) Cathodic protection cabinet.
- b) Cathodic protection rectifier
- c) Cathodic protection remote monitoring and control unit.

Each completed cathodic protection equipment assembly shall have identification marking showing the date, name and site number of the structure, and the assembler's name. The marking shall be weather resistant placed on a corrosion resistant plate permanently attached with adhesive to the inside of the door in a highly visible location.

The terminal block and each rectifier shall be labeled to show their respective zones.

2301.07.03 Quality Control

2301.07.03.01 Cathodic Protection Equipment Assembly

The entire assembly shall be tested using dummy loads prior to shipment to ensure that all components of the assembly are in good working order.

A representative of the supplier of the cathodic protection equipment assembly shall be on site for support and troubleshooting during testing of the installed cathodic protection system

2301.07.03.02 Cathodic Protection Rectifier

The following pre-installation inspection and testing shall be performed:

The rectifier shall be fully tested at low, high, and nominal line voltage. The AC input voltage, current, watts, and the output voltage, current, and efficiency shall be recorded at each input voltage. All rectifier circuits shall be individually tested to ensure that each circuit meets the requirements of this specification.

Each control card shall be subjected to a continuous 180 hour burn-in test. Initially, power shall be applied to each card for 72 hours at an ambient temperature of +60 °C. Power shall be removed and the card cooled for 18 hours in an environment at -30 °C. Power shall be reapplied for 18 hours at -30 °C. The card shall remain energized for 72 hours during which time the ambient temperature shall be +60 °C. The control card shall be tested immediately after removal from the final high temperature cycle. Control cards failing the test shall be replaced and the 180 hour burn-in procedure repeated.

The 180 hour burn-in test required for the entire rectifier operating unit, including control cards, shall be carried out at a testing facility that is certified to International Standards Organization (ISO) 9001.

2301.07.04.03 Cathodic Protection Remote Monitoring and Control Unit

The following pre-installation inspection and testing shall be performed:

The RMU shall be fully tested at low, high, and nominal line voltage.

Each circuit card shall be subjected to a continuous 180 hour burn-in test. Initially, power shall be applied to each card for 72 hours at an ambient temperature of +60 °C. Power shall be removed and the card cooled for 18 hours in an environment at -30 °C. Power shall be reapplied for 18 hours at -30 °C. The card shall remain energized for 72 hours during which time the ambient temperature shall be +60 °C. The card shall be tested immediately after removal from the final high temperature cycle. Circuit cards failing the test shall be replaced and the 180 hour burn-in procedure repeated on the new card.

The 180 hour burn-in test required for the entire RMU operating unit, including control cards, shall be carried out at a testing facility that is certified to ISO 9001.

2301.08**QUALITY ASSURANCE****2301.08.01****Inspection**

All work is subject to an inspection by the Owner's representative prior to shipment.

The Owner's representative shall have free access to the place of manufacture of the assembly while work on the unit is being performed for the purpose of inspecting the work and examining plant records and certificates, materials being used, process of fabrication, and to make any tests as may be considered necessary.

TABLE 1
Operator Menu Options

Option	Explanation
DATE	The DATE option shall display the present date in the form of yyyy/mm/dd (year/month/day). Provision shall be made to permit the OPERATOR to change the date.
TIME	The TIME option shall display the present time in form of hh:mm:ss (hour:minute:second). Provision shall be made to permit the OPERATOR to change the time.
DOCUMENTATION	The DOCUMENTATION option shall provide for the display at least 10 lines of site information as last set by the OPERATOR and shall permit the OPERATOR to change information.
READ	The READ option shall be designed to measure the values of the parameters of applied voltages, applied currents, and reference potentials in all the zones of the cathodic protection system and to display specific zones and all zones when requested by the user. Measurements shall be taken when the power to the rectifier is in the "on" or "off" state. Provisions shall be made for the number of zones specified with 16 channels one for each parameter per zone. The parameters required to be input shall be specified and shall be entered by the supplier. Each parameter shall be labelled and its corresponding unit displayed. The range and resolution required is as follows: Output current - 0 to 10 A with 10 mA resolution Output voltage - 0 to 30 V with 10 mV resolution Reference cell potential - ± 3 V with 1 mV resolution

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Option	Explanation
INSTANT-OFF	The INSTANT-OFF reading option shall be designed to simultaneously measure the instant-off readings of the output voltages, output current, reference cell potentials, and voltage probes in all the zones when the rectifier current is interrupted and display them for a specific zone or all zones. Provision shall be made to permit the OPERATOR to change the "off" time when the instant-off readings of the parameters are taken. The off time shall be measured in increments of 50 milliseconds, starting at 250 milliseconds. Each parameter shall be labelled appropriately and its unit displayed. The range and resolution required shall be as follows: Output current - 0 to 10 A with 10 mA resolution Output voltage - 0 to 30 V with 10 mV resolution Reference cell potential ± 3 V with 1 mV resolution The rectifier shall automatically switch on again after the "instant-off" readings are recorded.
DEPOLARIZATION	The DEPOLARIZATION option shall be designed to perform a depolarization test. Provision shall be made to allow the OPERATOR to change the test duration and sampling rate of the depolarization test. The test duration shall be entered in hours 01 to 999 with a resolution of one hour. The sampling rate shall be shown in minutes 01 to 120 with a resolution of one minute. The values to be measured and stored for the test shall be: - i the value of each parameter before turning the rectifier off. - ii the "instant-off" value using the "off" period from the INSTANT-OFF option. - iii the depolarized value of each parameter at the end of the test. The shift between the "instant-off" and the depolarized readings of all parameters shall be calculated at the end of the test. If a depolarization test is in progress, the message "Depolarization Test is in Progress" and the time remaining in the test shall be displayed. Provision shall be made to permit the user to terminate the test in progress.
MODE	The MODE option shall be designed to enable the OPERATOR to switch between the current and voltage control of the rectifier.

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Option	Explanation
CURRENT ADJUSTMENT	The CURRENT ADJUSTMENT option shall be designed to make provision for the OPERATOR to adjust the current output level for each zone when the rectifier is operated in the current control mode. The output voltage shall be adjusted until the output current meets the set level.
VOLTAGE ADJUSTMENT	Adjust output voltage when the rectifier is operated in the voltage control mode.
PASSWORD CHANGE	The PASSWORD CHANGE option shall be designed to permit the OPERATOR to change the passwords for the MONITOR and OPERATOR levels. The passwords shall consist of alphabet A to Z or numbers 0 to 9 in any combination with a maximum of 12 characters.
PARAMETER CHANGE	The PARAMETER CHANGE option shall be designed to make provisions for the OPERATOR to modify the description and unit of any one parameter in each zone. The description shall consist of up to 20 characters.
TRENDING FREQUENCY CHANGE	The TRENDING FREQUENCY CHANGE option shall be designed to permit the OPERATOR to adjust the trending frequency. The trending frequency change shall be entered in increments of one minute from 1 to 180 minutes to control the amount of data stored in the trend and its resolution.
DOWNLOAD	The DOWNLOAD option shall be designed to permit the OPERATOR to download data from the RMU to the remote computer.
REPORT	The REPORT option shall be designed to provide a summary report showing the site information for the cathodic protection system as listed in the Documentation option, the "on" and "instant-off" values of the parameters, the depolarized readings at the end of the test, and the potential shift between the "instant-off" and the depolarized readings for each zone. Provision shall be made to permit the user to view the report on screen or to print a report at the users option.
BYE	The BYE option shall be designed to display the status of the rectifier indicating whether the rectifier is in the "on" or "off" state and the status of the depolarization test, and when the end of the session is confirmed shall terminate the communication.

TABLE 2
Monitor Menu Options

Option	Explanation
DATE	Display present date.
TIME	Display present time.
DOCUMENTATION	The DOCUMENTATION option shall display the information last set by the OPERATOR.
READ	Measure and display parameters in a specific zone or in all the zones when the power to the rectifier is "on" or "off."
INSTANT-OFF READING	The rectifier shall be automatically switched on after the instant-off readings are recorded. The "off" time shall be that last set by the OPERATOR.
DEPOLARIZATION	The test duration and sampling rate displayed for the depolarization test shall be those last set by the OPERATOR.
REPORT	Produce summary report of depolarization test.
BYE	Terminate communication.

TABLE 3
Cathodic Protection Terminal Block Assembly Terminal Points

	Terminal	Terminal Colour	Lettering	Extra Low Voltage Cable Size AWG
1	Anode	Black	A1	#6
2	Anode	Black	A2	#6
3	Anode	Black	A3	#6
4	Anode	Black	A4	#6
5	Cathode	White	CS1	#6
6	Cathode	White	CS2	#6
7	Cathode	White	CS3	#6
8	Cathode	White	CS4	#6
9	Cathode	Red	CM1	#10
10	Cathode	Red	CM2	#10
11	Cathode	Red	CM3	#10
12	Cathode	Red	CM4	#10
13	Graphite Reference Cell	Green	R1	#10
14	Graphite Reference Cell	Green	R2	#10
15	Graphite Reference Cell	Green	R3	#10
16	Silver-Silver Chloride Reference Cell	Blue	R4	#10

Appendix 2301-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



Note: The PROV published in November 2018 replaces OPSS 2401 COMMON, November 2010 with no technical content changes.

MATERIAL SPECIFICATION FOR ELECTRICAL HANDHOLES

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2401.04	DESIGN AND SUBMISSION REQUIREMENTS
2401.05	MATERIALS
2401.06	EQUIPMENT - Not Used
2401.07	PRODUCTION
2401.08	QUALITY ASSURANCE - Not Used

2401.01	SCOPE

This specification covers the material requirements for electrical handholes.

2401.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

A23.1-09/A23.2-09 (R2014)	Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete
G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
G164-18	Hot Dip Galvanizing of Irregularly Shaped Articles

ASTM International

A 48/A 48M-2016	Grey Iron Casting
C 857-2016	Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
F 593-2017	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

American National Standard Institute (ANSI)

SCTE 77-2017 Specifications for Underground Enclosure Integrity

2401.04 DESIGN AND SUBMISSION REQUIREMENTS

2401.04.01 Design Requirements

All material for non-concrete and semi-concrete handholes shall have a minimum compressive strength of 135 MPa and shall be suitable for installation and use through a temperature range of -40 to +70 °C.

2401.05 MATERIALS

2401.05.01 General

All concrete shall be according to CSA A23.1 and CSA A23.2.

All electrical handholes shall be according to ASTM C 857 and ANSI/SCTE 77.

As a minimum, all non-concrete and semi-concrete electrical handholes consisting of cover and box shall be according to ANSI/SCTE 77 TIER 22.

The thickness of each electrical handhole cover shall be minimum 10 mm.

Each electrical handhole cover shall be galvanized steel according to CAN/CSA G40.20/G40.21 and CAN/CSA G164 or cast ferrous alloy according to ASTM A 48, Class No. 30 C. The top side of each metallic electrical handhole cover shall have a checkered tread.

Non-concrete and semi-concrete electrical handholes installed in earth or sidewalk may have non-metallic covers. The top side of each non-metallic cover shall have a checkered tread or a surface with a static coefficient of friction that is a minimum of 0.5, as determined using the tests specified in ANSI/SCTE 77.

All electrical handholes shall have lugs, studs, or other means of bonding all metallic components to ground.

2401.05.02 Fastening Material

All bolts, studs, screws, nuts, washers and other fastening material shall be stainless steel and shall be according to ASTM F 593.

2401.07 PRODUCTION

2401.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

Electrical handholes shall be produced as specified in the Contract Documents.

2401.07.02 Marking

Each handhole shall have identification markings located on the outside vertical surfaces of the handhole showing the manufacturer's name or trademark and the date of manufacture (i.e., yyyy-mm-dd).

The top surface of the handhole cover shall be permanently marked, showing the manufacturer's name or trademark, the date of manufacture (i.e., yyyy-mm-dd), and the standard designation OPSS 2401. These markings shall be located on the top surface of the handhole cover or embossed into a corrosion-resistant metal plate securely cemented to the top surface of the handhole cover.

2401.07.03 Shipping

The supplier shall provide notice of intent to deliver 3 Business Days prior to the shipping date.



Note: The PROV published in November 2018 replaces OPSS 2409 COMMON, November 2014 with no technical content changes.

MATERIAL SPECIFICATION FOR TRAFFIC SIGNAL CABLE

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2409.01	SCOPE
2409.02	REFERENCES
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2409.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
2409.05	MATERIALS
2409.06	EQUIPMENT - Not Used
2409.07	PRODUCTION
2409.08	QUALITY ASSURANCE - Not Used

2409.01 SCOPE

This specification covers the requirements for traffic signal runner cable and traffic signal riser cable.

2409.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

C22.2 No. 239-17 Control and Instrumentation Cables

2409.03 DEFINITIONS

For the purposes of this specification, the following definitions apply:

Traffic Signal Runner Cable means the polyethylene insulated polyvinyl chloride jacketed multi-conductor cable, for use in traffic signal systems, suitable for direct burial or aerial installation and rated at 600 volts.

Traffic Signal Riser Cable means the polyethylene insulated polyethylene jacketed multi-conductor cable, for use in traffic signal systems, suitable for use on traffic signal pole installation and rated at 600 volts.

2409.05 MATERIALS

2409.05.01 Cable

Traffic signal cable shall be according to CSA C22.2 No. 239, rated 600 volts.

Conductors of the traffic signal runner cable shall be #14 AWG solid copper.

Conductors of the traffic signal riser cable shall be #14 AWG, minimum of 19 strands or #14 AWG solid copper.

2409.05.02 Insulation

Insulation of the conductors shall be according to CSA C22.2 No. 239.

2409.05.03 Jacket

Outside jacket of the traffic signal runner cable shall be as shown in Table 1 and the polyvinyl chloride shall be according to CSA C22.2 No. 239.

2409.05.04 Conductor Identification

Conductor identification shall be according to CSA C22.2 No. 239.

Colour coding and printing of the conductors shall be as shown in Table 2 to 7.

2409.07 PRODUCTION

2409.07.01 General

Traffic signal runner cable and traffic signal riser cable shall be according to CSA C22.2 No. 239.

2409.07.02 Marking

Cable shall be permanently marked according CSA C22.2 No. 239.

TABLE 1
Traffic Signal Runner Cable Outside Jacket Thickness

Diameter of Completed Conductor Assembly mm	Average Jacket Thickness mm	Minimum Jacket Thickness mm
0 - 10.9	2.0	1.6
11 - 17.9	2.4	2.0
18 - 26.9	2.8	2.2
27 - 38.9	3.2	2.6
39 - 50.9	3.6	3.0
51 - 75.9	4.0	3.2
76 and over	4.8	4.0

TABLE 2
4 Conductor Runner Cable

Conductor	Insulation Colour
#1	White
#2	Red
#3	Yellow
#4	Blue

TABLE 3
7 Conductor Runner Cable

Conductor	Insulation Colour	Lettering
#1	White	-
#2	Red	Red one
#3	Red	Red two
#4	Yellow	Amber one
#5	Yellow	Amber two
#6	Blue	Green one
#7	Blue	Green two

TABLE 4
12 Conductor Runner Cable

Conductor	Insulation Colour	Lettering
#1	White	-
#2	Black	-
#3	Orange	-
#4	Red	Red one
#5	Red	Red two
#6	Red	Red three
#7	Yellow	Amber one
#8	Yellow	Amber two
#9	Yellow	Amber three
#10	Blue	Green one
#11	Blue	Green two
#12	Blue	Green three

TABLE 5
19 Conductor Runner Cable

Conductor	Insulation Colour	Lettering
#1	White	White one
#2	White	White two
#3	Black	-
#4	Orange	-
#5	Red	Red one
#6	Red	Red two
#7	Red	Red three
#8	Red	Red four
#9	Red	Red five
#10	Yellow	Amber one
#11	Yellow	Amber two
#12	Yellow	Amber three
#13	Yellow	Amber four
#14	Yellow	Amber five
#15	Blue	Green one
#16	Blue	Green two
#17	Blue	Green three
#18	Blue	Green four
#19	Blue	Green five

TABLE 6
5 Conductor Riser Cable

Conductor	Insulation Colour
#1	White
#2	Red
#3	Yellow
#4	Blue
#5	Green with Yellow Tracer

TABLE 7
7 Conductor Riser Cable

Conductor	Insulation Colour	Lettering
#1	White	-
#2	Red	-
#3	Yellow	Amber one
#4	Yellow	Amber two
#5	Blue	Green one
#6	Blue	Green two
#7	Green with Yellow Tracer	-



MATERIAL SPECIFICATION FOR EXTRA LOW-VOLTAGE CABLE

TABLE OF CONTENTS

2410.01	SCOPE
2410.02	REFERENCES
2410.03	DEFINITIONS - Not Used
2410.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
2410.05	MATERIALS
2410.06	EQUIPMENT - Not Used
2410.07	PRODUCTION
2410.08	QUALITY ASSURANCE - Not Used

2410.01 SCOPE

This specification covers the requirements for extra low-voltage cables suitable for underground or aerial installation.

2410.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

International Municipal Signal Association

- 19-5 1997 Polyethylene Insulated, Polyethylene Belted, Copper Shielded, Polyvinyl Chloride Jacketed Signal Cable
- 50-2 1997 Polyethylene Insulated, Polyethylene Jacketed, Loop Detector Lead-in Cable

2410.05 MATERIALS

2410.05.01 Conductors

Conductors of all cables shall be according to IMSA 19-5 and shall be #14 AWG stranded tinned copper. The number of conductors shall be as specified in the Contract Documents.

2410.05.02 Communication Cables

2410.05.02.01 General

Communication cable shall be polyethylene insulated, polyethylene belted, and polyvinyl chloride jacketed.

2410.05.02.02 Insulation

Insulation and inner belt insulation shall be according to IMSA 19-5.

2410.05.02.03 Shielding

Shielding shall be according to IMSA 19-5.

2410.05.02.04 Jacket

Overall jacket shall be according IMSA 19-5.

2410.05.02.05 Fillers

Fillers shall be according to IMSA 19-5.

2410.05.03 Lead-In Cables

2410.05.03.01 General

Lead-in cables shall be polyethylene insulated and polyethylene jacketed.

2410.05.03.02 Insulation

Insulation shall be according to IMSA 50-2.

2410.05.03.03 Shielding

Shielding shall be according IMSA 50-2.

2410.05.03.04 Jacket

Overall jacket shall be according to IMSA 50-2.

2410.05.03.05 Drain Wire

Drain wire shall be according to IMSA 50-2.

2410.07 PRODUCTION

2410.07.01 Communication Cables

Communication cables shall be according to IMSA 19-5.

2410.07.01.01 Marking

Cable shall be permanently marked according to IMSA 19-5, at intervals not exceeding one metre, showing the following:

- a) Size of conductor.
- b) Voltage rating.
- c) Year of manufacture.
- d) IMSA specification number.

2410.07.02 Lead-In Cables

Lead-in cables shall be according to IMSA 50-2.

2410.07.02.01 Marking

Cable shall be permanently marked according to IMSA 50-2, at intervals not exceeding one metre, showing the following:

- a) Size of conductor.
- b) Voltage rating.
- c) Year of manufacture.
- d) IMSA specification number.



MATERIAL SPECIFICATION FOR POWER SUPPLY EQUIPMENT

TABLE OF CONTENTS

2414.01	SCOPE
2414.02	REFERENCES
2414.03	DEFINITIONS - Not Used
2414.04	DESIGN AND SUBMISSION REQUIREMENTS
2414.05	MATERIALS
2414.06	EQUIPMENT - Not Used
2414.07	PRODUCTION
2414.08	QUALITY ASSURANCE

2414.01 SCOPE

This specification covers the requirements for the following:

- a) Supply control cabinet assembly Type 1 - 120/240 V, 100 A, 1-phase, 3-wire.
- b) Supply control cabinet assembly Type 2A - 120/208 V, 100 A, 3-phase, 4-wire.
- c) Supply control cabinet assembly Type 2B - 347/600 V, 100 A, 3-phase, 4-wire.
- d) Supply control cabinet assembly Type 3 - 120/240 V, 100 A, 1-phase, 3-wire, no lighting contactor.
- e) Distribution assembly - 347/600 V.

2414.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

C9-2017	Dry-Type Transformers
C22.2 No. 0.12-M1985 (R2016)	Wiring Space and Wire Bending Space in Enclosures for Equipment Rated 750 V or Less
C22.2 No. 0.17-00 (R2018)	Evaluation of Properties of Polymeric Materials
C22.2 No. 0.4-2017	Bonding of Electrical Equipment

C22.2 No. 5-2016	Moulded-Case Circuit Breakers, Moulded-Case Switches and Circuit-Breaker Enclosures
C22.2 No. 9.0-1996 (R2016)	General Requirements for Luminaires
C22.2 No. 14-2018	Industrial Control Equipment
C22.2 No. 18.1-2013 (R2018)	Metallic Outlet Boxes
C22.2 No. 29-2015	Panelboards and Enclosed Panelboards
C22.2 No. 38-2018	Thermoset-Insulated Wires and Cables
C22.2 No. 41-2013 (R2017)	Grounding and Bonding Equipment
C22.2 No. 45.1-2007 (R2017)	Electrical Rigid Metal Conduit - Steel
C22.2 No. 45.2-2008 (R2013)	Electrical Metal Conduit - Aluminum, Red Brass, and Stainless Steel
C22.2 No. 55-2015	Special Use Switches
C22.2 No. 65-2018	Wire Connectors
C22.2 No. 66.1-2006 (R2015)	Low Voltage Transformers - Part 1: General Requirements
C22.2 No. 66.2-2006 (R2015)	Low Voltage Transformers - Part 2: General Purpose Transformers
C22.2 No. 76-2014	Splitlers
C22.2 No. 83-M1985 (R2017)	Electrical Metallic Tubing
C22.2 No. 94.1-2015	Enclosures for Electrical Equipment, Non-Environmental Considerations
C22.2 No. 94.2-2015	Enclosures for Electrical Equipment, Environmental Considerations
C22.2 No. 106-2005 (R2014)	HRC - Miscellaneous Fuses
C22.2 No. 144.1-16	Ground Fault Circuit Interrupters
C22.2 No. 227.2.1-2014	Liquid-Tight Flexible Nonmetallic Conduit
C227.5-2008 (R2018)	Three-Phase Live-Front Pad-Mounted Distribution Transformers
G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel
G164-2018	Hot Dip Galvanizing of Irregularly Shaped Articles
W59.2-M1991 (R2013)	Welded Aluminum Construction

Electrical Safety Authority (ESA)

Ontario Electrical Safety Code

Underwriter's Laboratories of Canada (ULC)

CAN/ULC-S102-10	Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

American National Standards Institute (ANSI)

B18.15-2008	Forged Eyebolts

ASTM International

A 480/A 480M-18	General Requirements for Flat Rolled Stainless Steel and Heat-Resisting Steel Plate, Sheet and Strip
A 489-18	Carbon Steel Lifting Eyes
A 666-15	Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
B 209-14	Aluminum and Aluminum-Alloy Sheet and Plate
G 34-01(2018)	Test Method for Exfoliation Corrosion Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test)

IEEE

C62.11-2012	Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)

National Equipment Manufacturers Association (NEMA)

NEMA 250-2014 Enclosure for Electrical Equipment (1000 Volts Maximum)

2414.04 DESIGN AND SUBMISSION REQUIREMENTS

2414.04.01 Design Requirements

2414.04.01.01 Power Supply Equipment Requirements

Supply control cabinet assemblies shall be according to the Contract Documents. Completed assemblies shall be "service entrance ready." The complete assembly shall pass Electrical Safety Authority (ESA) equipment inspection and have an ESA label of approval. These approvals shall be obtained prior to the unit being shipped.

Completed distribution assemblies shall be approved according to the Ontario Electrical Safety Code.

2414.04.02 Submission Requirements

2414.04.02.01 Working Drawings

The Contractor shall submit four sets of Working Drawings to the Contract Administrator at least 14 Days prior to the commencement of fabrication. An Engineer shall review the Working Drawings and affix a reviewed stamp with his or her signature to the Working Drawings verifying that the drawings are consistent with the Contract Documents and sound engineering practices.

As a minimum, the Working Drawings for supply control cabinet assemblies shall include the following information:

- a) Detailed dimensioned layout, including sections and details to show enclosures, equipment layouts and mounting arrangements, and exact weights.
- b) Detailed bill of materials.
- c) Wiring diagrams.
- d) Details of equipment nameplates.

As a minimum, the Working Drawings for distribution assemblies shall include the following information:

- a) Plans, elevations, sections, and details to show enclosures, structural details, equipment layouts and mounting arrangements, anchor bolt locations, and overall weights.
- b) Detailed bill of materials.
- c) Wiring diagrams.
- d) Details of equipment nameplates and notices.

Once fabrication of the equipment has commenced, materials and dimensions shown on the submitted Working Drawings shall not be changed.

2414.05 MATERIALS

2414.05.01 Enclosures

2414.05.01.01 Supply Control Cabinet Assemblies

Enclosures shall be welded 14 gauge stainless steel type 304 and shall have a No. 2B finish outside according to ASTM A 666 and ASTM A 480.

The panelboard cover for the supply control cabinet assembly shall be manufactured to accommodate the number of standard-sized single-pole branch circuit breakers as specified in the Contract Documents. Unused openings shall be covered with removable blank covers or inserts.

The removable internal equipment panel consisting of a combination backboard and drip shield shall be fabricated from 14 gauge stainless steel type 304 and shall have a No. 2B finish according to ASTM A 666 and ASTM A 480.

Barriers and dead-front panels shall be fabricated from clear thermoplastic polycarbonate according to CSA C22.2 No. 0.17.

2414.05.01.02 Distribution Assemblies

Exterior cubicles shall be according to CSA C22.2 No. 94.1 and CSA C22.2 No. 94.2, enclosure NEMA 250, Type 3.

Enclosures for electrical equipment inside the cubicle shall be according to CSA C22.2 No. 94.1 and CSA C22.2 No. 94.2, enclosure NEMA 250, Type 1.

The exterior of the cubicle shall be fabricated from 5052-H32 marine-type sheet aluminum according to ASTM G 34. The sheet aluminum shall be 4.7 mm thick minimum and reinforced. Fabrication shall be according to ASTM B 209 for 5052-H32 sheet aluminum.

The cabinet base shall be steel H-beam according to CSA G40.21, Grade 260W, and shall be hot dip galvanized according to CSA G164.

Equipment backplate supports shall be aluminum brackets welded to the aluminum sheeting. All other cabinet materials shall be sheet, formed, or cast aluminum or stainless steel.

Eyebolts shall be drop forged steel and according to ASTM A 489 and ANSI/ASME B18.15.

All mounting hardware shall be stainless steel.

2414.05.01.02.01 Insulation and Ventilation

Enclosure insulation shall be rated at minimum R 8/RSI 1.4 and have a flame spread rating not greater than 25 when tested according to CAN/ULC-S102. Insulation shall be applied to the entire surface of the walls, doors, and ceilings, except areas for openings to the exterior.

Enclosure ventilation shall be according to the Contract Documents. Ventilation openings shall be screened, vermin proof, and tamper proof louvres.

2414.05.02 Breakers

Breakers shall be according to CSA C22.2 No. 5 for use with copper bus.

2414.05.03 Contactors

Contactors shall be according to CSA C22.2 No. 14.

2414.05.04 Lightning Arrestors

Lightning arrestors shall be according to IEEE C62.11.

2414.05.05 Outlet Boxes and Fittings

Outlet boxes and fittings shall be according to CSA C22.2 No. 18.1.

2414.05.06 Thermoset Insulated Wires and Cables

All interconnecting wires and cables shall be copper with type RWU90 insulation and according to CSA C22.2 No. 38.

2414.05.07 Panelboards and Enclosed Panelboards

Panelboards and enclosed panelboards shall be according to CSA C22.2 No. 29. Buses shall be copper.

Panelboards shall accept bus bar bolt-on breakers and all bus work shall be of copper construction. All interconnecting wire and cables shall be of copper construction and bending radius according to CSA C22.2 No. 0.12.

2414.05.08 Grounding and Bonding Materials

All equipment used for grounding and bonding shall be according to CSA C22.2 No. 0.4 and C22.2 No. 41.

2414.05.09 Rigid Metal Conduits

Rigid metal conduits shall be according to CSA C22.2 No. 45.1 and CSA C22.2 No. 45.2.

2414.05.10 Dry-Type Distribution Transformers

Dry-type distribution transformers shall be according to CSA C9.

2414.05.11 Switches

Switches shall be according to CSA C22.2 No. 55.

2414.05.12 Ground Fault Circuit Interrupter (GFCI) Receptacles

Ground fault circuit interrupter (GFCI) receptacles shall be according to CSA C22.2 No. 144.1.

2414.05.13 Non-Metallic Liquid Tight Conduits and Connectors

Non-metallic liquid tight conduits and connectors shall be according to CSA C22.2 No. 227.2.1.

2414.05.14 Specialty Control Transformers

Specialty control transformers shall be according to CSA C22.2 No. 66.1 and CSA C22.2 No. 66.2.

2414.05.15 Electrical Metallic Tubing (EMT)

Electrical metallic tubing (EMT) shall be according to CSA C22.2 No. 83.

2414.05.16 Enclosure Lamps

Enclosure lamps shall be according to CSA C22.2 No. 9.0.

2414.05.17 Splitters

Splitters shall be according to CAN/CSA C22.2 No. 76.

2414.05.18 High Rupturing Capacity (HRC) Fuses

High rupturing capacity (HRC) fuses shall be according to CSA C22.2 No. 106.

2414.05.19 Wire Connectors

Wire connectors shall be according to CSA C22.2 No. 65.

2414.05.20 Neutral Bus Bars

Neutral bus bars shall be copper.

2414.07 PRODUCTION

2414.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

2414.07.02 Supply Control Cabinet Assemblies

2414.07.02.01 Cabinet Fabrication

Supply control cabinet assemblies shall be assembled and wired according to the Contract Documents.

2414.07.02.02 Enclosures

The enclosure for the supply control cabinet assembly shall be constructed so that exposure to weather, moisture, or external splashing do not impair the effectiveness of the enclosed electrical equipment. The enclosure shall be manufactured to meet the requirements of NEMA 250, Type 4X.

The enclosure shall consist of the following:

- a) Pole mounting brackets according to the Contract Documents.
- b) Doors with:
 - i. An inside mounted, continuous, piano-type stainless steel hinge.
 - ii. A latching mechanism to hold the door open at 90° and 150-180°.
 - iii. A copper or stainless steel flexible flat braid jumper connected between the door and the cabinet by means of welded studs.
 - iv. A stainless steel padlocking provision.
 - v. A stainless steel three-point padlocking handle with a nylon roller wheel complete with bearing.
 - vi. Tamperproof stainless steel mounting hardware accessible from the inside.

- vii. A door handle that travels and stops below the keyhole with minimum 25 mm clearance and rotates 90° pointing straight down for the closed position and pointing horizontally for the open position.
- c) Removable internal equipment panel with a combination backboard and drip shield. The drip shield shall be formed so that the electrical components mounted on the backboard are not affected by moisture forming on the interior at the top of the enclosure.
- d) Barriers formed according to CSA C22.2 No. 29 separating the service cables from the branch circuits and the photoelectric controller cables.
- e) Internal dead-front panels for the main breaker and circuit breaker sections that prevent unsafe contact by service personnel with the live circuits from all sides.
- f) A printed schedule for the supply control cabinet identifying circuits mounted on cardboard, inserted in a clear plastic bag, and permanently attached to the inside of the door.

Dead-front panels shall be formed so that the circuit breaker panel has to be removed prior to the main breaker panel can be removed. Both panels shall be supplied with quarter-turn screw latches welded to the dead-front panels.

2414.07.03 Distribution Cabinet Assemblies

2414.07.03.01 Cabinet Fabrication

Cabinets shall consist of self-supporting sheet aluminum cubicles and formed aluminum framework welded to form open bottom cubicles. The cabinet shall be tamperproof according to CSA C22.2 No. 94.1 and CSA C22.2 No. 94.2. Eyebolts suitable for lifting the cabinet shall be attached to the formed aluminum framework.

A minimum of three aluminum channels shall be mounted to the full height for the back side of the cabinet. Channels shall be welded to the aluminum sheeting and framework and may form part of the structural framework.

2414.07.03.02 Backplates

Aluminum backplates shall be installed for mounting of electrical components. Backplates shall be securely bolted to the aluminum channels using bolts through the channels with the heads tack-welded to the channels. Backplates shall be sized so that the total weight of the backplate plus electrical components does not exceed 70 kg.

Aluminum backplates shall be finished with fire-rated paint and provided with isolating means to minimize galvanic action between the backplates and the steel electrical components.

2414.07.03.03 Doors

Doors shall be according to CSA C227.5.

Doors shall be lapping and reinforced for strength and rigidity. Each door shall consist of:

- a) An inside mounted, continuous, piano-type stainless steel hinge.
- b) Two latching mechanisms to hold the door open at 90° and 150-180°, one at the top and one at the bottom.

- c) A copper or stainless steel flexible flat braid jumper connected between the door and the cabinet by means of welded studs.
- d) A stainless steel padlocking provision.
- e) A stainless steel three-point padlocking handle with a nylon roller wheel complete with bearing.
- f) Tamperproof stainless steel mounting hardware accessible from the inside.
- g) A door handle that travels and stops below the keyhole with minimum 25 mm clearance and rotates 90° pointing straight down for the closed position and pointing horizontally for the open position.
- h) Screened, vermin proof, and tamperproof louvres to give ventilation as required. All louvres shall be equipped with racks and 305 x 406 x 25 mm metal reusable filters.

2414.07.03.04 Welding

All welding shall be according to CSA W59.2. Welding on aluminum shall be done by the gas metal arc process.

2414.07.03.05 Cabinet Finish

Exterior and interior components of the cabinet shall have a natural aluminum finish with all welds and scratches ground smooth. Cabinets with scratches more than 0.5 mm wide, 0.5 mm deep, or 150 mm long shall not be accepted.

2414.07.03.06 Bonding and Grounding of Electrical Equipment

All non-current carrying metal parts of the electrical equipment shall be bonded according to CSA C22.2 No. 0.4.

2414.07.03.07 Spare Parts

Each cabinet shall include one set of contacts, packaged and identified for each contactor, and one set of fuses for each switch. A 450 x 150 x 150 mm spare part box shall be fabricated from sheet aluminum and mounted in a location inside the cabinet.

2414.07.03.08 Metering

Distribution assemblies shall have meter sockets acceptable to the power supply authority and mounted on a removable backplate in the metering cabinet cubicle.

2414.07.03.09 Warning Signs

Warning signs shall be as specified in the Contract Documents and be prominently displayed on the outside of each exterior door.

2414.07.03.10 Ground Bus

A continuous copper ground bus and ground connectors shall be installed in the distribution assembly according to CSA C227.5. The ground bus shall have four connectors suitable for #2/0 AWG cables in the lighting and services compartment, four connectors suitable for #6 AWG cables in the cubicle and extension cabinet assembly, and one connector suitable for #2/0 AWG cable in the metering cubicle for field connections.

2414.07.03.11 Electrical Components

The electrical components shall be as shown in Table 1.

2414.07.03.11.01 Installation of Electrical Components

Component arrangements shown on the Contract Documents are indicative of the general requirements and adjustments that may be made to component locations to suit different sizes of enclosures and regulations or physical requirements regarding spacing of enclosures.

Wiring shall be installed in flexible non-metallic liquid-tight conduit, rigid metal conduit, or electrical metallic tubing between enclosures.

2414.07.03.11.02 Nameplates for Electrical Components

The following nameplates shall be engraved lamacoid nameplates with 6 mm high, 1.5 mm stroke width black letters on yellow background fastened with stainless steel or aluminum pop rivets on the identified equipment for identification:

- a) To the main feed switch for distribution assemblies:

NOTICE READ BEFORE OPERATING Advanced Traffic Management Systems are 24 hour operational and <u>must remain ON</u> unless necessary to de-energize for safety reasons.

- b) To the 600 V utility disconnect:

NOTICE This breaker controls the feeder to the 120/240 V utility panel. Some circuits are 24 hour operational and <u>must remain ON</u> unless necessary to de-energize for safety reasons.

All other nameplates shall be engraved lamacoid with black letters on white background.

2414.07.03.11.03 Panelboard Schedules

A printed schedule for each panelboard shall be provided indicating equipment served and a description of circuit breaker sizes for each panel as specified in the Contract Documents. The schedule shall be mounted on cardboard, inserted in a clear plastic bag, and hung on the inside of the main door panel.

2414.07.04 Markings

Markings shall be engraved on a stainless steel plate permanently attached with stainless steel or aluminum pop rivets to the outside of the door and located in a highly visible location. Each power supply equipment shall have identification markings showing the following:

- a) Assembly manufacturer's name or trademark.

- b) Enclosure manufacturer's name or trademark.
- c) Standard designation OPSS 2414.
- d) Date of manufacture (i.e., yyyy-mm-dd).
- e) kVA rating (distribution assembly only).
- f) Total weight.

The manufacturer shall attach the label SERVICE ENTRANCE READY on the dead front panel of the supply control cabinet assembly.

2414.08 QUALITY ASSURANCE

2414.08.01 Inspection

The Contract Administrator shall be notified a minimum of three Business Days prior to the start of fabrication for the power supply equipment.

The Contract Administrator shall have free access to the place of manufacture of the power supply equipment for the purpose of inspecting and examining plant records and certificates; materials used; process of manufacturing, including welding and galvanizing; and to make any tests as may be considered necessary, while the power supply equipment is being fabricated.

The Contract Administrator and ESA shall be notified when the power supply equipment is ready for inspection.

All power supply equipment may be subject to an inspection by the Contract Administrator prior to shipment.

2414.09 OWNER PURCHASE OF MATERIAL

2414.09.01 Packaging and Shipment

The supplier shall provide four copies of Working Drawings when required by the Owner. Working Drawings shall include all detailed dimensions and a complete list of component materials and accessories.

The supplier is responsible for loading, delivery, and off-loading of power supply equipment to designated areas. Power supply equipment shall be subject to inspection during and on completion of off-loading. If any damage to the power supply equipment is encountered during the inspection, the supplier shall be responsible for the necessary corrective measures, which are subject to the approval of the Owner.

The supplier shall advise the Owner three Business Days prior to the shipping date of the intent to deliver and confirm that arrangements for off-loading has been made.

2414.09.02**Measurement and Payment**

For measurement purposes, a count shall be made of the number of power supply equipment delivered and accepted.

Payment at the price specified in the purchasing order shall be for the supply of the power supply equipment delivered to the destination on the date and time specified.

The cost of all testing, except that performed by the Owner, shall be included in the price.

TABLE 1
Electrical Components for Distribution Cabinet Assemblies

Electrical Components	Quantity
Service entrance disconnect - 600 V, 3-pole, fusible complete with three HRC1 Class R time delay fuses. Fuse holders and distribution blocks suitable for service cable.	1
Main feed switch - 600 V, 400 A, 3-pole, non-fusible switch complete with terminals suitable for service cable.	1
Lighting system disconnect - 600 V, 225 A, 3-pole, 4-wire, solid neutral complete with terminals suitable for lighting system feed cable.	1
Utility disconnect - 600 V, 30 A, 2-pole.	1
Lighting contactor - 600 V, 200 A, 3-pole, 120 V coil electrically operated, electrically held.	1
Lighting system panelboard - 600 V, 225 A, 3-phase, 4-wire, solid neutral, surface mount, enclosed, suitable for 48 branch circuits, 30 A, 1-pole, bolt-on type breakers.	1
Utility panelboard - 240 V, 3-wire, single phase, 100 A, surface mount, enclosed, suitable for 15 A, 1-pole, bolt-on type breakers.	1
Advanced Traffic Management System combination panelboard - 347/600 V, 225 A, 3-phase, 4-wire, solid neutral, surface mount, enclosed, suitable for 48 branch circuits, breakers suitable for load.	1
Relamp switch - 125 V, 15 A, 1-pole, toggle type, mounted in a utility box with steel cover.	1
Light switch - 125 V, 15 A, 1-pole, toggle type mounted in a utility box with steel cover.	1
GFCI receptacle - 125 V, 15 A, mounted in a utility box with steel cover.	1
Main splitter - 600 V, 400 A, 4-wire, surface mounted.	1
Incandescent lighting luminaire - 125 V, 150 W, wall-mounted type, enclosed, complete with gasket and clear glass globe.	1
Secondary lightning arrestor - 650 V, 3-pole, thyrite type, mounted on each load panel.	3
Dry type transformer -120/240/600 V, 15 KVA, 60 Hz, single phase.	1



Note: The PROV published in November 2018 replaces OPSS 2420 COMMON, November 2010 with no technical content changes.

MATERIAL SPECIFICATION FOR WOODEN POLES

TABLE OF CONTENTS

2420.01	SCOPE
2420.02	REFERENCES
2420.03	DEFINITIONS - Not Used
2420.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
2420.05	MATERIALS
2420.06	EQUIPMENT - Not Used
2420.07	PRODUCTION
2420.08	QUALITY ASSURANCE

2420.01	SCOPE

This specification covers the requirements for wooden poles and reinforcing stubs.

2420.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

O15-15 Wood Utility Poles and Reinforcing Stubs
O80 Series-15 Wood Preservation

2420.05	MATERIALS

2420.05.01	Wood Species

Wood species of poles and reinforcing stubs shall be western red cedar, red pine, jack pine, lodgepole pine, and southern yellow pine (i.e., long leaf, short leaf, loblolly, and slash).

2420.05.02 Quality of Poles before Treatment

Physical properties of western red cedar, red pine, jack pine, lodgepole pine, and southern yellow pine shall be according to CAN/CSA O15.

2420.05.03 Dimensions

Pole dimensions shall be according to CAN/CSA O15.

Pole class and length shall be as specified in the Contract Documents and the Pole Substitution subsection.

2420.05.04 Pole Substitution

If a pole of the desired class and length is not available, a pole of equal or greater ground line circumference may be substituted, provided any excess length is cut from the top.

2420.05.05 Preservatives

Preservatives shall be according to CAN/CSA O80 Series.

2420.07 PRODUCTION

2420.07.01 Preservation Treatment

2420.07.01.01 Preparation of Poles

Preparation of poles and reinforcing stubs for the preservative treatment shall be according to CAN/CSA O80 Series.

2420.07.01.02 Preservation Options

Western red cedar shall be butt treated according to CAN/CSA O80 Series to a length that brings the treatment to 300 mm above the ground line.

Red pine, jack pine, lodgepole pine, and southern yellow pine shall be full length treated according to CAN/CSA O80 Series.

2420.07.01.03 Preservative Retention

Penetration of the preservative shall be according to CAN/CSA O80 Series.

2420.07.02 Marking

Each pole shall have identification marking located 3 m from the butt of the pole. Poles shall be legibly and permanently marked with the following information in letters a minimum of 16 mm high:

- a) Class and length.
- b) Species.
- c) Manufacturer identification.
- d) Year in which pole was treated (i.e., yyyy).

2420.07.03 Shipping

The Contractor shall advise the Owner of the shipping date 3 Business Days prior to delivery.

2420.08 QUALITY ASSURANCE

2420.08.01 Inspection

All work is subject to an inspection by the Owner's representative prior to shipment.

The supplier shall notify the Owner of the date that the fabrication of the poles is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records and certificates, the materials used, the fabrication process, and to make any tests as may be considered necessary, while work on the poles is being performed.



**ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION**

**OPSS.PROV 2421
NOVEMBER 2017**
(Formerly OPSS 2421, November 2012)

Note: The PROV published in November 2017 replaces OPSS 2421 COMMON, November 2012 with no technical content changes.

**MATERIAL SPECIFICATION FOR
SPUN CONCRETE POLES**

TABLE OF CONTENTS

2421.01	SCOPE
2421.02	REFERENCES
2421.03	DEFINITIONS - Not Used
2421.04	DESIGN AND SUBMISSION REQUIREMENTS
2421.05	MATERIALS
2421.06	EQUIPMENT - Not Used
2421.07	PRODUCTION
2421.08	QUALITY ASSURANCE

2421.01 SCOPE

This specification covers the requirements for round spun concrete poles, maximum 21.3 metres in length.

2421.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1303	Admixtures for Concrete

CSA Standards

A14-07	Concrete Poles
A3001-08	Cementitious Materials for Use in Concrete
G30.18-09	Carbon Steel Bars for Concrete Reinforcement

2421.04 DESIGN AND SUBMISSION REQUIREMENTS

2421.04.01 Design Requirements

2421.04.01.01 General

All poles shall be of proper class according to CAN/CSA A14 and the Contract Documents.

If poles are not specified by class, the Owner shall provide the manufacturer with the load that the poles must resist and other sufficient information to allow the producer to determine the loads.

Extra stiff poles shall be manufactured according to CAN/CSA A14.

2421.04.02 Submission Requirements

2421.04.02.01 Working Drawings

Working Drawings shall be prepared for the fabrication of concrete poles.

Three (3) sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of fabrication of the concrete poles for information purposes only. Prior to making a submission, the seals and signatures of a design Engineer and a design-checking Engineer shall be affixed on the Working Drawings verifying that the Working Drawings are consistent with the Contract Documents.

Where multi-discipline engineering work is depicted on the same Working Drawing and the design or design-checking Engineer or both are unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be sealed and signed by as many additional design and design-check Engineers as necessary.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensions.
- b) Plans, elevations, sections, and details to show pole structural details.
- c) Equipment and hardware layout.
- d) Pole weight.
- e) List of hardware items.
- f) Nameplate details.

2421.04.02.02 Certification

A certificate signed by the manufacturer's Engineer stating that all steel and cementing materials used in the production of spun concrete poles supplied meet the requirements of this specification shall be submitted with the Working Drawings.

2421.05 MATERIALS

2421.05.01 Cementing Materials

Cementing materials shall be according to OPSS 1301 and CAN/CSA A3001.

Silica fume or blended cement containing silica fume shall not be used.

2421.05.02 Water

Water used in the production of spun concrete poles shall be according to OPSS 1302.

2421.05.03 Air Entraining, Chemical, and Superplasticizing Admixtures

Air entraining, chemical, and superplasticizing admixtures shall be according to OPSS 1303. Relative density and pH of air entraining admixtures and non-volatile content and relative density of chemical and superplasticizing admixtures shall be within tolerances stated in OPSS 1303, and to the requirements shown in the MTO's pre-qualified products list or, when specified in the Contract Documents, the Owner's pre-qualified products list.

2421.05.04 Reinforcement

When mill test certificates originate from a mill outside of Canada or the United States of America, the Contractor shall have the information on the mill test certificate verified by testing by a Canadian laboratory. This laboratory shall be accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC DIS 17025 for the specific tests or types of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and appropriate wording stating that the material is in accordance with the specified Contract requirements. The stamp shall include the appropriate material specification number, testing date, and the signature of an authorized officer of the Canadian laboratory.

2421.05.04.01 Non-Prestressed Longitudinal Reinforcing Steel

Non-prestressed longitudinal reinforcing steel shall be according to CAN/CSA A14 and shall be weldable according to CSA G30.18.

2421.05.04.02 Prestressed Longitudinal Reinforcing Steel and Helical Reinforcement

Prestressed longitudinal reinforcing steel and helical reinforcement shall be according to CAN/CSA A14.

2421.05.05 Apertures and Handholes

Apertures and handholes shall be according to CAN/CSA A14 and the Contract Documents.

2421.07 PRODUCTION

2421.07.01 General

Dimensions and class of the pole shall be as specified in the Contract Documents.

Concrete for poles shall be placed monolithically.

The pole top shall have a smooth finish plane at right angles to the axis of the pole.

Apertures in poles shall be of a size and if necessary shall be locally reinforced or framed so that the required bending capacity at the aperture is sustained.

Apertures shall have a smooth inside finish without sharp corners.

The handhole cover plate shall be formed to suit the contour of the pole.

2421.07.02 Concrete

Concrete shall be produced to meet the compressive strength as specified in CAN/CSA A14.

Sufficient cylinders shall be cast to verify the 28-Day compressive strength of the poles supplied to the Contract. Compressive strength testing shall be according to CAN/CSA A14.

Concrete shall be tested according to the frequency and requirements of CAN/CSA A14.

2421.07.03 Grounding

A stranded #6 AWG bare copper grounding conductor shall be attached to the non-prestressed longitudinal reinforcing steel rod brazed to the zinc cast handhole frame with a 13 mm standard lug.

2421.07.04 Marking

Each pole shall have the following identification markings located approximately 100 mm above the top of the handhole:

- a) Manufacturer's name or trademark.
- b) Year of manufacture.
- c) Overall length.
- d) Class identification number.
- e) Prestressed poles shall be marked and identified by the letter P.

These markings shall be on a corrosion-resistant metal plate securely attached to the surface of the pole.

The pole shall have the pick-up point or points for unloading purposes marked with black tape around the complete circumference.

2421.07.05 Packaging and Shipping

Each pole shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity.

The Owner shall be notified of the shipping date a minimum of 3 Business Days prior to delivery.

2421.08 QUALITY ASSURANCE

2421.08.01 General

All work is subject to an inspection by the Owner's representative prior to shipment.

Poles not meeting the requirements of this specification shall be rejected by the Owner.

The Owner shall be notified a minimum of 1 Business Day in advance of the date that the fabrication of the poles is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records; certificates; materials used; fabrication process, including welding and galvanizing; and to make any tests as may be considered necessary, while the poles are being fabricated.

The manufacturer's Engineer shall provide a stamped certification that the poles supplied to the Work meet the requirements of the Contract Documents and the requirements of CAN/CSA A14.

2421.08.02 Acceptance or Rejection

2421.08.02.01 Structural Testing

Acceptance shall be according to a stamped certification by the manufacturer's Engineer that ongoing testing has been performed and evaluated according to CAN/CSA A14 and that the most recent two tests for classification, torsion, and transverse testing meet the requirements of the Contract Documents and the requirements of CAN/CSA A14. All required supporting test data and certificates shall be less than 12 months old at the time of submission.

2421.08.02.02 Marking

Markings not meeting the requirements of the Marking subsection shall be rejected by the Owner.



**MATERIAL SPECIFICATION FOR
HEAVY CLASS STEEL AND
SECTIONAL STEEL POLES, BASE MOUNTED**

TABLE OF CONTENTS

2422.01	SCOPE
2422.02	REFERENCES
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2422.05	MATERIALS
2422.06	EQUIPMENT - Not Used
2422.07	PRODUCTION
2422.08	QUALITY ASSURANCE
2422.09	OWNER PURCHASE OF MATERIAL

APPENDICES

Appendix 2422-A	Commentary

2422.01 SCOPE

This specification covers the requirements for base mounted galvanized heavy class steel and sectional steel poles 6.0, 7.5, 9.0, and 10.50 metres in height.

2422.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2422.01.02

Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2422.02

REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Structural Manual

CSA Standards

G40.20-13/G40.21-13 General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel

G164-M92 (R2003) Hot Dip Galvanizing of Irregularly Shaped Articles

S6-14 Canadian Highway Bridge Design Code

W59-13 Welded Steel Construction (Metal Arc Welding)

American Association of State Highway and Transportation Officials (AASHTO)

LTS-5-M Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 5th Edition, Interim Revisions (2010)

2422.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Product Drawings means drawings prepared by the manufacturer that have been approved by the Owner for use with the product.

2422.04 DESIGN AND SUBMISSION REQUIREMENTS

2422.04.01 Design Requirements

All poles shall be designed to support the required traffic signal and lighting system components and shall be according to CSA S6 and MTO Structural Manual. All poles shall be according to CSA S6 and AASHTO LTS-5-M for fatigue requirements, AASHTO Fatigue Importance Category 2.

2422.04.01.01 Wind Loading

Wind loading shall be based on the maximum wind pressure for Ontario according to CSA S6.

2422.04.01.02 Ice Loading

Ice loading shall be based on the maximum ice loading for Ontario according to CSA S6.

2422.04.01.03 Geometric Parameters

Latitude of design and fabrication details is at the discretion of the supplier and is subject to approval of the design by the Owner.

2422.04.01.04 Supported Load Parameters

Design calculations shall employ force and dimensions for various items of equipment to be mounted on the poles as shown in Table 1.

2422.04.01.05 Heavy Class Steel and Sectional Steel Pole

Heavy class steel and sectional steel poles used for traffic signal or combination traffic signal and lighting system shall be capable of bearing the loads associated with configurations shown in Table 2.

2422.04.01.06 Location of Equipment

Mast arms shall be to be solidly attached to the pole at a height above the pole base plate as given by:

$$H_A = 5,650 \text{ mm} - H$$

where: H_A = mast arm height above the pole base plate
 H = mast arm height from Table 1

Where more than one mast arm is considered, the shorter arm shall be attached to the pole at a point 300 mm above that of the longer arm.

Pedestrian heads shall be mounted at a height of 2,750 mm above the pole base plate.

Luminaire brackets shall be mounted at a point 150 mm from the top of the pole.

2422.04.02 Submission Requirements

2422.04.02.01 Product Drawings

The heavy class steel and sectional steel pole manufacturer shall submit the product drawings and the design assumptions and calculations for the poles to the Contract Administrator.

As a minimum, the product drawings shall include the following information:

- a) Material properties and standards.
- b) Dimensions.
- c) Hardware requirements.
- d) Plans, elevations, sections, and details to show pole structural details.
- e) Anchor bolt locations.
- f) Welds.
- g) Joining method for heavy class steel poles sections.

The product drawings and calculations shall bear the seals and signatures of the design and design-checking Engineers.

2422.04.02.02 Working Drawings

Working Drawings shall be prepared for the fabrication of heavy class steel and sectional steel poles.

Three sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of fabrication of the heavy class steel and sectional steel poles for information purposes only. An Engineer shall affix his or her seal and signature on the Working Drawings verifying that the Working Drawings are consistent with the Contract Documents and sound engineering practices.

Where multi-discipline engineering work is depicted on the same Working Drawing and a single Engineer is unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be signed and sealed by as many additional Engineers as necessary.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensions.
- b) Plans, elevations, sections, and details to show pole structural details.
- c) Equipment layout.
- d) Anchor bolt locations.
- e) Exact pole weight.
- f) Detailed bill of materials.
- g) Details of equipment nameplates.

A copy of the Working Drawings shall be retained at the fabricator's plant during and after the heavy class steel and sectional steel pole fabrication.

2422.05 MATERIALS

2422.05.01 General

All steel used in the production of poles shall be according to CAN/CSA G40.21, Grade 300WT, for pole shafts, base plates, and gussets.

All galvanized steel shall be according to CSA G164.

All welding shall be according to CSA W59.

2422.07 PRODUCTION

2422.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

All welds, except for fillet welds, shall be ground smooth.

The pole base plate for any height of pole shall be made with mounting holes suitable for the anchor rod or anchorage assembly. The pole base plate shall be reinforced with four welded gussets equally spaced around the pole or with a welded collar or combination of both welded collar and gussets.

The underside of the anchor base shall be true, distortion free, and perpendicular to the centreline of the pole shaft after fabrication.

A waterproof, removable galvanized steel top cap shall be furnished with the pole. The cap shall blend with the general pole design to present a neat overall appearance. The cap shall be rigidly secured to the top of the pole by a hexagonal head stainless steel set screw.

Wiring apertures at the bracket mounting level and at the handhole shall be accurately positioned on the pole. The wiring apertures shall provide a smooth cable entrance.

For lighting applications, a wiring aperture, complete with rubber grommet, shall be provided.

Handholes, complete with covers, shall be reinforced with a steel handhole frame of such strength and cross-section that the strength of the pole is not reduced.

2422.07.02 Heavy Class Steel Poles

The poles, as specified in the Contract Documents, shall be round or octagonal in cross-section and shall taper uniformly inwards from the base for the height of the pole.

Poles shall have one or two longitudinal automatically electrically welded joints from top to bottom.

The maximum permitted number of circumferential (transverse) welded joints shall be as shown in Table 3.

The pole sections shall be joined by an electrical weld before galvanizing.

Sweep shall not exceed 3.2 mm per 4.57 m, and the overall sweep shall not be greater than:

$$(\text{Pole height (m)} / 4.57 \text{ m}) \times 3.2 \text{ mm}$$

In all cases, the base shall telescope the butt end of the pole and be secured with one continuous weld on the inside of the base at the end of the pole and another continuous weld on the outside at the top of the base. All welding at base shall be made in such a manner as to ensure that the welded connection shall develop the same strength of the adjacent pole section to resist any bending action.

2422.07.03 Heavy Class Sectional Steel Poles

The pole sections shall be of round tapered construction so that a number of sections may be assembled by means of an overlapping press fit to form a tapered steel pole of the height specified in the Contract Documents.

Each section shall have one longitudinal automatically electrically welded joint from top to bottom.

Each section shall be stencilled with O-L (nominal overlap requirement) and graduations in one-inch increments.

2422.07.04 Ground Bar

A ground bar with a bronze ground connector suitable for No. 6 AWG wire shall be welded to the inside of each pole. The bronze ground connector shall be attached to the ground bar before shipment.

2422.07.05 Marking

Each pole shall have identification marking located approximately 300 mm above the top of the handhole showing the following:

- a) Manufacturer's name or trade mark.
- b) Height of pole.
- c) Gauge of steel.
- d) Bolt circle diameter.
- e) Designation OPSS 2422.
- f) Date of manufacture (i.e., yyyy-mm-dd).

This marking shall be on a corrosion-resistant metal plate securely attached to the surface of the pole.

2422.07.06 Packaging and Shipping

Each pole shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity.

The Contract Administrator shall be notified of the shipping date 3 Business Days prior to delivery.

2422.08 QUALITY ASSURANCE

2422.08.01 Inspection

All work is subject to an inspection by the Contract Administrator prior to shipment.

The supplier shall notify the Contract Administrator of the date that the fabrication of the poles is to commence.

The Contract Administrator shall have free access to the place of fabrication of the poles for the purpose of inspecting and examining plant records and certificates while work on the poles is being performed; materials used; process of fabrication, including welding and galvanizing; and to make any tests as may be considered necessary.

2422.09**OWNER PURCHASE OF MATERIAL****2422.09.01****Working Drawings**

Within 30 Days of receipt of a purchasing order to supply heavy class steel and sectional steel poles, the supplier shall submit 4 copies of pole Working Drawings, as described in the Submission Requirements subsection, to the Owner, for approval.

Working Drawings shall be given final approval by the Owner, if found to be acceptable, or shall be marked with deficiencies, if unacceptable.

Unacceptable drawings shall be returned to the supplier for correction. The supplier shall resubmit 4 copies of corrected Working Drawings within 14 Days. When the resubmitted drawings are acceptable to the Owner, they shall be given final approval.

One copy of the final approved drawings shall be returned to the supplier along with written notification to commence fabrication. Within 14 Days of receipt of the notification to commence fabrication, the supplier shall submit 4 copies of all final approved Working Drawings to the Owner.

Fabrication of the equipment shall not commence until the supplier has received final approved Working Drawings and written notification to commence fabrication from the Owner. All fabrication shall conform to the dimensions indicated on the final approved Working Drawings.

The supplier shall advise the Owner of the shipping date 3 Business Days prior to delivery.

2422.09.02**Measurement and Payment**

For measurement purposes, a count shall be made of the number of heavy class steel and sectional steel poles supplied and accepted.

Payment at the price specified in the purchasing order shall be for the supply of the heavy class steel and sectional steel poles delivered to the destination on the date and time specified.

The cost of all testing, except that performed by the Owner, shall be included in the price.

TABLE 1
Supported Load Parameters

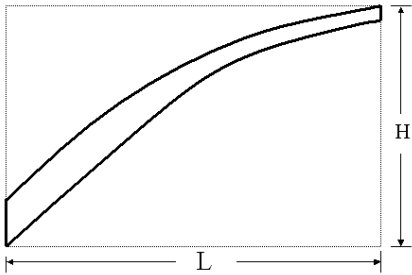
Item of Equipment	Dimensions mm	Projected Area m ²	Weight N
Roadway Lighting Luminaire (Ovuloid)	990 L x 380 H	0.22	107
Roadway Lighting Bracket (Aluminum)	2400 L x 1200 H (tapered)	0.15	112
Double Arm Brackets (Aluminum)	400 L x 42 Dia. (2 per set)	0.04	24
Mast Arm (Aluminum) 	610 L x 250 H (tapered)	0.04	78
	1200 L x 530 H (tapered)	0.10	91
	1800 L x 610 H (tapered)	0.15	114
	2400 L x 840 H (tapered)	0.19	65
	3000 L x 610 H (tapered)	0.23	94
	3600 L x 840 H (tapered)	0.38	113
	4600 L x 1070 H (tapered)	0.47	216
	5500 L x 910 H (tapered)	0.70	324
	6100 L x 1070 H (tapered)	0.79	307
	6700 L x 1150 H (tapered)	0.85	354
	7600 L x 1140 H (tapered)	1.10	504
Traffic Signal Heads (Aluminum: 4-Section)	1650 H x 610 W	1.01	123
Pedestrian Heads (Aluminum: 2-Section)	690 H x 345 W	0.23	78
Traffic Signs	Varies: see Table 2	1.50	23

TABLE 2
Heavy Class Steel and Sectional Steel Pole Configurations

Pole Height m	Luminaire and Bracket set	Longest Mast Arm with Head m	Maximum Mast Arm Total Length (Note 1) m	Number of Pedestrian Heads (Note 2)	Traffic Signs (Note 3) m ²
10.5	1	7.6	13.1	2	0.75
9.0	1	7.6	13.1	2	0.75
7.5	1	7.6	13.1	2	0.75
6.0	0	7.6	13.1	2	0.75
Notes: 1. Mast arm total length applies to the sum of the lengths of two mast arms at 90-degree orientation. 2. Two pedestrian heads at 90-degree orientation include a set of double arm brackets for each. 3. Traffic signs shall be split to give 0.25 m ² mounted on the mast arm beside the signal head and 0.5 m ² mounted at 2.75 m height above the pole base plate.					

TABLE 3
Circumferential Welded Joints

Pole Height m	Maximum Number of Welds
6.0	1
7.5	1
9.0	1
10.5	2

Appendix 2422-A: November 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



MATERIAL SPECIFICATION FOR STEEL POLES, BASE MOUNTED

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2423.01 SCOPE

This specification covers the requirements for base mounted galvanized steel poles maximum 15.1 m in length.

2423.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2423.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2423.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

G40.20-13/G40.21-13	General Requirements for Rolled or Welded Structural Quality Steel / Structural Quality Steel
W59-13	Welded Steel Construction (Metal Arc Welding)

ASTM International

A123 / A123M-15	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

2423.04 DESIGN AND SUBMISSION REQUIREMENTS

2423.04.01 Submission Requirements

2423.04.01.01 Working Drawings

Working Drawings shall be prepared for the fabrication of steel poles.

Three (3) sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to commencement of fabrication of the steel poles, for information purposes only. Prior to making a submission, the seals and signatures of a design Engineer and a design-checking Engineer shall be affixed on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

Where multi-discipline engineering work is depicted on the same Working Drawing and the design or design-checking Engineer or both are unable to seal and sign the Working Drawing for all aspects of the

work, the drawing shall be sealed and signed by as many additional design and design-checking Engineers as necessary.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensions.
- b) Plans, elevations, sections, and details to show pole structural details.
- c) Equipment layout.
- d) Anchor bolt locations.
- e) Exact pole weight.
- f) Detailed bill of materials.
- g) Details of equipment nameplates.

2423.05 MATERIALS

2423.05.01 General

All steel used in the production of poles shall be according to CSA G40.21, grade 300W, for pole shafts, and grade 300WT, for base plates and gussets.

All steel shall be galvanized according to ASTM A 123.

2423.07 PRODUCTION

2423.07.01 General

The length of the poles shall be as specified in the Contract Documents.

Shafts shall be round or octagonal in cross-section as specified in the Contract Documents and taper uniformly inwards from the base for the length of the pole.

Shafts shall have one or two longitudinal automatically electrically welded joints from top to bottom.

All welding shall be according to CSA W59.

All welds, except for fillet welds, shall be ground smooth.

The maximum permitted number of circumferential welded joints shall be as shown in Table 1.

The pole sections shall be joined by an electrical weld.

After fabrication, the poles shall be galvanized.

Sweep shall not exceed 3.2 mm per 4.57 m, and the overall sweep shall not be greater than:

$(\text{Pole length (m)} / 4.57 \text{ m}) \times 3.2 \text{ mm}$

The pole shall be supplied with a one-piece fabricated rolled steel base plate. The pole may be supplied as specified in the Contract Documents with a one-piece fabricated rolled steel plate without gussets.

The base shall telescope the butt end of the shaft and be secured with one continuous weld on the inside of the base at the end of the shaft and another continuous weld on the outside at the top of the base. All welding at the base shall be made in such a manner that the welded connection develops the same strength of the adjacent shaft section to resist any bending action.

After fabrication, the underside of the base plate shall be true, distortion free, and perpendicular to the centreline of the pole shaft.

A removable galvanized steel or aluminum top cap shall be supplied with the shaft. The cap shall blend with the general pole design to present an overall neat appearance. The cap shall be secured rigidly to the shaft by a hexagonal head stainless steel set screw.

Wiring apertures at the bracket mounting level and at the handhole shall be accurately positioned on the pole. Wiring apertures, complete with neoprene grommets, shall provide a smooth cable entrance.

Handholes shall be complete with covers and shall be reinforced with a steel handhole frame of such strength and cross section that the strength of the shaft is not reduced.

2423.07.02 Mounting Plate for Grounding

The mounting plate for the grounding post shall be welded to the shaft in such a manner as to present a smooth surface on the exterior of the shaft.

A mounting plate with a bronze split-bolt type ground connector suitable for No. 6 AWG wire shall be welded to the inside of each pole. The bronze ground connector shall be attached to the mounting plate prior to shipment.

2423.07.03 Marking

Each pole shall have the following identification markings located approximately 100 mm above the top of the handhole:

- a) Manufacturer's name or trade mark.
- b) Length.
- c) Gauge of steel.
- d) Bolt circle diameter.
- e) Designation OPSS 2423.
- f) Date of manufacture (i.e., yyyy-mm-dd).

These markings shall be on a corrosion-resistant metal plate securely attached to the surface of the pole.

2423.07.04 Packaging and Shipping

Each pole shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity.

The grounding connector shall be assembled inside the pole prior to shipment.

The Owner shall be notified of the shipping date 3 Business Days prior to delivery.

2423.08 QUALITY ASSURANCE

2423.08.01 Inspection

All work is subject to an inspection by the Owner's representative prior to shipment.

The Owner shall be notified a minimum of 1 Business Day in advance of the date that the fabrication of the poles is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records; certificates; materials used; fabrication process, including welding and galvanizing; and to make any tests as may be considered necessary, while the poles are being fabricated.

TABLE 1
Circumferential Welded Joints

Pole Length m	Maximum Number of Welds
6.0	1
7.5	1
9.0	1
10.5	2
12.0	2
13.6	2
15.1	3



MATERIAL SPECIFICATION FOR STEEL TRUSS BRACKETS

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2426.06	EQUIPMENT - Not Used
2426.07	PRODUCTION
2426.08	QUALITY ASSURANCE

2426.01 SCOPE

This specification covers the requirements for steel truss brackets for use with spun concrete poles and metal poles and associated hardware.

2426.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

G40.21-13	Structural Quality Steels
G164-M92 (R2003)	Hot Dip Galvanizing of Irregularly Shaped Articles
W59-13	Welded Steel Construction (Metal Arc Welding)

ASTM International

A 53/A 53M-12	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

2426.05 MATERIALS

2426.05.01 Brackets

Brackets shall be fabricated from Schedule 40 steel pipe and according to ASTM A 53, Grade B.

2426.05.02 Steel Bracket Clamp Plates

Steel shall be according to CSA G40.21, Grade 38WT.

2426.07 PRODUCTION

2426.07.01 General

Steel truss brackets shall be fabricated according to the Contract Documents.

All welding shall be continuous and according to CSA W59.

When fabricating the steel truss bracket, the manufacturer shall make provision between members to ensure good internal flow and adequate drainage during the process of hot dip galvanizing the assembled steel truss bracket. Hot dip galvanizing shall be according to CAN/CSA G164.

Galvanized steel bracket mounting plates shall be supplied complete with stainless steel hardware and two fabricated galvanized steel bracket clamp plates according to the Contract Documents.

A galvanized steel or aluminum end cap shall be fastened on the end of the lower member.

2426.07.02 Marking

Each steel truss bracket shall have identification markings in a visible location indicating the following:

- a) Manufacturer's name or trademark.
- b) Bracket length.
- c) Date of manufacture.
- d) Designation OPSS 2426.

Identification markings shall be embossed on the steel truss bracket or on a corrosion-resistant metal plate securely attached to the steel truss bracket.

2426.07.03 Packaging and Shipment

Each steel truss bracket shall be shipped complete with mounting hardware, suitably packaged to ensure that all parts are delivered as a complete unit. A complete parts list shall be included in the shipment.

2426.08 QUALITY ASSURANCE

2426.08.01 Inspection

All steel truss brackets are subject to an inspection by the Contract Administrator prior to shipment.



**MATERIAL SPECIFICATION FOR
ALUMINUM TAPERED ELLIPTICAL BRACKETS**

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2428.07	PRODUCTION
2428.08	QUALITY ASSURANCE

2428.01 SCOPE

This specification covers the requirements for aluminum tapered elliptical brackets and associated hardware.

2428.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

W59.2-M1991 (R2013) Welded Aluminum Construction

ASTM International

B 221-14 Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

2428.05 MATERIALS

2428.05.01 Aluminum Alloy

Aluminum alloy shall be according to ASTM B 221, Type 6063-T6.

2428.07 PRODUCTION

2428.07.01 General

All welding shall be continuous and according to CSA W59.2.

Brackets shall be fabricated according to the Contract Documents.

2428.07.02 Marking

A permanent label shall be attached to the tapered elliptical bracket in a visible location indicating the following:

- a) Manufacturer's name or trademark.
- b) Bracket length.
- c) Date of manufacture.
- d) Designation OPSS 2428.

2428.07.03 Packaging and Shipment

Each tapered elliptical bracket shall be shipped complete with mounting hardware, suitably packaged to ensure that all parts are delivered as a complete unit. A complete parts list shall be included in the shipment.

2428.08 QUALITY ASSURANCE

2428.08.01 Inspection

All tapered elliptical brackets may be subject to an inspection by the Contract Administrator prior to shipment.



Note: The PROV published in November 2017 replaces OPSS 2432 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR HIGH PRESSURE SODIUM LUMINAIRES FOR HIGHWAY LIGHTING

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2432.07	PRODUCTION
2432.08	QUALITY ASSURANCE

2432.01 SCOPE

This specification covers the requirements for highway lighting luminaires with integral ballasts for use in conventional and high mast lighting.

2432.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

C22.2 No. 9.0-96 (R2011)	General Requirements for Luminaires
C653-13	Photometric Performance of Roadway and Street Lighting Luminaires
C811-13	Performance of Highmast Luminaires for Roadway Lighting
C863-11	Energy Efficiency of High-Intensity Discharge (HID) and Low-Pressure Sodium (LPS) Lamp Ballasts

2432.04 DESIGN AND SUBMISSION REQUIREMENTS

2432.04.01 Design Requirements

2432.04.01.01 Photometric Requirements

As a minimum, the photometric performance of the luminaires for conventional lighting shall be according to CSA C653.

As a minimum, the photometric performance of the luminaires for high mast lighting shall be according to CSA C811.

Photometric test results shall be provided for the luminaires supplied and shall include the following data:

- a) Isolux curves and mounting height correction factors.
- b) Utilization charts or graphs.
- c) Candlepower distribution curves indicating peak intensity.
- d) Luminous intensity tables to Illuminating Engineering Society format (I-tables).
- e) Luminaire efficiency values.
- f) Luminous outputs above and below horizontal.
- g) Lamp lumen outputs and wattages.

2432.04.01.02 Electrical Requirements

All electrical components and assembled luminaires shall be according to CSA C22.2 No. 9.0.

Ballasts, lamp sockets, ground connectors, internal wiring, and all other components shall be suitable for the supply voltage as specified in the Contract Documents and the maximum temperature encountered in totally enclosed outdoor weatherproof luminaires.

Ballasts shall be constant wattage auto-transformer or isolated secondary transformer type for grounded systems. Auto-transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 5% variation in line voltage. Isolated secondary transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 10% variation in line voltage.

Ballasts shall be Class H, 180 °C insulation; 60 hertz; and low temperature, -35 °C with a power factor not less than 0.90.

The minimum nominal secondary open circuit voltage of the ballast for various lamps shall be sufficient to provide reliable starting at -35 °C.

Ballasts shall be suitable for the lamp's nominal operating voltage. Terminal blocks shall be held rigidly and shall provide a positive connection for terminating the field wiring.

The current crest factor of the ballast shall not exceed 1.8 for high pressure sodium lamps.

Energy efficiency of lamp ballasts shall be according to CAN/CSA C863.

2432.04.01.03**Mechanical Requirements**

The luminaire shall be comprised of a cast aluminum ballast housing, spun or formed aluminum optical housing with a glass lens or refractor, and stainless steel hardware.

The ballast housing shall form a watertight enclosure for the ballast components that shall be readily interchangeable without removing the luminaire from the mounting bracket. The ballast housing shall be either integral or modular design. If it is of modular design, it shall be attached to the housing using stainless steel hardware.

Mounting arrangements shall consist of a slip fitter assembly for a 50 mm diameter internal pipe size tenon. The slip fitter shall be secured using stainless steel hardware with an independent levelling device. Adjustment of the luminaire in the vertical plane shall be 3 degrees minimum.

The lamp socket shall be a mogul type with a porcelain-enclosed, nickel-plated brass shell rated for 4,000 volts, and spring-loaded centre contact. The lamp holder shall have an electrically insulated lamp stabilizer and shall hold the lamp's outer envelope to precise alignment with suitable means for vibration damping.

The optical assembly shall consist of a precision formed specular aluminum reflector with an anodized finish and accurately positioned within the luminaire outer housing. The assembly shall be sealed at the top by a high temperature neoprene or silicone rubber gasket between the ballast casting and reflector and at the bottom by a hinged door assembly.

Alternatively, the optical assembly shall consist of a pressed borosilicate glass reflector and refractor of open ventilated design. The reflector shall have a smooth non-porous inner surface and be encased within the luminaire outer housing. The refractor shall be attached to the reflector using stainless steel hardware. The reflector or refractor assembly shall be readily removable without removing the luminaire from the mounting bracket.

The door assembly shall consist of a gasketed doorframe and a clear tempered shock-resistant glass lens and shall be attached to the reflector housing using stainless steel toggle latches, one of which shall be hinged.

2432.04.02**Submission Requirements****2432.04.02.01****Working Drawings**

Three copies of Working Drawings shall be submitted to the Contract Administrator a minimum of 14 Days prior to the commencement of fabrication.

As a minimum, the Working Drawings shall include the following information:

- a) All mechanical details, including dimensions, layouts, weights, and mounting arrangements for components.
- b) All electrical details, including wiring diagrams and component ratings.
- c) All photometric information regarding the luminaires, including, but not limited to lamp position and photometric data sheets.
- d) Shield details.
- e) Certification by an Engineer that the luminaires for conventional lighting comply with CSA C653.
- f) Certification by an Engineer that the luminaires for high mast lighting comply with CSA C811.

Each Working Drawing shall be sealed and stamped by an Engineer certifying that the Working Drawings comply with the Contract Documents.

One copy of the final accepted Working Drawings shall be returned to the supplier, along with written notification to commence fabrication. Within 14 Days of receipt of notification to commence fabrication, the supplier shall submit 3 copies of all final accepted Working Drawings to the Contract Administrator.

Fabrication of the equipment shall not commence until the Working Drawings have been accepted by the Contract Administrator.

Once fabrication of the equipment has commenced, materials and dimensions shown on the final accepted Working Drawings shall not be changed.

2432.05 MATERIALS

2432.05.01 Marking

A permanent label shall be attached to the interior of the luminaire indicating the manufacturer's name or trademark, catalogue number, date of manufacture, and the American National Standards Institute (ANSI) or Illuminating Engineering Society (IES) photometric classification and distribution type; the suitable supply voltage and frequency; the lamp type; the lamp wattage; and the nominal operating voltage of the lamp so that it is clearly visible during maintenance operations.

A label including a wiring diagram shall be attached to each ballast showing the ballast schematic wiring diagram and shall be visible during maintenance operations.

For asymmetrical luminaires with adjustable optical systems, a permanent embossed identification mark shall be located on the luminaire that is clearly visible and identifiable as an orientation mark.

2432.07 PRODUCTION

2432.07.01 Ballast Assemblies

Ballast assemblies shall be factory pre-wired with all connections clearly marked and identified.

2432.07.02 Lamp Socket Positions

The lamp socket position shall be pre-set at the factory for the specified distribution.

2432.08 QUALITY ASSURANCE

2432.08.01 Inspection

The supplier shall notify the Owner of the date that the fabrication of the luminaires is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records, certificates, materials used, fabrication process, and to make any tests as may be considered necessary, while the luminaires are being fabricated.

All luminaires are subject to an inspection by the Owner's representative prior to shipment.



MATERIAL SPECIFICATION FOR HIGH PRESSURE SODIUM LUMINAIRES FOR UNDERPASS LIGHTING

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APPENDICES

2434-A	Commentary

2434.01 SCOPE

This specification covers the requirements for underpass luminaires with integral ballast for use with 70 to 400 watt high pressure sodium lamps.

2434.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2434.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2434.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

C22.2 No. 89-15	Swimming-Pool Luminaires, Submersible Luminaires and Accessories
C863-16	Energy Efficiency of High-Intensity Discharge (HID) and Low-Pressure Sodium (LPS) Lamp Ballasts

ASTM International

B 117-11	Standard Practice for Operating Salt Spray (Fog) Apparatus
D 1654-08	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

American National Standards Institute (ANSI)

C136.31-2010	Roadway and Area Lighting Equipment - Luminaire Vibration

International Electrotechnical Commission (IEC)

60598 (2014-05)	Luminaires
62262 (2002-02)	Degrees of Protection Provided by Enclosures for Electrical Equipment Against External Mechanical Impacts (IK code)

2434.04 DESIGN AND SUBMISSION REQUIREMENTS

2434.04.01 Submission Requirements

2434.04.01.01 Working Drawings

Three copies of Working Drawings shall be submitted to the Contract Administrator a minimum of 14 Days prior to the commencement of fabrication.

As a minimum, the Working Drawings shall include the following information:

- a) All mechanical details, including dimensions, layouts, weights, shield details, and mounting arrangements for components.
- b) All electrical details and certified test reports, including wiring diagrams and component ratings.
- c) All photometric information and certified test reports regarding the luminaires, including, but not limited to lamp position, photometric data sheets, and photometric test reports.
- d) Certified Test Reports for UL/CSA listing, IP rating, IK rating, and ANSI C136.31 vibration.

2434.04.01.02 Photometric Test Results

Photometric test results for the luminaires supplied shall be submitted to the Contract Administrator and include the following data:

- a) Isolux curves and mounting height correction factors.
- b) Utilization charts or graphs.
- c) Candlepower distribution curves indicating peak intensity.
- d) Luminous intensity tables to Illuminating Engineering Society format (I-tables).
- e) Luminaire efficiency values.
- f) Luminous outputs above and below horizontal.
- g) Lamp lumen outputs and wattages.

2434.04.01.03 Luminaire Test Results

Certified test results for the luminaires supplied shall be submitted to the Contract Administrator and include the following data:

- a) UL/CSA Listing Report according to CSA C22.2 No. 89.
- b) Minimum IP65 Rating according to IEC 60598.
- c) Minimum IK08 Rating according to IEC 62262.
- d) 1.5G Vibration Test Report according to ANSI C136.31.

2434.05**MATERIALS****2434.05.01****Electrical Components**

All electrical components and assembled luminaires shall be according to CSA C22.2 No. 89.

Ballasts, lamp sockets, ground connectors, internal wiring, and all other components shall be suitable for the supply voltage as specified in the Contract Documents and the maximum temperature encountered in totally enclosed, outdoor, weatherproof luminaires.

Ballasts shall be constant wattage auto-transformer or isolated secondary transformer type for grounded systems. Auto-transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 5% variation in line voltage. Isolated secondary transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 10% variation in line voltage.

Ballasts shall be Class H, 180 °C insulation; 60 hertz; and low temperature, -35 °C with a power factor not less than 0.90.

The minimum nominal secondary open circuit voltage of the ballast for various lamps shall be sufficient to provide reliable starting at -35 °C.

Ballasts shall be suitable for the lamp's nominal operating voltage. Terminal blocks shall be held rigidly and shall provide a positive connection for terminating the field wiring.

The current crest factor of the ballast shall not exceed 1.8 for high pressure sodium lamps.

Energy efficiency of lamp ballasts shall be according to CAN/CSA C863.

All wiring within fixture shall have a minimum temperature rating of 125 °C.

2434.05.02**Mechanical Components**

The luminaire shall be comprised of a polycarbonate, aluminum, or stainless steel enclosure with a specular reflector and a glass prismatic refractor. Enclosure shall meet a scribe creepage rating of 7 according to ASTM D 1654, when tested for 5,000 hours according to ASTM B 117.

The luminaire shall be provided with a 20 mm threaded duct entry in each end of the enclosure and a cable entry hole in the rear of the enclosure together with a suitable waterproof gasket.

The luminaire shall have continuous captive gasket between the door and enclosure and between the refractor and the enclosure to provide a weatherproof seal.

All fixture hardware shall be Type 316 stainless steel and shall be captive. Proper dielectric insulation shall be provided between luminaire housing and fixture hardware of dissimilar metals, to prevent galvanic reaction.

The luminaire shall be provided with a ground terminal or lug for a single conductor #12 AWG stranded copper wire.

All unused cable and duct entry holes shall be plugged with approved filler caps.

The lamp socket shall be a porcelain-enclosed, nickel-plated brass shell rated for 4,000 volts, and spring-loaded centre contact. The lamp holder shall have an electrically insulated lamp stabilizer and shall hold the lamp's outer envelope to precise alignment with suitable means for vibration damping.

The refractor shall be heat-resistant and non-discolouring, with high resistance to breakage from thermal shock. It shall be securely attached to the housing by hinges and a safety device to hold it in the open position.

The reflector shall be fabricated of polished, chemically brightened, anodized aluminum not subject to distortion and shall be readily removable.

The luminaire shall be accessible with tool-less entry.

The luminaire shall not be subject to damage by vibration when closed and in the operating position.

2434.05.03 Marking

A permanent non-corrosive nameplate shall be attached to the exterior of the luminaire and located so that the marking is clearly visible after installation. The nameplate shall indicate the manufacturer's name or trademark, catalogue number, lamp wattage, and nominal voltage.

A permanent label shall be attached to the interior of the luminaire indicating the manufacturer's name or trademark, catalogue number, date of manufacture, and the American National Standards Institute (ANSI) or Illuminating Engineering Society (IES) photometric classification and distribution type; the suitable supply voltage and frequency; the lamp type; the lamp wattage; and the nominal operating voltage of the lamp so that it is clearly visible during maintenance operations.

A label including a wiring diagram shall be attached to each ballast showing the ballast schematic wiring diagram and shall be visible during maintenance operations.

For asymmetrical luminaires with adjustable optical systems, a permanent embossed identification mark shall be located on the luminaire that is clearly visible and identifiable as an orientation mark.

2434.07 PRODUCTION

2434.07.01 Ballast Assemblies

Ballast assemblies shall be factory pre-wired with all connections clearly marked and identified.

2434.07.02 Lamp Socket Positions

The lamp socket position shall be pre-set and legibly marked at the factory for the specified distribution.

2434.08 QUALITY ASSURANCE

2434.08.01 Inspection

The supplier shall notify the Contract Administrator of the date that the fabrication of the luminaires is to commence.

The Contract Administrator shall have access to the place of fabrication for the purpose of inspecting and examining plant records, certificates, materials used, fabrication process, and to make any tests as may be considered necessary, while the work is being performed.

All luminaires are subject to an inspection by the Contract Administrator prior to shipment.

2434.09**OWNER PURCHASE OF MATERIAL****2434.09.01****Packaging and Shipment**

The supplier shall provide 3 copies of the luminaire ballast engineering data and shielding data such as material type, gauge thickness, and mounting arrangement to the Owner.

Each luminaire shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity. A complete parts list shall be included in the shipment. All cartons shall be marked with the ANSI or IES luminaire classification and distribution types.

The supplier is responsible for loading, delivery, and off-loading of luminaires to designated areas. Luminaires shall be subject to inspection during and on completion of off-loading. If any damage to the luminaires is encountered during the inspection, the supplier shall be responsible for the necessary corrective measures subject to the approval of the Owner.

The supplier shall advise the Owner 3 Working Days prior to the shipping date of the intent to deliver and confirm that arrangements for off-loading have been made.

2434.09.02**Measurement and Payment**

For measurement purposes, a count shall be made of the number of the underpass luminaires delivered and accepted.

Payment at the price specified in the purchasing order shall be full compensation for the supply and delivery of the underpass lighting luminaires to the destination at the date and time specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.

Appendix D 2434-A, November 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



Note: The PROV published in November 2018 replaces OPSS 2452 COMMON, November 2010 with no technical content changes.

MATERIAL SPECIFICATION FOR ALUMINUM POLES, BASE MOUNTED

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2452.01 SCOPE

This specification covers the requirements for base mounted aluminum poles maximum 15.1 m in length with cast shoe bases.

2452.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

W47.2-2011 (R2015) Certification of Companies for Fusion Welding of Aluminum

ASTM International

B 221M-13 Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wires, Profiles, and Tubes (Metric)
B 108/B108M-18e1 Standard Specification for Aluminum-Alloy Permanent Mold Castings

2452.04 DESIGN AND SUBMISSION REQUIREMENTS

2452.04.01 Submission Requirements

2452.04.01.01 Working Drawings

Working Drawings shall be prepared for the fabrication of aluminum poles.

Three sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to commencement of fabrication of the aluminum poles, for information purposes only. Prior to making a submission, the seals and signatures of a design Engineer and a design-checking Engineer shall be affixed on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

Where multi-discipline engineering work is depicted on the same Working Drawing and the design or design-checking Engineer or both are unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be sealed and signed by as many additional design and design-checking Engineers as necessary.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensions.
- b) Plans, elevations, sections, and details to show pole structural details.
- c) Equipment layout.
- d) Anchor bolt locations.
- e) Exact pole weight.
- f) Detailed bill of materials.
- g) Details of equipment nameplates.

A copy of the Working Drawings shall be retained for 7 years.

2452.05 MATERIALS

2452.05.01 General

Aluminum used in the production of pole shafts shall be according to ASTM B 221, alloy 6063-T4.

Aluminum used in the production of base castings shall be according to ASTM B 108, alloy A 356.0-T6.

2452.07 PRODUCTION

2452.07.01 General

The length of the poles shall be as specified in the Contract Documents.

The completed pole assembly shall be tempered to T6 condition and have a minimum yield strength of 165 MPa and a minimum ultimate tensile strength of 193 MPa.

Shafts shall be round in cross-section and taper from bottom to top.

Shafts shall be fabricated from a single tube with a wall thickness of 4.775 or 6.35 mm as specified in the Contract Documents.

Welded joints shall not be permitted for shafts.

Sweep shall not exceed 3.2 mm per 4.57 m, and the overall sweep shall not be greater than:

$(\text{Pole length (m)} / 4.57 \text{ m}) \times 3.2 \text{ mm}$

The pole shall be supplied with a one-piece cast shoe base complete with 8 gussets and a factory installed dampener for poles over 9.0 m in length.

After fabrication, the underside of the cast shoe base shall be true, distortion free, and perpendicular to the centreline of the pole shaft. When the cast shoe base is in contact with concrete, a cold tar epoxy coating shall be applied to the underside.

A removable aluminum top cap shall be supplied with the shaft. The cap shall be secured rigidly to the shaft by a hexagonal head stainless steel set screw.

Wiring apertures at the bracket mounting level and at the handhole shall be accurately positioned on the pole. Wiring apertures, complete with neoprene grommets, shall provide a smooth cable entrance.

All welding shall be according to CSA W47.2.

The handhole shall be formed by extrusion or other appropriate method and be designed such that the strength and cross-section of the shaft is not reduced.

Handhole covers shall be provided complete with a neoprene gasket, secured with stainless steel fasteners, aluminum back bar, and stainless steel inserts.

The shaft shall be rotary sanded and protective wrapped for shipment.

2452.07.02 Mounting Plate for Grounding

The mounting plate for the grounding post shall be welded to the shaft in such a manner that the temper of the shaft is not impaired and to present a smooth surface on the exterior of the shaft.

2452.07.03 Marking

Each pole shall have the following identification markings located approximately 100 mm above the top of the handhole:

- a) Manufacturer's name or trademark.
- b) Length.
- c) Wall thickness.
- d) Bolt circle diameter.
- e) Designation OPSS 2452.
- f) Date of manufacture (i.e., yyyy-mm-dd).

These markings shall be on a corrosion-resistant metal plate securely attached to the surface of the pole.

2452.07.04 Packaging and Shipping

Each pole shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity.

The grounding connector shall be assembled inside the pole prior to shipment.

The Owner shall be advised of the shipping date 3 Business Days prior to delivery.

2452.08 QUALITY ASSURANCE

2452.08.01 Inspection

All work is subject to an inspection by the Owner's representative prior to shipment.

The supplier shall notify the Owner of the date that the fabrication of the poles is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records; certificates; materials used; fabrication process, including welding; and to make any tests as may be considered necessary, while the poles are being fabricated.



MATERIAL SPECIFICATION FOR SECTIONAL STEEL POLES

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2453.09	OWNER PURCHASE OF MATERIAL

2453.01	SCOPE

This specification covers the requirements for sectional steel poles.

2453.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Ontario Traffic Manual (OTM):
Book 12 - Traffic Signals

Structural Manual

CSA Standards

G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
S6-14	Canadian Highway Bridge Design Code
W59-18	Welded Steel Construction (Metal Arc Welding)

ASTM International

A123/A123M-17 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

American Association of State Highway and Transportation Officials (AASHTO)

LTS-5-M Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition, with 2015 and 2019 Interim Revisions

2453.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Product Drawings means drawings prepared by the manufacturer that have been approved by the Owner for use with the product.

2453.04 DESIGN AND SUBMISSION REQUIREMENTS

2453.04.01 Design Requirements

All poles shall be designed to support the required traffic signal and lighting system components and shall be according to CSA S6 and MTO Structural Manual. All poles shall be according to CSA S6 and AASHTO LTS-5-M for fatigue requirements, AASHTO Fatigue Importance Category 2.

2453.04.01.01 Wind Loading

Wind loading shall be based on the maximum wind pressure for Ontario according to CSA S6.

2453.04.01.02 Ice Loading

Ice loading shall be based on the maximum ice loading in Ontario according to CSA S6.

2453.04.01.03 Geometric Parameters

Latitude of design and fabrication details is at the discretion of the supplier and is subject to approval of the design by the Owner.

2453.04.01.04 Supported Load Parameters

Design calculations shall employ force and dimensions for various items of equipment to be mounted on the poles as shown in Table 1.

2453.04.01.05 Sectional Steel Poles

Sectional steel poles used for traffic signal or combination of traffic signal and lighting system shall be base mounted and shall be capable of bearing the loads associated with configurations shown in Table 2.

Direct buried sectional steel poles shall be capable of bearing the loads associated with the equipment shown in Table 3.

Flasher/sign poles shall be capable of bearing the loads associated with the equipment shown in Table 4.

2453.04.01.06 Location of Equipment

Mast arms shall be solidly attached to the pole at a height above the pole base plate as given by:

$$H_A = 5,650 \text{ mm} - H$$

Where:

H_A = mast arm height above the pole base plate

H = mast arm height from Table 1

When more than one mast arm is considered, the shorter arm shall be attached to the pole at a point 300 mm above that of the longer arm.

Pedestrian heads shall be mounted as specified in the Contract Documents.

Luminaire brackets shall be mounted at a point 150 mm from the top of the pole.

2453.04.02 Submission Requirements

2453.04.02.01 Product Drawings

The sectional steel pole manufacturer shall submit the product drawings and the design assumptions and calculations for the poles to the Contract Administrator.

As a minimum, the product drawings shall include the following information:

- a) Material properties and standards.
- b) Dimensions.
- c) Hardware requirements.
- d) Plans, elevations, sections, and details to show pole structural details.
- e) Anchor bolt locations.
- f) Welds.
- g) Joining method for sectional steel poles sections.

The product drawings and calculations shall bear the seals and signatures of the design and design-checking Engineers.

2453.04.02.02 Working Drawings

Working Drawings shall be prepared for the fabrication of sectional steel poles.

Three sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of fabrication of the sectional steel poles for information purposes only. An Engineer shall affix his or her seal and signature on the Working Drawings verifying that the Working Drawings are consistent with the Contract Documents and sound engineering practices.

When multi-discipline engineering work is depicted on the same Working Drawing and a single Engineer is unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be signed and sealed by as many additional Engineers as necessary.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensions.
- b) Plans, elevations, sections, and details to show pole structural details.
- c) Equipment layout.
- d) Anchor bolt locations.
- e) Exact pole weight.
- f) Detailed bill of materials.
- g) Details of equipment nameplates.

2453.05 MATERIALS

2453.05.01 General

All steel used in the production of poles shall be according to CAN/CSA G40.21, Grade 300WT, Category 2, for pole shafts, base plates, and gussets.

All welding shall be according to CSA W59.

2453.07 PRODUCTION

2453.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

The pole base plate for any height of pole shall be made with mounting holes suitable for the anchor rod or anchorage assembly.

The underside of the anchor base shall be true, distortion free, and perpendicular to the centreline of the pole shaft after fabrication.

A waterproof, removable galvanized steel top cap shall be furnished with the pole. The cap shall blend with the general pole design to present a neat overall appearance. The cap shall be rigidly secured to the top of the pole by a hexagonal head stainless steel set screw.

Wiring apertures at the bracket mounting level and at the handhole shall be accurately positioned on the pole.

All wiring apertures shall provide a smooth cable entrance and be complete with rubber grommets.

Handholes, complete with covers, shall be reinforced with a steel handhole frame of such strength and cross-section that the strength of the pole is not reduced.

2453.07.01.01 Galvanizing

All components shall be hot dip galvanized according to ASTM A 123.

2453.07.02 Steel Sections

2453.07.02.01 General

The following covers types and lengths of sectional steel poles:

- a) Base mounted: 7.00, 8.70, and 10.50 m
- b) Direct buried: 5.25, 7.00, 8.70, 10.25, and 12.00 m
- c) Flasher/sign: 3.30 m

Pole sections shall be of round tapered construction so that a number of sections may be assembled by means of an overlapping press fit to form a tapered steel pole of the desired length.

Each section shall have one longitudinal automated electrically welded joint from top to bottom.

Each section shall be stencilled with O-L and graduations in one inch increments. O-L represents the nominal overlap requirement for each section.

2453.07.02.02 Base Mounted and Direct Buried Poles, 5.25 m and Longer

For lighting applications, a wiring aperture, complete with 28.5 mm ID rubber grommet shall be drilled 300 mm from the top of the pole.

Each base mounted pole shall be supplied with a reinforced 180 x 300 mm handhole, complete with cover. Each direct buried pole shall be supplied with a reinforced 100 x 200 mm handhole, complete with cover. A 6 x 38 x 250 mm long plate shall be welded inside the pole opposite the handhole. A ground connector shall be mounted on the plate. The ground connector shall be suitable for No. 6 AWG wire.

Each direct buried pole to be mounted solely with a power supply control cabinet shall have no handhole.

The centre of the handhole on base mounted poles shall be 1.1 m from the bottom of the pole and on direct buried poles the centre of the handhole shall be 2.75 m from the bottom of the pole.

Base mounted poles shall have a steel plate anchor base with 4 holes on a 449 mm bolt circle, suitable for mounting on 32 mm diameter studs.

Direct buried sectional steel poles shall have 65 x 300 mm wiring apertures on each side of the pole, the centre of the apertures shall be 1.25 m from the bottom of the pole.

2453.07.02.03 Flasher Poles

The flasher pole shall be comprised of two pole sections totalling 2.3 m in length with a 1.2 m length of 50 mm IPS Schedule 40 pipe inserted 230 mm into the top and welded in place to provide a total length of 3.3 m.

The top end of the extension shall be threaded, and the thread cleaned after galvanizing.

Each pole shall be supplied with a 75 x 100 mm handhole, complete with cover. The bottom edge of the handhole shall be 150 mm from the bottom of the pole.

A ground terminal shall be provided in the handhole.

The flasher pole shall be supplied with a steel plate anchor base with 4 holes on a 150 mm bolt circle, suitable for mounting on 16 mm diameter studs.

2453.07.03 Marking

Each pole shall have identification marking located approximately 100 mm above the top of the handhole showing the following:

- a) Manufacturer's name or trademark.
- b) Length.
- c) Designation OPSS 2453.
- d) Manufacturer's catalogue number.
- e) Date of manufacture (i.e., yyyy-mm-dd).

This marking shall be on a corrosion-resistant metal plate securely attached to the surface of the pole.

2453.07.04 Ground Bar

A ground bar with a bronze ground connector suitable for No. 6 AWG wire shall be welded to the inside of each pole. The bronze ground connector shall be attached to the ground bar before shipment.

2453.07.05 Packaging and Shipping

Each pole shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity.

The Contract Administrator shall be advised of the shipping date 3 Business Days prior to delivery.

2453.08 QUALITY ASSURANCE

2453.08.01 Inspection

All work is subject to an inspection by the Contract Administrator prior to shipment.

The supplier shall notify the Contract Administrator of the date that the fabrication of the poles is to commence.

The Contract Administrator shall have free access to the place of fabrication of the poles for the purpose of inspecting and examining plant records and certificates while work on the poles is being performed; materials used; process of fabrication, including welding and galvanizing; and to make any tests as may be considered necessary.

2453.09 OWNER PURCHASE OF MATERIAL

2453.09.01 Working Drawings and Shipment

Within 30 Days of receipt of a purchasing order to supply sectional steel poles, the supplier shall submit 3 copies of pole Working Drawings, as described in the Submission Requirements subsection, to the Owner.

The supplier shall advise the Owner of the shipping date 3 Business Days prior to delivery.

2453.09.02**Measurement and Payment**

For measurement purposes, a count shall be made of the number of sectional steel poles supplied and accepted.

Payment at the price specified in the purchasing order shall be for the supply of the sectional steel poles delivered to the destination on the date and time specified.

The cost of all testing, except that performed by the Owner, shall be included in the price.

TABLE 1
Supported Load Parameters

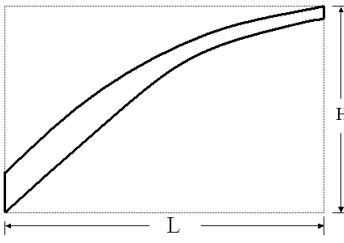
Item of Equipment	Dimensions mm	Projected Area m ²	Weight N
Roadway Lighting Luminaire (Ovaloid)	990 L x 380 H	0.22	107
Roadway Lighting Bracket (Aluminum)	2400 L x 1200 H (tapered)	0.15	112
Double Arm Brackets (Aluminum)	400 L x 42 Dia. (2 per set)	0.04	24
Mast Arm (Aluminum) 	610 L x 250 H (tapered)	0.04	78
	1200 L x 530 H (tapered)	0.10	91
	1800 L x 610 H (tapered)	0.15	114
	2400 L x 840 H (tapered)	0.19	65
	3000 L x 610 H (tapered)	0.23	94
	3600 L x 840 H (tapered)	0.38	113
	4600 L x 1070 H (tapered)	0.47	216
	5500 L x 910 H (tapered)	0.70	324
Traffic Signal Heads (Aluminum: 4-Section)	1650 H x 610 W	1.01	123
Pedestrian Heads (Aluminum: 2-Section)	690 H x 345 W	0.23	78
Traffic Signs	Varies: see Table 2	1.50	23

TABLE 2
Base Mounted Sectional Steel Pole Configurations

Pole Height m	Luminaire and Bracket set	Longest Mast Arm with Head m	Maximum Mast Arm Total Length (Note 1) m	Number of Pedestrian Heads (Note 2)	Traffic Signs (Note 3) m ²	Street Name Sign (Note 4) m ²
7.00	1	5.5	11.0	2	0.75	0.97
8.70	1	5.5	11.0	2	0.75	0.97
10.50	1	5.5	11.0	2	0.75	0.97

Notes:

1. Mast arm total length applies to the sum of the lengths of two mast arms at 90-degree orientation.
2. Two pedestrian heads at 90-degree orientation include a set of double arm brackets for each.
3. Traffic signs shall be split to give 0.25 m² mounted on the mast arm beside the signal head and 0.5 m² mounted at 2.75 m height above the pole base plate.
4. Street name or roadway identification sign shall have a maximum height of 0.45 m and a maximum length of 2.10 m. The sign shall be mounted on each mast arm or pole and the distance between the centre of the sign and the surface of the pole shall not exceed half the length (L) of the mast arm. Pole mounted street name signs shall be mounted at the same height as the mast arm mounted signs or at the top of the pole, whichever is less.

TABLE 3
Direct Buried Sectional Steel Pole Configurations

Pole Height m	Luminaire and Bracket (Note 1) set	Supply Control Cabinet Type 1 (Note 2) each
5.25	2	N/A
5.25	N/A	2
7.00	2	N/A
7.00	N/A	2
8.70	2	N/A
8.70	N/A	2
10.25	2	N/A
10.25	N/A	2
12.00	2	N/A
12.00	N/A	2
Notes: 1. See Table 1. 2. Each supply control cabinet shall have maximum dimensions of 865 mm H x 465 mm W x 250 mm D and a maximum weight of 700 N.		

TABLE 4
Flasher/Sign Pole Configurations

Pole Height m	Beacons (Note 1) each	Traffic Signal Head (3 display sections) (Note 1) each	Traffic Signs m²
3.3	2	N/A	0.5
3.3	N/A	1	0.5
Note: 1. Each beacon or traffic signal display shall be a 300 mm display according to OTM Book 12 and the total weight of the beacons or the three section traffic signal head shall be a maximum of 200 N.			



**MATERIAL SPECIFICATION FOR
TRAFFIC SIGNAL ARMS, BRACKETS,
HANGERS, FITTINGS, AND HARDWARE**

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2460.01	SCOPE

This specification covers the requirements for single member arms, aluminum pipe arms, double arm brackets, traffic signal hanger assemblies, and traffic signal mounting hardware and accessories.

2460.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 2461 Signal Heads

CSA Standards

G40.20-13/G40.21-13	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
S157-05/S157.1-05 (R2015)	Strength Design in Aluminum
W47.2-11 (R2015)	Certification of Companies for Fusion Welding of Aluminum
W59-13	Welded Steel Construction (Metal/Arc Welding)

ASTM International

A 123/A 123M-15	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A 307-14e1	Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
A 563-15	Carbon and Alloy Steel Nuts
B 108/B108M-15	Aluminum-Alloy Permanent Mold Castings
F 593-13ae1	Stainless Steel Bolts, Hex Cap Screws, and Studs
F 594-09 (2015)	Stainless Steel Nuts

American National Standards Institute (ANSI)

B18.2.1-2012	Square, Hex, Heavy Hex, and Asken Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
B18.2.2-2015	Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
B18.21.1-2009	Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

2460.04 DESIGN AND SUBMISSION REQUIREMENTS

2460.04.01 Design Requirements

2460.04.01.01 Traffic Signal Arms, Brackets, Hangers, Fittings, and Hardware

All traffic signal equipment shall be designed to accommodate a five section signal head with 300 mm lenses complete with backboard according to OPSS 2461.

2460.04.01.02 Aluminum Components

Structural design shall be according to CAN/CSA S157.

2460.04.02 Submission Requirements

2460.04.02.01 Working Drawings

Four sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of fabrication. An Engineer shall review and sign the Working Drawings verifying that the drawings are consistent with the Contract Documents and sound engineering practices.

Where multi-discipline engineering work is depicted on the same Working Drawing and a single Engineer is unable to sign the Working Drawing for all aspects of the work, the drawing shall be signed by as many additional Engineers as necessary.

Once fabrication of the equipment has commenced, materials and dimensions shown on the submitted Working Drawings shall not be changed.

2460.05 MATERIALS

2460.05.01 Structural Steel

Structural steel shall be according to CSA G40.20/G40.21, minimum yield strength 300 MPa.

2460.05.02 Steel Hardware

Steel bolts shall be according to ANSI B18.2.1 and ASTM A 307, Grade A, minimum yield strength 400 MPa. Steel nuts shall be according to ANSI B18.2.2 and ASTM A 563, Grade A, minimum yield strength 400 MPa. Steel washers shall be according to ANSI B18.21.1.

Stainless steel bolts shall be according to ASTM F 593 with head marking F593C. Stainless steel nuts shall be according to ASTM F 594. Stainless steel washers shall be fabricated from 18.8 alloy.

2460.05.03 Cast Alloy Materials

Fittings cast from non-ferrous alloys shall be according to ASTM B 108 and strength requirements compatible with other components and the design requirements. Fittings shall be cast with aluminum alloy, grade A356.2 or G6290. Castings shall be F or T6.

2460.05.04 Aluminum Pipe and Tube

Aluminum pipe shall be 38 mm (1½") diameter, schedule 40, 6061-T6, and strength requirements compatible with other components and the design requirements.

Aluminum tubes shall be fabricated from 6063 alloy.

2460.07 PRODUCTION

2460.07.01 General

2460.07.01.01 Galvanizing

All structural steel, steel hardware, and cast ferrous components shall be hot dip galvanized according to ASTM A 123.

2460.07.01.02 Welding

All welding of steel shall be according to CSA W59.

All welding of aluminum shall be according to CSA W47.2.

2460.07.02 Single Member Arms

Single member arms shall be fabricated by tapering and bending aluminum tube to the required dimensions. The end of the arm shall be provided with a 50 mm IPS (iron pipe size) tenon, 100 mm long for mounting of a hanger. The tenon shall be horizontal when the arm is mounted on a vertical surface. After fabrication, arms shall be heat treated to T-6 temper.

The vertical rise of the mast arm shall be according to Table 1.

The pole attachment assembly shall be fabricated from structural steel complete with:

- a) Flat steel pole straps with four hex head bolts, nuts, and lock washers for mounting on metal or concrete poles.
- b) Four 20 mm diameter bolt holes for mounting on wooden poles.

The pole plate collar attachment to the aluminum arm shall be retained by hex head bolts with nuts and lock washers. The number of hex head bolts shall be according to Table 1.

Pole attachment assemblies for use with wooden, metal, or concrete poles shall be fabricated to suit arms and pole diameters.

Pole plate assemblies for use with wooden poles shall be fabricated to suit arms and pole diameters.

The completed aluminum signal member arm shall be as specified in the Contract Documents.

2460.07.03 Aluminum Pipe Arms

Aluminum pipe arms shall be fabricated from 50 mm IPS aluminum pipe. The pipe shall be bent such that the tenon end is horizontal when the arm is mounted on a vertical surface to give the vertical rise, as measured from the top of the pole plate to the centre of the tenon according to Table 2.

The pole plate for attachment of the mast arm shall be a cast alloy universal plate with adjustment set screws permitting adjustment of the angle of the mast arm over a range of 15° and shall be complete with two 20 mm diameter bolt holes for mounting on wooden poles and with a lipped portion, top and bottom, suitable for attachment of pole attachments.

Pole attachment assemblies shall be fabricated from flat structural steel complete with pole plate straps, 12.7 mm diameter U bolts, nuts, lock washers, and round washers for mounting on metal or concrete poles. Pole attachment assemblies shall be provided for aluminum pipe arm pole plates and be fabricated to suit pole diameters.

2460.07.04 Double Arm Brackets

Double arm brackets shall be fabricated from 38 mm IPS schedule 40, aluminum pipe to the length specified in the Contract Documents. Each bracket shall consist of a cast aluminum 90° flanged street elbow, pole plate, and hexagonal or octagonal locknut and a neoprene washer. The cast pole plate shall be provided with four 16 mm diameter bolt holes for mounting on wooden poles and with lipped edges, top and bottom, suitable for use with 16 mm wide stainless steel strapping. The completed double arm bracket shall be as specified in the Contract Documents.

2460.07.05 Traffic Signal Hanger Assemblies

Traffic signal hanger assemblies shall be of the following types, as specified in the Contract Documents:

- a) adjustable mid-section hanger
- b) dual-end hanger

Traffic signal hanger assemblies shall be fully adjustable to provide the required signal visibility.

2460.07.06 Signal Mounting Hardware, Fittings, and Accessories

Signal mounting hardware, fittings, and accessories for aerial installation shall be as specified in the Contract Documents.

2460.07.07 Packaging

Aluminum arms shall be wrapped in heavy paper to protect the finish.

Steel components shall be strapped together with external corners protected with packing material. Small components, hardware, fittings, and accessories shall be packaged securely in cardboard containers and protected with packing material.

2460.08**QUALITY ASSURANCE****2460.08.01****Inspection**

The Contract Administrator shall be notified a minimum of 3 Business Days prior to the start of fabrication for the traffic signal arms, brackets, and hangers.

The Contract Administrator shall have free access to the place of manufacture of the traffic signal arms, brackets, and hangers for the purpose of inspecting and examining plant records and certificates; materials used; process of manufacturing, including welding and galvanizing; and to make any tests as may be considered necessary, while the traffic signal arms, brackets, and hangers are being fabricated.

The Contract Administrator shall be notified when the traffic signal arms, brackets, and hangers are ready for inspection.

All traffic signal arms, brackets, and hangers may be subject to an inspection by the Contract Administrator prior to shipment.

TABLE 1
Aluminum Single Member Arm Requirements

Arm Length m (Note 1)	Arm Rise m	Number of Hex Head Bolts for Pole Plate Collar Attachment
1.2	0.53	2
1.8	0.61	2
2.4	0.84	2
3.0	0.61	3
3.6	0.84	3
4.6	1.07	3
5.5	0.91	3
6.1	1.07	3
6.7	1.14	3
7.6	1.20	3
Notes: 1. Measured from the centre of the pole plate to the centre of the tenon.		

TABLE 2
Aluminum Pipe Arm Dimensions

Arm Length m	Arm Rise m
0.6	0.25
1.2	0.25



MATERIAL SPECIFICATION FOR SIGNAL HEADS

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2461.01	SCOPE

This specification covers the requirements for traffic signal heads and associated components and accessories.

2461.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Ontario Traffic Manual (OTM):
Book 12 - Traffic Signals

CSA Standards

C22.2 No. 0.4-17	Bonding of Electrical Equipment
C22.2 No. 127-15	Equipment and Lead Wires
S157-17	Strength Design in Aluminum

Institute of Transportation Engineers

ST-017B	Equipment and Material Standards of the Institute of Transportation Engineers, April 3, 2006
ST-052	Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Circular Signal Supplement, June 27, 2005
ST-054	Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement, January 1, 2008
ST-055	Pedestrian Traffic Control Signal Indicators: Light Emitting Diode (LED) Signal Modules, February 1, 2011

ASTM International

D4956-19 Retroreflective Sheeting for Traffic Control

Others

Federal Specification Colour Yellow 595B-33538
Federal Specification Colour Gray MVCL-14187
Ontario Highway Traffic Act, R.S.O. 1990, Chapter H.8

2461.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Backboard means a panel surrounding a signal head used for the purpose of increasing the attention value of the signal.

Chromaticity means the colour quality of light that is defined by the wavelength (hue) and saturation.

LED Lamp means a light emitting diode (LED) signal module, LED arrow signal module, or LED pedestrian signal module.

LED Arrow Signal Module means a signal unit comprised of an array of LEDs, lens, and related power supply that provides an arrow traffic signal indication.

LED Pedestrian Signal Module means a signal unit comprised of an array of LEDs, lens, and related power supply that provides a pedestrian signal indication consisting of a walking pedestrian or hand icon.

LED Signal Module means a signal unit comprised of any array of LEDs and related power supply and any required lenses that provides a circular traffic signal indication when connected to appropriate power.

Programmable Visibility Head means the traffic signal head that can be programmed to limit the visible area of the indication.

2461.04 DESIGN AND SUBMISSION REQUIREMENTS

2461.04.01 Design Requirements

2461.04.01.01 Signal Head Requirements

Signal heads shall be designed to be attached to the traffic signal hanger assemblies using cushion hangers, adjustable mid-section hangers, or dual-end hangers with standard 38 mm internal pipe size gusseted pipe and fittings. Structural design of aluminum shall be according to CSA S157.

2461.05 MATERIALS

2461.05.01 General

Signal heads, components, and accessories shall be according to ITE ST-017B and as specified in the Contract Documents.

2461.05.02 Signal Head Housings

Signal head housings shall be a die-cast aluminum or a moulded polycarbonate body with hinged door assembly to provide a water and dust tight enclosure. The openings of the signal head housing shall be provided with a removable sealing device. Aluminum alloy shall be according to CSA S157. The polycarbonate signal head shall be moulded, ultraviolet and heat stabilized, flame retardant resin, and shall be yellow according to Federal Specification Colour Yellow 595B-33538.

When specified in the Contract Documents, the colour of the signal head housing with grey body and the back of the aluminum or polycarbonate backboard shall be according to Federal Specification Colour Gray MVCL-14187.

Stainless steel reinforcing plates shall be provided according to the manufacturer's recommendation for the mounting arrangement as specified in the Contract Documents for the signal head.

2461.05.03 Visors

Each lens shall be provided with a removable visor of the cowl (cap) type. When specified in the Contract Documents, lenses shall be provided with removable visors of the tunnel, full-circle, or louvre type.

2461.05.04 Snow Shields

When specified in the Contract Documents, snow shields shall be provided and installed according to the manufacturer's recommendation. Snow shields shall be a one-piece injection molded unit, resistant to fading and discoloration with exposure to direct sunlight, and contain no electronic heaters or circuitry. The unit shall be entirely transparent and shall not degrade the LED photometric requirements in any way.

Each snow shield shall be provided with a new neoprene rubber gasket, and be compatible with all traffic module sizes listed in Table 1.

2461.05.05 Wiring

Wiring shall be #18 AWG stranded copper type TEW and according to CSA C22.2 No. 127.

2461.05.06 Ground Terminals

Ground lugs shall be provided in signal heads to accommodate a #14 AWG bonding wire.

2461.05.07 Backboards

As a minimum, backboards shall be fabricated from 1.00 mm thick aluminum sheets or 3.00 mm thick high-density polyethylene sheets and shall project a minimum of 125 mm all around beyond the signal head housing. The signal head backboard shall be standard colour yellow according to Federal Specification Colour Yellow 595B-33538.

All backboards shall be opaque, and shall be outfitted with a strip of 75 mm wide fluorescent yellow prismatic retroreflective sheeting according to ASTM D4956, Type XI, around the front facing border.

2461.05.08 Reflectors

Reflectors shall be Alzak aluminum and the reflective surface shall be according to ITE ST-017B.

2461.05.09 Lenses

Lenses shall be convex prismatic of the polycarbonate or glass type according to chromaticity characteristics specified in ITE ST-017B and with the size, type, colour, and orientation specified in the Contract Documents.

2461.05.10 Paint

Paint shall be synthetic resin enamel and according to Federal Standard Colour Yellow 595B-33538.

2461.05.11 LED Lamps

2461.05.11.01 Physical and Mechanical Requirements

The LED signal modules at minimum shall be according to ITE ST-052 and the Contract Documents.

The LED arrow signal modules at minimum shall be according to ITE ST-054 and the Contract Documents.

The LED pedestrian signal modules at minimum shall be according to ITE ST-055 and the Contract Documents.

Each LED lamp shall have a single lens with a smooth outer surface. All circular red lenses shall be tinted red and all circular amber lenses shall be tinted amber. The use of tinting or other materials to enhance ON/OFF contrasts shall not affect chromaticity and shall be uniform across the face of the lens. The lens shall be UV stabilized and shall be capable of withstanding direct ultraviolet sunlight exposure for a minimum period of 60 months without exhibiting evidence of deterioration or colour change.

All circular red, amber, and green LED lamps shall have an incandescent look that provides a softened and uniform appearance.

The LED lamps shall be capable of retrofitting and replacing incandescent lamps without modifications to a standard ITE traffic signal housing. Installation shall only require the removal of the existing lens, lamp reflector assembly, and gasket. Each LED lamp shall have secured jacketed and colour coded cables for connecting to power and for bonding to system ground. The connecting cable shall be rated 600 volts. All wire leads shall be one metre in length, pre-stripped, and tinned.

Each LED lamp shall be a sealed unit that includes all parts necessary for operation (e.g., printed circuit board, power supply, lens, and gasket) and shall be weatherproof after installation and connection. A one-piece 12.5 mm wide neoprene gasket shall be provided and installed on the LED lamp prior to delivery.

All LED lamps shall be according to the size, colour, and design specified in the Ontario Highway Traffic Act and the OTM Book 12.

The LED pedestrian signal module shall be the single unit with the walking pedestrian and hand superimposed in the same unit according to the Ontario Highway Traffic Act and the OTM Book 12.

All LED lamps shall be approved by the Electrical Safety Authority or by an organization accredited by the Standards Council of Canada.

The LED lamps for use in programmable visibility head shall comply with the general requirements for LED signal modules. The LED lamps shall be designed and constructed to be installed in a programmable visibility head without modification to the housing.

2461.05.11.02 Electrical Requirements

Electrical requirements for LED signal modules shall be according to ITE ST-052; the LED arrow signal modules shall be according to ITE ST-054; and the LED pedestrian signal modules shall be according to ITE ST-055.

Maximum power consumption for LED lamps shall be according to Table 1 and Table 2.

Power factor shall be a minimum of 0.95.

2461.05.11.03 Photometric Requirements

Photometric requirements of the LED signal modules shall be according to ITE ST-052. Photometric requirements of the LED arrow signal modules shall be according to ITE ST-054.

All LED signal and arrow signal modules shall be the expanded view type.

2461.05.11.04 LED Lamp Identification

Each LED lamp shall have the manufacturer's name, trademark, model number, serial number, and date of manufacture (i.e., month-year) marked on the back of the module.

The following operating characteristics shall be permanently marked on the back of the module: nominal operating voltage; power consumption, in watts; and volt-amperes.

Each LED lamp shall have a symbol of the type of module (e.g., circle or arrow) in the colour of the module marked on the back of the module. The colour of the module shall be written out next to the symbol.

When specific mounting orientation is required, each module shall have prominent and permanent marking consisting of an up arrow or the word UP or TOP.

2461.05.11.05 LED Lamp Warranty

The warranty period for each LED lamp shall be 60 months, commencing from the date of switch on for operation of the traffic signals in which the LED lamp is used. Any LED lamp deemed to have a visual or operational deficiency shall be replaced within 30 days. The warranty shall cover all delivery, parts, and material costs.

2461.07 PRODUCTION

2461.07.01 General

Sectional signal heads consisting of one to six sections shall be supplied as specified in the Contract Documents.

Lenses shall be arranged in the following order commencing from the top of the signal head to the bottom:

- a) Red
- b) Amber
- c) Green
- d) Straight Through Green Arrow

e) Left Turn Green / (Amber) Arrow

f) Right Turn Green Arrow

When any of the foregoing indications are not required, the order of arrangement shall be maintained by omitting those sections, which are not required.

Each section shall consist of a signal head housing, wiring, visor, LED lamps, reflectors, and lens, as specified in the Contract Documents.

Each complete assembly shall consist of a ground terminal and, when specified in the Contract Documents, a backboard.

Pedestrian signal heads shall consist of one or two housing sections suitable for rectangular signals. One display shall be a translucent lunar orange hand and the other display shall be a translucent lunar white walking pedestrian. Standard square visors shall be provided.

2461.07.02 Wiring

Loops of 150 mm length of wire shall be left in each section.

2461.07.03 Bonding

Metallic components shall be bonded together and grounded to the ground terminal according to CSA C22.2 No. 0.4.

2461.07.04 Assembly

All components shall be factory assembled using mechanical devices according to the strength requirements of ITE ST-017B.

2461.07.05 Painting

All externally visible portions or components of the metal signal heads, with the exception of lenses and the underside of visors, shall be painted yellow. The underside of the visors of the metal signal heads and the visors of the polycarbonate signal heads shall be painted matte black.

2461.07.06 Signal Head Identification

Each signal head shall have identification markings in a visible location indicating the manufacturer's name or trademark, date of manufacture, and standard designation OPSS 2461.

Identification markings shall be embossed on the signal head or on a corrosion-resistant metal plate securely attached to the signal head.

2461.07.07 Packaging

Each signal head shall be packaged securely in cardboard cartons. Backboards and separately ordered components may be packaged separately.

2461.08 QUALITY ASSURANCE

2461.08.01 Inspection

The Contract Administrator shall be notified a minimum of three Business Days prior to the start of fabrication for the signal heads.

While work is being performed, the Contract Administrator shall have access to the place of manufacture of the signal heads for the purpose of inspecting and examining plant records and certificates, materials used, process of manufacturing, and to make any tests as may be considered necessary.

All signal heads may be subject to an inspection by the Contract Administrator prior to shipment.

TABLE 1
LED Signal and Arrow Signal Modules
Maximum Power Consumption (Watts) based on Operating Temperatures (°C)

	Red		Amber		Green	
	25°C	74°C	25°C	74°C	25°C	74°C
Circular 300 mm	11	17	22	25	15	15
Circular 200 mm	8	13	13	16	12	12
300 mm Arrow	9	12	10	12	11	11
Programmable Visibility Indication	11	17	22	25	15	15

TABLE 2
LED Pedestrian Signal Modules
Maximum Power Consumption (Watts) based on Operating Temperatures (°C)

	25°C	74°C
Hand	10	12
Walking Pedestrian	9	12



MATERIAL SPECIFICATION FOR SECTIONAL STEEL HIGH MAST LIGHTING POLES

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2471.01	SCOPE

This specification covers the requirements for base mounted sectional steel high mast lighting poles 25, 30, 35, 40, and 45 metres in height with a multisided cross-section.

2471.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 906 Structural Steel
OPSS 911 Coating Structural Steel Systems

Ontario Ministry of Transportation Publications

Structural Manual
Designated Sources for Materials (DSM)

CSA Standards

B95-1962 (R2002)	Surface Texture (Roughness, Waviness and Lay)
G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel
S6:19	Canadian Highway Bridge Design Code

W47.1-09 (R2014)	Certification of Companies for Fusion Welding of Steel
W59-18	Welded Steel Construction (Metal Arc Welding)
W178.1-18	Certification of Welding Inspection Organizations
W178.2-18	Certification of Welding Inspectors

ASTM International

A500/A500M-18 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

Canadian General Standards Board (CGSB)

48.9712-2014 Non-Destructive Testing - Qualification and Certification of NDT Personnel

American Association of State Highway and Transportation Officials (AASHTO)

LTS-5-M Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 5th Edition, Interim Revisions (2010)

International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)

17025:2017 General Requirements for the Competence of the Testing and Calibration Laboratories

Others

Federal Standard 595C Color Standards

2471.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Multisided Cross-Section means a steel section having either eight or twelve sides as specified in the Contract Documents.

2471.04 DESIGN AND SUBMISSION REQUIREMENTS

2471.04.01 Design Requirements

Sectional steel high mast lighting poles shall be designed according to CSA S6, Structural Manual, AASHTO LTS-5M, DSM product drawings, and as specified in the Contract Documents. Each pole shall be capable of supporting a total load of 2,000 kg with a combined effective projected area of all the luminaires, shroud, and shields of 4.0 m².

2471.04.02 Submission Requirements

2471.04.02.01 Working Drawings

Working Drawings shall be prepared for the fabrication of the sectional steel high mast lighting poles.

Three sets of Working Drawings shall be submitted to the Contract Administrator 14 Days prior to commencement of fabrication of the sectional steel high mast lighting poles, for information purposes only. An Engineer shall review the drawings and affix a reviewed stamp with his or her signature to the Working Drawings verifying that the Working Drawings are consistent with the Contract Documents and sound engineering practices.

Where multi-discipline engineering work is depicted on the same Working Drawing and a single Engineer is unable to seal and sign the Working Drawings for all aspects of the work, the drawing shall be signed and sealed by as many additional Engineers as necessary.

A copy of the Working Drawings shall be retained at the fabricator's plant during and after pole fabrication.

The Working Drawings shall contain all information necessary to fabricate the sectional steel high mast lighting poles including:

- a) Dimensioned drawings, including lengths, sizes, cross-sections, and details of the sectional steel pole, and exact weights of pole sections.
- b) Final forces for field assembly of pole sections.
- c) Details for the mounting supports of the winch assembly, the head frame assembly, and the electrical panel assembly.
- d) Details of access opening and of access door.
- e) Welding details, including welding procedures to be used for each joint.
- f) Detailed bill of materials.
- g) Details of identification nameplates.

2471.04.02.02 Mill Test Certificates

Mill test certificates shall be submitted according to OPSS 906.

2471.04.02.03 Welding Procedures

Welding procedure data sheets for each joint configuration to be welded shall be prepared according to CSA W59, stamped with CWB's acceptance, and available for review during fabrication of the sectional steel high mast lighting poles. Three sets of welding procedures shall be submitted to the Contract Administrator 14 Days prior to commencement of fabrication of the sectional steel high mast lighting poles, for information purposes only.

2471.04.02.04 Welder's Qualification

Welders shall have valid CWB issued qualification cards indicating the welding processes and the positions for which they are qualified to weld. Prior to the commencement of fabrication, three copies of the Welders' and Welding Operators' current qualification cards shall be submitted to the Contract Administrator.

2471.05 MATERIALS

2471.05.01 Steel

All structural steel shall be CSA G40.20/G40.21, Grade 350WT, Category 3. Higher grades of steel shall not be accepted.

Steel for tenon pipe shall be CSA G40.20/G40.21, Grade 300W, or A 500M Grade C.

For pole masts, silicon content reported on the mill test certificate shall be less than or equal to 0.06%.

2471.05.02 Electrodes

Electrodes and flux used for welding shall have a low hydrogen content and shall be as specified in the fabricator's CWB approved welding procedures.

2471.05.03 Paint Coatings

Paint coatings shall be according to OPSS 911 and the Contract Documents.

The colour of the finish coat shall be equivalent to 16307 grey according to Federal Standard 595C.

2471.07 PRODUCTION

Requirements for electrical work shall be as specified in the Contract Documents.

Production shall be done in fabrication facilities listed in the relevant DSM listing.

Structural steel fabrication shall be according to OPSS 906, CSA W59, Contract Documents, and the Working Drawings.

2471.07.01 Tolerances

Fabrication shall be according to the dimensions on the sealed and signed Working Drawings.

The dimensions of the assembled high mast lighting pole shall be within the following tolerances:

- a) Overall height of pole mast: 5 mm for every 1 m in height.
- b) Cross-sectional width of shaft across flats:
 - i. 1.0%, for widths less than 500 mm,
 - ii. 0.75% for widths greater than 500 mm.
- c) Maximum sweep of the pole mast on its overall length measured from a chord joining the extremities and the centreline of the mast shall not exceed 0.2% of its overall length.
- d) Maximum deviation from straight of the shaft wall on any 3 m length of pole mast shall not exceed 5 mm.
- e) Offset between the centreline of the top section of the pole and the centreline of the bottom section of the pole shall not exceed 150 mm.
- f) Offset between the centreline of the base plate and the centre of the pole mast at base shall not exceed 5 mm.
- g) Wall thickness shall be within the tolerance permitted in CSA G40.20/G40.21 and ASTM A500M.

2471.07.02 Fabrication

2471.07.02.01 General

The pole mast shall be cold formed from steel plate and each section shall be fabricated with one or two continuous longitudinal welds. If two welds are used, they shall be on opposite sides of the pole shaft.

One circumferential shop splice per section shall be permitted. Where possible, the shop splice shall be completed prior to forming the pole cross-section.

In the area of the lap splice between pole segments, there shall be no protrusions preventing proper alignment of one section with the next. Any excess weld material shall be removed by grinding to form a smooth surface maintaining a uniformly tapered section.

Each pole shall be supplied with a reinforced handhole complete with a cover. The cover shall have provision for padlocking and shall be fitted with a silicone rubber gasket such that, upon locking, the cover shall be tightly fitted to the handhole.

Each pole shall be supplied with the appropriate mounting plate, brackets, and other attachments required for the installation of the raising and lowering equipment. The mounting plate, brackets, and other attachments shall be attached to the shaft wall by welds as specified in the Contract Documents. Nuts for securing the electrical panel shall be welded to the back of the mounting plate at each mounting hole as specified in the Working Drawings.

The head frame shall be assembled to the pole by means of a tenon mounting system. The tenon shall be compatible with the head frame and raising and lowering device.

In the tenon mounting system, a circular plate with nominal thickness of 12 mm shall be welded to the top of pole as specified in the Contract Documents. The plate shall have a circular opening through its centre, equal to the outside diameter of the tenon, through which the tenon shall be inserted.

The pole section joints shall be slip fitted connections as specified in the Contract Documents. Joint details shall not interfere with the raising or lowering of the luminaire assembly.

The maximum overlap shall be such that the height of the completed mast complies with the permitted overall tolerances. The minimum overlap length shall be as per the Working Drawings.

Shop trial-assembly shall be carried out to check the fit of the sections. The manufacturer shall determine the necessary compressive assembly forces and lap lengths to be achieved during the pre-assembly operation to ensure the final field assembly shall meet the requirements of the Contract Documents. Sections shall be match-marked to facilitate the field assembly. The markings shall be permanent and the location, size, and marking medium shall not interfere with the slip joint.

All cut edges of the base plate shall have a surface finish not greater than 1,000 (25µm) as defined in CSA B95. All corners shall be ground to a radius of 3 mm.

2471.07.02.02 Fabrication Outside of Canada and USA

For high mast lighting poles fabricated in a production facility outside of Canada and USA, the following additional requirements shall apply:

- a) The fabrication facility must be listed on List #6.60.40 in the Electrical Division of the DSM.
- b) Fabrication of high mast lighting poles shall not begin until the information on the mill test certificates is verified by testing at a Canadian laboratory according to OPSS 906. The mill test certificates by the Canadian laboratory shall be stamped with the name of the laboratory and state that the material is according to the specified Contract requirements.

Two copies of these stamped mill test certificates shall be submitted to the Contract Administrator.

- c) All high mast lighting poles fabricated outside of Canada and USA shall be shipped to a facility in Canada certified in accordance with CSA W47.1, Division 1 or 2 for quality verification.
- d) Shipped high mast lighting poles shall be accompanied by reports containing the results of all inspection and testing performed in the production facility outside of Canada and USA demonstrating compliance with the Quality Control subsection of this Specification.
- e) Shipped high mast lighting poles shall not be galvanized or coated and shall be in a condition that permits inspection and testing.
- f) The Contractor shall hire an independent welding inspection company to perform quality verification of shipped high mast lighting poles according to the Quality Control subsection of this Specification. All costs incurred to perform inspection and testing at a Canadian facility shall be the responsibility of the Contractor.

- g) Acceptance of high mast lighting poles shall be based on satisfactory inspection of one randomly selected complete pole from a lot. The size of a lot shall consist of a maximum 5 poles. All of the components of the pole shall be inspected and tested according to the Quality Control subsection of this Specification. The reports accompanying the shipment shall also be reviewed by the welding inspector. Inspection, testing, and reporting shall be done on each shipment received.
- h) The welding inspector shall ensure that traceability of all structural steel has been maintained by:
 - i. Correlation of heat numbers on high mast pole steel to the mill test certificates.
 - ii. Review of mill test certificates, verifying that materials used conform to the contract requirements.
- i) If the inspection or testing performed on the high mast lighting poles demonstrate that they do not meet the requirements of the Contract Documents, all poles in that lot shall be rejected.

2471.07.03 Welding

All welding shall be according to CSA W59, including its provisions for cyclically loaded structures, and shall be undertaken by a manufacturer certified in accordance with CSA W47.1, Division 1 or 2.

During fabrication, upon request the Contractor shall make available to the Contract Administrator the CWB approved qualification cards for each Welder and Welding Operator employed on the work.

Welds for circumferential splices shall be full strength complete joint penetration.

The longitudinal seam welds shall be single V and shall be made from the outside of the structure. Throat thickness shall be according to CSA W59, to ensure a minimum of 60% joint penetration.

Longitudinal seam welds within 150 mm of a complete penetration circumferential weld or within the lap of the slip joints plus an additional 150 mm extending from the slip joint shall be full strength complete penetration groove welds and shall be ground smooth.

Any section of weld that does not meet the acceptance standards shall be removed, re-welded, and re-inspected.

2471.07.04 Coating

2471.07.04.01 Galvanizing

All steel components of sectional steel high mast lighting poles shall be hot dip galvanized according to OPSS 911.

2471.07.04.02 Paint Coating

After galvanizing and prior to paint coating, each component of the sectional steel high mast lighting pole shall be checked for continuity and smoothness of the galvanized coating. Any deficiencies in galvanized coating shall be corrected according to OPSS 911.

Components specified to be paint coated shall then be paint coated after surface preparation according to OPSS 911, using one of the approved paint systems for coating galvanized surfaces from the ministry's DSM. The dry film thickness of galvanized coating after surface preparation by sweep blasting shall be at least 87 µm.

During trial-assembly, care shall be taken not to damage the coatings of the pole. Any damage to the coatings that occur during the trial-assembly or any other operations shall be repaired according to OPSS 911.

2471.07.05 Identification Nameplate

Each sectional steel high mast lighting pole shall have an identification nameplate as specified in the Contract Documents.

The nameplate shall be made of stainless steel and shall be securely attached to the outside upper part of the handhole cover by rivets. A neoprene or rubber gasket shall be placed between the handhole cover and the nameplate to prevent corrosion effects.

2471.07.06 Quality Control

The Contract Administrator shall be notified of the fabrication, testing, and delivery dates.

2471.07.06.01 Certification

2471.07.06.01.01 Welding Inspection Company

The company undertaking welding inspection shall be certified under the Bridges category in accordance with CSA W178.1. Certification shall include visual inspection as well as all non-destructive testing methods required to fulfill the inspection and testing requirements of this specification.

2471.07.06.01.02 Welding Inspectors for Visual Inspection and Non-Destructive Testing

Visual inspection of the sectional steel high mast lighting poles shall be performed by welding inspectors certified in accordance with CSA W178.2. Certification shall be to either CWB level 2 or CWB level 3.

Non-destructive testing of the sectional steel high mast lighting poles shall be performed by an ultrasonic or radiographic technician, or both, certified in accordance with CAN/CGSB 48.9712, to either CGSB level 2 or CGSB level 3 for the method used.

2471.07.06.01.03 Coating Inspectors

Coating inspectors shall have successfully completed National Association of Corrosion Engineers Coating Inspection Program (NACE CIP) Level 1 and Level 2 with a minimum of 3 years of proven coating inspection experience.

2471.07.06.02 Inspection, Testing, and Reporting

2471.07.06.02.01 Welding Inspection and Testing

The welding inspector shall inspect and test the sectional steel high mast lighting poles as follows:

a) Visual Inspection

- i. The fabrication of steel components shall be visually inspected to ensure material, dimensions, fit-up, and welding are according to specifications. Certification of conformance by the welding inspector for each phase of the fabrication shall be based on the applicable Working Drawings, codes, and specifications.

The welding inspector shall witness the trial-assembly of the pole sections to ensure compliance with the Contract Documents.

When the sectional steel high mast lighting poles have been delivered to the Working Area and prior to installation, the inspector with the required credentials shall inspect them to ensure that all the components of the high mast lighting poles are according to the Contract Documents.

b) Non-Destructive Testing

- i. All complete penetration groove welds, including shaft to base welds, circumferential splices in shaft and welds at slip joints, shall be 100% tested. Longitudinal welds at the bottom of the shaft shall be tested for a length of 2.0 m from the base plate. All testing of groove welds shall be by radiographic or ultrasonic test method and shall be according to CSA W59 for cyclically loaded structures. Any weld repairs shall be tested by appropriate methods as determined by an Engineer.

2471.07.06.02.02 Coating Inspection

The coating inspector shall inspect each phase of the cleaning and coating work for compliance with the Contract Documents prior to proceeding to the next phase. Acceptance of the surface preparation and coating thickness measurements shall be according to OPSS 911.

2471.07.06.02.03 Reporting

Prior to shipping the high mast lighting poles to site, the Contractor shall submit 2 copies of the inspection reports, containing the results of all the inspection and testing performed during fabrication, welding, and coating work, to the Contract Administrator. The inspection reports shall be completed and certified by the applicable inspector and signed and sealed by an Engineer.

2471.08 QUALITY ASSURANCE

Sectional steel high mast lighting poles are subject to inspection by the Owner at any time during the course of fabrication and installation.

Welding is subject to inspection by the Owner using both visual and non-destructive testing procedures and techniques according to CSA W59 for cyclically loaded structures.

The surface preparation and coating of sectional high mast steel lighting poles are subject to inspection by the Owner during the coating work. Acceptance of the work shall be based on the applicable OPS specification and SSPC Standards.



MATERIAL SPECIFICATION FOR ANCHORAGE ASSEMBLY - HIGH MAST LIGHTING POLE

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APPENDICES

2474-A	Commentary

2474.01	SCOPE

This specification covers the requirements of anchorage assemblies for the 25, 30, 35, 40, and 45 m base mounted sectional steel high mast lighting poles.

2474.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2474.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2474.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

G40.20-13/G40.21-13	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
G164-M92 (R2003)	Hot Dip Galvanizing of Irregularly Shaped Articles
W59-13	Welded Steel Construction (Metal Arc Welding)
W178.2-14	Certification of Welding Inspectors

ASTM International

A 153/A 153M-16	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A 449-14	Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
A 563-15	Carbon and Alloy Steel Nuts

Canadian General Standards Board

48.9712-2014	Non-Destructive Testing - Qualification and Certification of NDT Personnel

2474.04 DESIGN AND SUBMISSION REQUIREMENTS

2474.04.01 Submission Requirements

2474.04.01.01 Working Drawings

Six sets of Working Drawings shall be submitted to the Contract Administrator a minimum 14 Days prior to the commencement of fabrication. An Engineer shall affix his or her seal and signature on the Working Drawings verifying that the drawings are consistent with the Contract Documents and sound engineering practices.

When multi-discipline engineering work is depicted on the same Working Drawing and a single Engineer is unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be signed and sealed by as many additional Engineers, as necessary.

As a minimum, the Working Drawings for anchorage assemblies shall include the following information:

- a) Dimensioned drawings, including plans, elevations, sections of the anchor rods, nuts, top and bottom plates, and their exact weights.
- b) Mill test certificates reports of all steel being used.

2474.05 MATERIALS

2474.05.01 Steel

Anchor rods shall be made of new billet steel round bar, quenched and tempered medium carbon steel, with a minimum yield strength of 517 MPa and a minimum tensile strength of 725 MPa, and shall satisfy Charpy V Notch test requirements of 20 joules at minus 30 °C.

The length, number, and size of the anchor rods shall be as specified in the Contract Documents.

Other general requirements shall be according to ASTM A 449 for anchor rods and ASTM A 563 for anchor rod nuts.

Anchor assembly top and bottom plates shall be made of PL10 x 100 mm according to CSA G40.20/G40.21, Grade 300W.

2474.05.02 Anchorage Setting Templates

The anchorage setting template shall be made of 20 mm thick plywood or hard wood or metal. Metal templates shall be a minimum of 12 gauge steel.

2474.07 PRODUCTION

2474.07.01 General

All fabrication shall be according to dimensions specified in the Working Drawings and as specified in the Contract Documents.

Anchorage assembly shall be supplied complete, as specified in the Contract Documents. Each assembly shall be supplied complete with anchor rods, hexagonal nuts, hardened steel washers, and steel top and bottom plates.

Each anchorage assembly shall be supplied with one anchorage setting template for positioning of the anchor rods to suit the required bolt circle diameter of the pole.

2474.07.02 Tolerance

Dimensions, threads, and hexagonal nuts tolerances shall be according to ASTM A 563, Grade DH. Exposed nuts are to be tapped oversized according to ASTM A 563 to allow for the thickness of the zinc coating on the rod threads.

2474.07.03 Welding

Hexagonal nuts shall be welded to the top and bottom plates according to CSA W59.

2474.07.04 Coating

The anchorage assembly shall be completely galvanized according to CAN/CSA G164M or ASTM A 153.

The exposed hexagonal nuts and washers shall be galvanized according to CAN/CSA G164M or ASTM A 153.

2474.07.05 Quality Control

Certification from the manufacturer shall be submitted to the Contract Administrator certifying that the anchorage assembly is according to the strength and material requirements as specified in the Contract Documents.

An inspector retained by the manufacturer shall inspect and test the anchorage assemblies. The inspector shall be certified for testing bridges according to CSA W178.2. The certification shall be either Level 2 or Level 3 for the methods used as specified in CAN/CGSB 48.9712.

The inspector shall inspect the place of manufacture of the anchorage assemblies while work on the units is being performed and shall inspect and examine the plant records and certificates, the materials used, and the fabrication process and shall conduct any tests as it may be considered necessary.

Two copies of the completed inspection report shall be submitted to the Contract Administrator. Inspection reports shall be completed and certified by the inspector.

When the anchorage assemblies have been delivered to the Working Area and prior to installation, the inspector shall inspect the anchorage assemblies to ensure that they meet all the Contract requirements.

2474.07.06 Testing

Visual inspection of the anchorage assemblies shall be performed by welding inspectors certified by the Canadian Welding Bureau under CSA W178.2 at a Level 3 category or working under a Level 2 inspector.

2474.07.07 Packaging and Shipment

Each anchorage assembly shall be shipped complete with hardware suitably packaged to ensure that all parts are delivered as an entity. A complete parts list shall be included in the shipment.

The supplier shall be responsible for loading, delivery, and off-loading of the anchorage assemblies to the designated areas. Anchorage assemblies shall be subject to inspection during and on completion of off-loading. If any damage is encountered during the off-loading inspection, the supplier shall be responsible for the necessary corrective measures subject to the approval of the Owner.

2474.08 QUALITY ASSURANCE

2474.08.01 Welding

All welding shall be subject to a visual inspection. Procedures and techniques for visual testing shall be according to CSA W59, Clause 7 and 8.

If faulty welding or material is encountered during the inspection procedures, the manufacturer shall submit corrective measures to the Contract Administrator for approval.

2474.08.02 Inspection

The Contract Administrator shall be notified a minimum of 3 Business Days prior to the start of fabrication, testing, and delivery.

The Contract Administrator shall have free access to the place of manufacture of the anchorage assemblies for the purpose of inspecting and examining plant records and certificates; materials used; process of manufacturing, including welding and galvanizing; and to make any tests as may be considered necessary, while the anchorage assembly is being fabricated.

All anchorage assemblies may be subject to an inspection by the Contract Administrator prior to shipment.

2474.09 OWNER PURCHASE OF MATERIAL

2474.09.01 Measurement and Payment

For measurement purposes, a count shall be made of the number of anchorage assemblies supplied and accepted.

Payment at the price specified in the purchasing order shall be for the supply of the anchorage assemblies delivered to the destination on the date and time specified.

The cost of all testing, except that performed by the Owner, shall be included in the price.

Appendix 2474-A, November 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



**MATERIAL SPECIFICATION FOR UNINTERRUPTIBLE
POWER SUPPLY SYSTEMS FOR LED TRAFFIC SIGNALS**

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2475.01 SCOPE

This specification covers the requirements for uninterruptible power supply (UPS) systems for traffic signals utilizing light emitting diode (LED) modules.

2475.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

2475.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

2475.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

CSA Standards

C22.1-15 Canadian Electrical Code
C22.2 No. 94-M91 (R2001) Special Purpose Enclosures

Electrical Safety Authority

Ontario Electrical Safety Code

National Electrical Manufacturer's Association

TS 2-2016 Traffic Controller Assemblies with NTCIP Requirements Version 03.07

2475.03 DEFINITIONS

AGM VRLA Battery means a sealed battery using absorbed glass mat and valve regulated lead acid technology.

CSA Enclosure Type 3 means an enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, and windblown dust, undamaged by the external formation of ice on the enclosure.

Gel Cell Battery means a sealed battery containing acid in a gel form.

2475.04 DESIGN AND SUBMISSION REQUIREMENTS

2475.04.01 Design Requirements

Each UPS system shall be designed for the traffic signal controller cabinet and equipment to which the UPS system will be connected. A comprehensive and detailed wiring diagram for each UPS system shall be designed and documented. The wiring diagram shall clearly indicate all UPS system wiring and connections, and shall clearly indicate all wiring and connections between the UPS system and the traffic signal controller cabinet and equipment.

2475.04.02 Submission Requirements

Prior to the installation of the UPS system, three copies of a comprehensive and detailed wiring diagram for each UPS system at each traffic control signal shall be submitted to the Contract Administrator.

2475.05 MATERIALS

2475.05.01 General

The UPS system shall provide uninterruptible power and conditioning of the utility power required for the operation of all electronic equipment used to operate the traffic control signals in the event of main utility power supply failure or voltage or frequency fluctuations.

The UPS system shall be supplied complete with UPS automatic switch.

The UPS control unit shall be a line interactive or double conversion type with automatic voltage regulation for 120V, 60Hz, single phase.

The UPS system shall include all wiring necessary to interconnect the UPS control unit to the power source and to the traffic signal control components.

The UPS control unit must latch from line to battery and from battery to line (transfer time) in less than 60 milliseconds.

When installed at a traffic signal using LED signal lamps, the UPS system shall be capable of maintaining full signal display operation for a minimum of 4 hours after which it shall be capable of maintaining a flashing signal display for a further 6 hours minimum.

Switching from full operation to a flashing operation may be determined by a timer circuit or based on battery capacity.

If the UPS control unit or the batteries fail, the system shall automatically switch back to utility line power.

If line power is restored during flashing operation, the traffic control signals shall commence the start-up sequence specified in the traffic control signals' timing sheet.

The UPS cabinet shall be supplied complete with pedestal or pole mounting hardware as indicated in the Contract Documents.

The battery installation and wiring to the batteries shall be according to Ontario Electrical Safety Code.

The UPS system components shall operate properly for the time periods specified above under the following conditions:

- a) Ambient temperature -37 °C to +74 °C
- b) Humidity: 5 percent to 95 percent
- c) The UPS system components shall withstand shock and vibration according to NEMA TS 2.

2475.05.02 UPS Cabinet

The cabinet shall be approved according to the Ontario Electrical Safety Code.

The UPS cabinet shall be a CSA Enclosure Type 3 cabinet constructed of aluminum and shall be painted grey. The cabinet shall be fabricated using sheet aluminum 3.17 mm thick and adequately reinforced by welded aluminum members.

The dimensions and details of the UPS cabinet shall be according to the Contract Documents.

The cabinet shall have one door hinged on one side with a continuous stainless steel piano hinge.

The door shall use a latch and lock mechanism. The door handle shall be zinc coated and painted the same colour as the cabinet.

The opening in the UPS cabinet shall allow full access to UPS components housed in the cabinet.

The cabinet shall be vented according to the Ontario Electrical Safety Code.

The circuit providing power to the battery heating mats shall be thermostat controlled and the thermostat shall be located in the UPS cabinet.

2475.05.03 Batteries

Batteries shall be AGM VRLA or gel cell technology.

Battery leads to UPS control unit shall be of suitable length and not less than 2.5 metres.

Each battery shall be placed on its own heater mat with all heater mats being supplied with AC power by the UPS control unit.

Battery mats shall become inoperable with loss of line voltage.

The batteries shall be protected by a circuit breaker or a fuse.

Each battery shall be labelled with the date of manufacture. The label shall be at a visible location on the top of the battery.

In addition to any other warranty, the Contractor shall provide a 3 year warranty on the batteries. The warranty period for each battery shall be 3 years, commencing from the date of "switch on" for operation of the UPS system in which the batteries are used. Any defective battery shall be replaced within 30 days. The warranty shall include all labour, Equipment, and Materials required to replace the batteries, including traffic control and all removal and disposal work. The Contractor shall be responsible for the removal and disposal of any defective batteries replaced under warranty. The Owner shall be the sole judge in determining if a battery is defective.

2475.05.04 UPS Control Unit

The UPS control unit shall be rack mountable with the following maximum dimensions: width of 483 mm (19-inch), depth of 254 mm (10 inches), and height of 153 mm (6 inches).

The front face of the control unit shall have indicators capable of displaying the following:

- a) Number of times the system was on battery supply
- b) Total time on battery supply
- c) Battery charge status to indicate the battery capacity

Each of the battery supply indicators listed above shall have a manual reset switch.

The UPS control unit shall have a minimum of one standard 120V grounded socket located on either the back or the front panel.

The UPS control unit shall contain over-current protection located on the front panel to switch power on/off from the batteries and to switch AC input and output power on/off.

The UPS control unit shall have a self-test feature to test the UPS automatic switch and the control circuitry.

The UPS control unit shall have an open collector output or an AC or DC contact closure to indicate when the traffic signal is operating on battery supply.

The UPS control unit shall have an open collector output or an AC or DC contact closure to indicate low battery alarm.

The UPS control unit shall have a minimum of 1 switched AC output that will switch on when the traffic signal has been on battery supply continuously for 4 hours.

A 9 pin male serial port and/or Ethernet port shall be located on the front panel to allow for communication to a laptop computer for changing software settings. The Ethernet port shall support dynamic host configuration protocol (DHCP).

A set of battery voltage test points, or a readout indicating battery voltage condition shall be located on the front panel.

2475.05.05 UPS Automatic Switch

The UPS automatic switch shall allow the UPS control unit to be removed for replacement or maintenance without turning off the traffic signal system.

The utility line power shall be connected to the input of the automatic switch. Under normal operating conditions the automatic switch shall connect the utility line power to the UPS control unit. In the event that the UPS control unit is not present or does not function, the automatic switch shall automatically connect the utility line power directly to the traffic signal system, bypassing the UPS control unit.

2475.05.06 Power Conditioning and the Use of Batteries by the UPS

Under normal operating conditions the utility line power shall flow through the UPS control unit to the traffic signal system and any other connected loads.

When the utility line power is within the operating parameters specified by the UPS manufacturer and the Contract Documents the UPS control unit shall condition and deliver the power to the loads without drawing power from the batteries.

When the utility line power is not within the operating parameters specified by the UPS manufacturer and the Contract Documents the UPS control unit shall condition and deliver the power to the loads by drawing power from the batteries as required.

2475.05.07 Electrical

The UPS system shall accept an AC voltage input range of 85 to 135 VAC, single phase, 2 wire plus ground without drawing on battery power.

The UPS system shall provide voltage regulation at 120 VAC $\pm$ 3 percent under any line, load or battery conditions other than "low battery", and a frequency regulation of 60 Hz $\pm$ 3 Hz synchronized to the utility line power.

Power rating shall be a minimum of 1000 VA (700W). The UPS system shall provide pure sine wave output, computer grade power compatible with all equipment loads, with power factor correction.

The UPS system shall include full time protection from sudden voltage increase with inrush protection and AC line filtering.

The UPS system shall provide complete isolation from the line operating as a separately derived power source according to Section 10, Grounding and Bonding, CSA C22.1.

The direct current (DC) system of the UPS system shall have a nominal DC system voltage of 60 VDC or less. The UPS DC system short circuit current shall not exceed 5000 A.

2475.07 PRODUCTION

All wires and leads shall be tied and secured within the UPS cabinet prior to delivery.



**MATERIAL SPECIFICATION FOR
RAISING AND LOWERING EQUIPMENT
FOR HIGH MAST LIGHTING POLES**

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2476.01 SCOPE

The specification covers the requirements for raising and lowering equipment for high mast lighting poles.

2476.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 911 Coating Structural Steel Systems

Ontario Provincial Standard Specifications, Material

OPSS 1704 Paint Coating Systems for Structural Steel

CSA Standards

C22.2 No. 38-18	Thermoset-Insulated Wires and Cables
C22.2 No. 42-10 (R2015)	General Use Receptacles, Attachment Plugs, and Similar Wiring Devices
C22.2 No. 49-18	Flexible Cords and Cables

C22.2 No. 94-M91 (R2011)	Special Purpose Enclosures
G40.20-13/G40.21-13 (R2018)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steels
W47.1-09 (R2014)	Certification of Companies for Fusion Welding of Steel
W59-18	Welded Steel Construction
W178.1-18	Certification of Welding Inspection Organizations
W178.2-18	Certification of Welding Inspectors

Canadian General Standards Board (CGSB)

48.9712-2014	Non-Destructive Testing - Qualification and Certification of NDT Personnel

ASTM International

A 123/A 123M-17	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
F 593-17	Stainless Steel Bolts, Hex Cap Screws, and Studs
F 594-09 (2015)	Stainless Steel Nuts

IEEE

C62.1-1989	Gapped Silicon-Carbide Surge Arresters for AC Power Circuits

National Electrical Manufacturers Association (NEMA)

250-2018	Enclosures for Electrical Equipment (1000 Volts Maximum)

2476.04 DESIGN AND SUBMISSION REQUIREMENTS

2476.04.01 Design Requirements

Raising and lowering equipment for high mast lighting poles shall be designed such that under all conditions the load on the winch cable shall never exceed 25% of the minimum breaking strength of the winch cable.

Raising and lowering equipment for high mast lighting poles shall be designed such that under all conditions the load on each support cable shall never exceed 25% of the minimum breaking strength of each support cable.

2476.04.02 Submission Requirements

2476.04.02.01 Working Drawings

Working Drawings shall be prepared for the fabrication of raising and lowering equipment for high mast lighting poles.

Three sets of Working Drawings shall be submitted to the Contract Administrator at least 14 Days prior to commencement of fabrication of the raising and lowering equipment for high mast lighting poles, for information purposes only. Prior to making a submission, the seals and signatures of a design Engineer and a design-checking Engineer shall be affixed on the Working Drawings.

Where multi-discipline engineering work is depicted on the same Working Drawing and the design or design-checking Engineer or both are unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be sealed and signed by as many additional design and design-checking Engineers as necessary.

A copy of the Working Drawings shall be retained at the fabricator's plant during and after pole fabrication.

Working Drawings shall include the following:

- a) Detailed dimensioned layouts, including plans, elevations, and sections to clearly indicate the following:
 - i. Luminaire support rings and arms
 - ii. Luminaire mounting arrangements
 - iii. Counter-balancing arrangements
 - iv. Head assembly balancing arrangements
 - v. Motor mounting arrangements
 - vi. Winch mounting arrangements
 - vii. Electrical breaker box mounting arrangements
 - viii. Junction box details and mounting arrangements
 - ix. Electrical control enclosure mounting arrangements
- b) Detailed wiring diagrams for the internal drive luminaire raising and lowering equipment.
- c) Detailed wiring diagrams for the portable power units.
- d) Detailed bill of materials for the following:
 - i. Support cables and connectors
 - ii. Electrical cables and connectors
 - iii. Electrical circuit breakers
 - iv. Motors, reducers, and torque limiters
 - v. Electrical control enclosures
 - vi. Motor control circuitries
- e) Functional test data reports on the raising and lowering mechanism indicating that the gearbox mechanism meets manufacturer's specifications.
- f) Detailed parts list and sources of supply for each of the items listed.

2476.05 MATERIALS

2476.05.01 Attachment Hardware

All bolts, washers, spacers, springs, and locknuts shall be stainless steel type 304. Locknuts shall be vibration-proof and of the captive type. Self-tapping screws shall be stainless steel type 302HQ. Bolts shall be according to ASTM F 593 and nuts according to ASTM F 594.

2476.05.02 Latch Shaft and Locking Pin

The latch shaft and locking pin shall be formed from a continuous casting of type 316 stainless steel.

2476.05.03 Pulleys

Pulleys shall be fabricated from stainless steel or steel with a chromate finish.

2476.05.04 Luminaire Support Ring

The ring shall be fabricated from steel channel according to CAN/CSA G40.21, Grade 300W, and hot dip galvanized according to ASTM A 123. If required, counter balancing galvanized hardware shall be

supplied as part of the ring assembly. The steel shall be certified to be impact tested per heat to Category 3 and shall satisfy the Charpy V-Notch test requirements of 20 joules for Grade 300 WT. Silicon content in the steel shall be equal to or less than 0.06%.

2476.05.05 Luminaire Tenon Arms

The luminaire tenon arms shall be HSS 60 mm diameter x 6.4 mm thick. The tenon arms shall be fabricated according to CSA G40.20/G40.21, Grade 260 WT, for high strength weldable notch tough steel, and hot dip galvanized according to ASTM A 123. The steel shall be certified to be impact tested per heat to Category 3 and shall satisfy the Charpy V-Notch test requirements of 20 joules for Grade 260 WT. Silicon content in the steel shall be equal to or less than 0.06%.

2476.05.06 Electrical Junction Box on the Ring

The electrical junction box on the ring shall be of stainless steel, CSA C22.2 No. 94, Type 4X, or NEMA 250, Type 4X, size 300 x 300 x 150 mm complete with connector and terminal blocks.

The connector shall be according to CSA C22.2 No. 42. The connector shall be protected with a cover and shall be housed in a CSA C22.2 No. 94, Type 3R, or NEMA 250, Type 3R, weatherproof, gasketed, polyester fibreglass reinforced housing.

2476.05.07 Lightning Arresters

Secondary thyrite-type lightning arrestors shall be rated to 650 V and according to IEEE C62.1.

2476.05.08 Electrical Cables

The electrical wiring on the ring shall be type SOW or SOOW according to CSA C22.2 No. 49 or Type TWH according to CSA C22.2 No. 38.

The power riser cable shall be type SO, SOW, or SOOW according to CSA C22.2 No. 49.

The circuit breaker cable shall be type SO, SOW, or SOOW according to CSA C22.2 No. 49.

The motor power cable and remote operating switch cable shall be type SOW or SOOW according to CSA C22.2 No. 49.

The motor cable shall be #12 AWG, number of conductors suitable for single or 3 phase motors.

The remote switch cable shall be #14 AWG, 4 conductor cable.

2476.05.09 Bumper Guard

The bumper guard shall be made from extruded santoprene thermoplastic rubber.

2476.05.10 Centring Arms

Centring arms shall be stainless steel spring-loaded complete with rubber non-marking rollers.

2476.05.11 Latch Indicator Flags

Indicator flags shall be flat stainless steel and shall be covered on the bottom side with high reflectance material.

2476.05.12 Twist Lock Plug Connectors

Twist lock plug connectors shall be according to CSA C22.2 No. 42.

2476.05.13 Winch Cable

As a minimum, the winch cable shall be 7.94 mm (5/16") diameter pre-stretched, stainless steel type 302/304, 7 x 19 strand aircraft cable.

2476.05.14 Internal Drive Motor

The internal drive motor shall be a 600 V, 3-phase, 1.5 hp reversible motor suitable for the 347/600 V system or a 240 V, single-phase, 1.5 hp reversible motor suitable for the 120/240 V system.

2476.05.15 Portable Power Unit

Portable power units shall be supplied when external drive mechanisms are used for driving the winch and shall be capable of operating the system at the capacity described and as specified in the Contract Documents.

The portable power unit shall be provided with a remote operating switch.

The portable power unit shall be provided with a torque limiting device between the power unit and the winch.

The portable power unit shall be equipped with a shear key that will give way before the breaking strength of the support cables is exceeded.

The portable power unit shall operate using a 120 V single-phase power source. When required to suit the power distribution system, a step down transformer shall be supplied with the unit. The portable power unit and the transformer shall be equipped with a female connector component of the combination twist lock plug connector type unit as described in the Electrical Connectors and Fittings clause in the Electrical Cables and Equipment subsection to match the plug for the luminaire riser wire and so ensure that the riser cable is disconnected prior to lowering the luminaire support ring. The transformer is to be housed in a weatherproof enclosure suitable for portable use.

2476.05.16 Reversing AC Magnetic Starter

The reversing AC magnetic starter shall comprise of an overload relay and a reversing contactor assembly rated 600 V, 7.5 hp for the 347/600 V system or 240 V, 3 hp for the 120/240 V system. Coil voltage for the contactors shall be 30 V or less.

The magnetic starter shall be electrically and mechanically interlocked to ensure against both contactors being energized simultaneously.

2476.05.17 Control Transformer and Power Supply

A control transformer, 347/30 V for the 347/600 V system or 120/30 V for the 120/240 V system shall be used to provide the 30 V or less coil voltage for the starter.

2476.05.18 Torque Limiter

The torque limiter shall be fabricated from corrosion resistant materials.

The torque limiter shall have automatic resetting features and provide flexibility between shafts.

2476.05.19 Remote Operating Switch Assembly

The complete remote operating switch shall have a CSA C22.2 No. 94, Type 4X, or NEMA 250, Type 4X, enclosure and operate at 30 V or less.

2476.05.20 Support Cables and Fittings

As a minimum, the support cables shall be flexible, 4.76 mm (3/16") diameter, pre-stretched, stainless steel type 302/304, 7 x 19 strand aircraft cables with a nominal breaking strength of 1,678 kg.

All cable fittings shall be stainless steel compression type and their load rating shall be at least 95% of the minimum breaking strength of the cable.

2476.05.21 Shroud Material and Coating

The shroud shall be 1.5 mm thick reinforced anodized aluminum. Coating shall be according to OPSS 911 and OPSS 1704.

2476.05.22 Electrical Connectors and Fittings

Electrical plugs and connectors for use with the riser wiring shall be a combination twist lock type that includes a disconnect switch according to CSA C22.2 No. 42.

2476.05.23 Housing for Connector

The housing for connector shall be CSA C22.2 No. 94, Type 3R, or NEMA 250, Type 3R, weatherproof, gasketed, polyester fibreglass reinforced housing.

2476.05.24 Electrical Breaker and Control Enclosure

The electrical breaker and control enclosure shall be CSA C22.2 No. 94, Type 4X, or NEMA 250, Type 4X, aluminum enclosure.

2476.07 PRODUCTION

2476.07.01 General

General requirements for electrical work shall be as specified in the Contract Documents.

All fabrication shall be according to the dimensions on the Working Drawings and the Contract Documents.

2476.07.02 Head Frame Assembly

The head frame assembly shall consist of the following:

- a) Pulleys designed to support the power riser and support cables. The pulleys shall be fabricated from stainless steel or steel with a chromate finish and shall run on permanently lubricated bearings. Pulley diameters shall be large enough to prevent damage to the riser and support cables.
- b) A slip fitter to suit the pole tenon.
- c) Guides to ensure cables remain on their pulleys.
- d) Guides and stops to ensure the luminaire support ring is properly positioned.
- e) Spun aluminum dome cover to protect the pulleys from the elements. The cover shall be bolted to the head frame with stainless steel hardware.

- f) Three latching mechanisms to support the ring when it is in the locked position. The latching mechanisms shall consist of a stainless steel cam cover, a latch cam, and a latch shaft with a locking pin. The latch shaft and locking pin shall be formed from a continuous casting of type 316 stainless steel. The locking pin shall not be welded onto the latch shaft. The latch shall engage the latch plate. The latching mechanisms shall remove all the load from the winch and support cables when in the locked position.

2476.07.03 Luminaire Support Ring Assembly

The luminaire support ring shall support a maximum of 12 luminaires weighing a total maximum of 400 kg. The ring for the 25, 30, 35, 40, and 45 m poles shall support luminaires complete with shields and shroud having a combined maximum luminaire effective projected area of 4.0 m². Rings shall be capable of being drilled to accept up to 12 equally spaced HSS 60 mm diameter x 6.4 mm thick wall luminaire tenon arms. The arms shall be bolted to the ring.

The ring shall be fabricated from steel channel and hot dip galvanized. The ring shall be a balanced assembly and, if required, counter balancing galvanized hardware shall be supplied as part of the ring assembly.

Each tenon arm shall be capable of supporting a luminaire and shield having a maximum combined effective projected area of 0.2 m².

One weatherproof, stainless steel junction box, size 300 x 300 x 150 mm complete with connector and terminal blocks shall be mounted to the ring in-line with the pole handhole. The box shall be readily accessible for maintenance and shall not obstruct the raising or lowering of the ring. The male connector mounted on the ring-mounted junction box shall be used for testing the luminaires when the ring is in the lowered position. The connector shall be angled downward and shall be mounted on the surface of the junction box. This male connector shall be the inlet component of a combination twist lock plug connector unit and shall be compatible with the female connector unit supplied with the riser wiring. The connector shall be protected with a cover and shall be housed in a weatherproof, gasketed, polyester fibreglass reinforced housing. Liquid-tight, strain-relief, zinc-plated steel cable fittings complete with stainless steel locknuts and sealing washers shall be used for cable entries.

Secondary thyrite-type lightning arrestors shall be installed from the phase conductor to ground. The arresters shall be mounted on the ring junction box.

The ring shall be wired to the junction box and luminaire arms as required. All wiring on the ring shall be SOW or SOOW, with the number, size, and phase of conductors as specified in the Contract Documents.

The ring shall be equipped with a bumper guard. The bumper shall be continuous and securely fastened to the inside of the ring using plastic bolts and an appropriate bonding agent.

The ring shall be equipped with three equally spaced centring arms.

The ring shall be equipped with a top latching mechanism. The top latching mechanism shall lock and maintain the ring in the raised position, allowing the tension on the winch cable to be released.

The ring shall have three high visibility reflector indicator flags showing the latched and unlatched condition of the latches.

2476.07.04 Transition Assembly

The transition assembly shall consist of a galvanized transition plate and attachment hardware for the winch and support cables. Each support cable shall be terminated with a galvanized or stainless steel thimble and compression sleeve and shall be attached to the transition plate either through a galvanized forged eyebolt or an anchor spring. The winch cable shall be terminated similarly and shall be attached to the plate through a galvanized or stainless steel shank ball or swivel of sufficient size to sustain the

loading on the cable. The support cables shall travel through the pole shaft, over the head frame pulleys to the luminaire support ring where they are led through guides and are terminated with a collet type device or strand vise. Shock-absorbing compression springs shall be installed either at the transition assembly or at the cable attachment on the ring. The transition assembly design shall prevent twisting of the support cables and assure smooth winding of the winch cable.

The power riser cable originating from the ring junction box shall enter the head frame assembly such that no pressure is exerted on the cable while the ring is raised or lowered. The cable shall be supported by head frame pulleys and terminated with a male connector which is the inlet component of a combination twist lock plug connector unit and shall be compatible with the female unit provided with the riser wiring. It shall be protected with a cover and shall be housed in a weatherproof, gasketed, polyester fibreglass reinforced housing.

2476.07.05 Winch Assembly

The winch to raise and lower the luminaire support ring shall be a sealed, maintenance free, oil bath worm gear that incorporates an internal friction drag brake to prevent free spooling. The winch drum shall have a cable guide assembly to guide the uncoiled cable neatly on the drum. The winch shall have a minimum lifting capacity of 750 kg and operate at $3 \text{ m/min} \pm 0.5 \text{ m/min}$. The winch drive shall be a horizontal drive and through a 16 mm (5/8") hex socket input shaft.

The drum shall be large enough to hold sufficient cable to meet individual pole height requirements. As a minimum, the winch cable shall be 7.94 mm (5/16") diameter pre-stretched, stainless steel type 302/304, 7 x 19 strand aircraft cable. The free end of the cable shall be finished with a galvanized or stainless steel thimble and compression sleeve. The winch cable shall be connected to the transition assembly through a galvanized or stainless steel shank ball or swivel.

The winch shall fit through the handhole opening and shall be mounted to the winch mounting plate with the hex socket input shaft to the right of the drum and pointing up. The winch mounting plate shall be attached to the pole mounting plate inside the handhole.

Operating instructions for raising and lowering the ring shall be provided and inscribed on a piece of anodized aluminum. The operating instructions shall be mounted on the inside of the pole handhole cover using silicone sealant. The lettering shall be large enough to be easily discernible.

2476.07.06 Internal Drive Motor

The internal drive motor shall be totally enclosed, fan cooled, and require no maintenance.

The internal drive motor shall be assembled and mounted on the support plate by unistrut supports or similar products that facilitate quick easy removal of the complete unit when required. The removal of the internal drive motor shall be possible with a ring in either the latched or unlatched position without causing freewheeling of the winch drum.

The internal drive motor shall be operated by a remote operating switch.

2476.07.07 Reducer

A reducer used to reduce the speed of the motor shall be installed between the motor and torque limiter. The reducer shall be set such that the winch operates at $3 \text{ m/min} \pm 0.5 \text{ m/min}$.

2476.07.08 Torque Limiter

The torque limiter shall have automatic resetting features and provide flexibility between shafts. The torque limiter shall be bidirectional and factory pre-set at a torque value such that the raising and lowering equipment is according to the Design Requirements subsection and the manufacturer's recommendations.

2476.07.09 Remote Operating Switch Assembly

The remote operating switch shall be enclosed in a yellow, soft rubber moulded box. The box shall be provided with a tongue-and-groove cover and have a weatherproof, neoprene gasket seal and compression type nylon cord grip. The remote switch shall be clearly marked "Raise" and "Lower" and be attached to a 13 m cord. The raise and lower labels shall coincide with the supporting mechanism in the raised and lowered positions respectively. The raise and lower labels or nameplates shall be attached to the face of the remote operating switch assembly.

When an internal drive motor is used, the switch shall include a stainless steel bracket complete with S hook.

2476.07.10 Shroud

The shroud shall be attached to the luminaire support ring by means of mounting brackets.

The shroud support brackets, stiffeners, and mounting arms shall be fabricated from aluminum angle with an anodized finish. All fastening bolts and hardware shall be stainless steel.

The interior surface of the shroud assembly, shroud sections, supporting brackets, stiffeners, and mounting arms shall have a matte black finish. The exterior surface of the shroud shall be painted to suit the colour and finish of the high mast lighting pole.

The shroud and its supporting mounting brackets shall be constructed as specified in the Contract Documents.

The diameter of each shroud shall accommodate the luminaires and tenon arms that it encompasses.

2476.07.11 Electrical Cables and Equipment

2476.07.11.01 Electrical Cables

The power riser cable shall be terminated with a male connector of the inlet type that shall be a component of a combination plug connector unit. The connector shall be protected with a cover and shall be housed in a weatherproof, gasketed, polyester fibreglass reinforced housing. The cable shall have sufficient length to meet individual pole height requirements. In addition, there shall be a 2 m type SO, SOW, or SOOW jumper cable installed at the cover mounted electrical panel. The jumper cable shall be used for the following:

- a) Connection to the power riser cable with a ring in the raised position.
- b) Connection to the connector on a ring junction box for luminaire testing with the ring in the lowered position.

The motor power cable shall be able to be disconnected by means of a combination plug connector. The cable shall consist of a male and female cord-to-cord device that is sized to match the line voltage, phasing, and horsepower rating of the motor, and be of the ampacity rating specified in the Contract Documents. The unit shall include a spring-loaded connector lid, safety shutter, and spring-loaded pawl to prevent the plug from disengaging from the connector. The dead front connector shall be provided with spring-loaded silver nickel contacts that make or break the circuits. The unit as a whole shall be housed in a weatherproof, gasketed, polyester fibreglass reinforced housing.

The cable colour coding for each phase shall be according to CSA C22.2 No. 49 and shall be consistent both in the head and panel circuitry and as specified in the Contract Documents.

A braided copper strap shall be connected between the pole handhole cover and ground stud.

2476.07.11.02 Electrical Connectors and Fittings

Electrical plugs and connectors for use with the riser wiring shall be a combination twist lock type that includes a disconnect switch. The cord-to-cord unit shall be sized to match the line voltage, phasing, and horsepower rating of the motor, and be of the ampacity rating specified in the Contract Documents. It shall include a spring-loaded receptacle lid, safety shutter, and spring-loaded pawl to prevent the plug from disengaging from the connector and, that when operated, disconnects the circuits. The dead front connector shall be provided with spring-loaded silver nickel contacts that make or break the circuits. The unit as a whole shall be housed in a weatherproof, gasketed, polyester fibreglass reinforced housing.

2476.07.11.03 Electrical Breaker and Control Enclosure

One aluminum enclosure, sized as required, shall be used to house one main disconnect switch; branch circuit breakers; and motor controller complete with control transformer, terminal board, and 30 V or less power supply as required for the equipment located in the pole handhole and the system voltage. The enclosure shall be mounted on the inside of the pole using angle brackets or standoffs as specified in the Contract Documents.

2476.07.12 Welding

All welding shall be according to CSA W59. Welding shall only be undertaken by a fabricator fully approved under the requirements of CSA W47.1.

Prior to commencement of welding, the Canadian Welding Bureau Qualification Certificates for each person to be employed on the work shall be made available to the Contract Administrator. Certificates shall be currently valid and shall indicate the positions that the operator is qualified to weld.

2476.07.13 Testing

The company and inspector undertaking welding inspection shall be engaged by the Contractor. All welds shall be 100% examined by Magnetic Particle Inspection (MPI). The raising and lowering equipment shall be subjected to all visual and non-destructive testing.

The company undertaking welding inspection shall be certified for testing bridges in conformance with CSA W178.1. The certification shall encompass at least the following methods: radiograph, ultrasonic, and magnetic particle.

The inspector undertaking welding inspection shall be certified for testing bridges in conformance with CSA W178.2. Certification shall be to either Level II or III for the methods used, as required by CAN/CGSB 48.9712.

2476.07.14 Quality Control

The manufacturer shall certify that the raising and lowering devices are according to the strength and material requirements as specified in the Contract Documents.

The inspector shall perform the visual inspection and non-destructive testing of the raising and lowering devices. Both the inspector and the company employing the inspector shall be certified according to the Testing subsection.

The inspector shall inspect the place of manufacture of the raising and lowering equipment while work on the units is being performed and shall inspect and examine the plant records and certificates, materials used, and fabrication process. The inspector shall conduct any tests as may be considered necessary.

Two copies of the completed inspection report shall be submitted to the Contract Administrator. The inspection report shall be completed and certified by the inspector.

2476.07.15 Packaging and Shipping

Raising and lowering equipment shall be shipped complete with hardware, suitably packaged to ensure that all parts are delivered as an entity. A complete parts list shall be included in the shipment. All cartons shall be marked with appropriate pole numbers.

Raising and lowering equipment shall be subject to inspection during and on completion of off-loading. If any damage is encountered during the inspection, the Contractor shall be responsible for the necessary corrective measures subject to the approval of the Owner.

The Contractor shall advise the Owner 3 Business Days prior to the shipping date of the intent to deliver and confirm that arrangements for off-loading have been made.

2476.08 QUALITY ASSURANCE

2476.08.01 Welding

All welding may be subject to inspection by both visual and non-destructive testing. The procedure and technique for visual and non-destructive testing shall be according to CSA W59, Clause 7 and 8.

If faulty welding is encountered during the inspection, corrective welding measures shall be submitted to the Contract Administrator by the Contractor.

2476.08.02 Inspection

The Contract Administrator shall be notified of the dates that fabrication and testing of the raising and lowering equipment will commence.

The Contract Administrator shall have free access to the place where the raising and lowering equipment is manufactured for the purpose of inspecting and examining the plant records, certificates, materials used, and fabrication process, while work is being performed. The Contract Administrator shall make or witness any tests as may be considered necessary.

All raising and lowering equipment may be inspected by the Contract Administrator prior to shipment.



Note: The PROV published in November 2017 replaces OPSS 2479 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR FLOODLIGHT LUMINAIRES USED IN HIGH MAST LIGHTING

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2479.01 SCOPE

This specification covers the requirements for high mast floodlight luminaires with integral ballast for use in high mast lighting.

2479.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

C22.2 No. 9.0-96 (R2011)	General Requirements for Luminaires
C863-11	Energy Efficiency of High-Intensity Discharge (HID) and Low-Pressure Sodium (LPS) Lamp Ballasts

2479.04 DESIGN AND SUBMISSION REQUIREMENTS

2479.04.01 Design Requirements

2479.04.01.01 Photometric Requirements

Photometric test results shall be provided for the floodlight type luminaire supplied and shall include the following data:

- a) Isolux curves and mounting height correction factors.
- b) Utilization charts or graphs indicating the total beam utilization.
- c) Candlepower distribution curves indicating peak intensity.
- d) Luminous intensity tables to Illuminating Engineering Society format (I-tables).
- e) Luminaire efficiency values.
- f) Lamp lumen outputs and wattages.

2479.04.01.02 Electrical Requirements

All electrical components and assembled luminaires shall be according to CSA C22.2 No. 9.0.

Ballasts, lamp sockets, ground connectors, internal wiring, and all other components shall be suitable for the supply voltage as specified in the Contract Documents and the maximum temperature encountered in totally enclosed, outdoor, weatherproof luminaires.

Ballasts shall be constant wattage auto-transformer or isolated secondary transformer type for grounded systems. Auto-transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 5% variation in line voltage. Isolated secondary transformer type ballasts shall have a maximum tolerance of 12% variation in lamp wattage for a 10% variation in line voltage.

Ballasts shall be of Class H, 180 °C insulation; 60 hertz; and low temperature, -35 °C with a power factor not less than 0.90.

The minimum nominal secondary open circuit voltage of the ballast for various lamps shall be sufficient to provide reliable starting at -35 °C.

Ballasts shall be suitable for the lamp's nominal operating voltage. Terminal blocks shall be held rigidly and shall provide a positive connection for terminating the field wiring.

Energy efficiency of lamp ballasts shall be according to CAN/CSA C863.

2479.04.01.03 Mechanical Requirements

The luminaire housing shall be cast aluminum or heavy-duty sheet aluminum. The ballast shall be integral. All external fasteners and associated hardware shall be stainless steel. The luminaire shall be provided with a built-in aiming device.

Mounting arrangements shall be trunnion type or slip fitter for a 50 mm diameter internal pipe size tenon with provisions for vertical and horizontal adjustment. The luminaire shall be complete with all external fasteners and associated hardware required for the aiming of the luminaire and attachment to the slip fitter or mounting pad.

The optical assembly shall consist of a specular high purity anodized aluminum reflector. The reflector shall be precision formed and assembled in a way that the formed contour is maintained when it is removed from the luminaire housing. The optical assembly shall be sealed with a high temperature neoprene or silicone rubber gasket located between the door frame and luminaire housing.

When required and as specified in the Contract Documents, a secondary reflector or louvre shall be provided inside the sealed optical assembly. The louvre shall effectively screen the lamp from direct view and provide a cut-off 10° above the peak intensity on the vertical plane.

The door assembly shall consist of a gasketed door frame and a clear tempered shock-resistant glass lens and shall be hinged to the luminaire housing. The luminaire shall be accessible with tool-less entry.

The lamp socket shall be a mogul type with a porcelain-enclosed, nickel-plated brass shell rated for 4,000 volts, and spring-loaded centre contact. The lamp holder shall have an electrically insulated lamp stabilizer and shall hold the lamp's outer envelope in precise alignment with suitable means for vibration damping.

The luminaire assembly when closed and in the operating position shall not be subject to damage by vibration.

2479.04.02 Submission Requirements

2479.04.02.01 Working Drawings

Three copies of Working Drawings shall be submitted to the Contract Administrator a minimum of 14 Days prior to the commencement of fabrication.

As a minimum, the Working Drawings shall include the following information:

- a) Detailed dimensioned layout, including plans, elevations, and weight.
- b) Photometric curve data.
- c) Details of optical system.

Each Working Drawing shall be sealed and stamped by an Engineer certifying that the Working Drawings comply with the Contract Documents.

One copy of the final accepted Working Drawings shall be returned to the supplier, along with written notification to commence fabrication. Within 14 Days of receipt of notification to commence fabrication, the supplier shall submit 3 copies of all final accepted Working Drawings to the Contract Administrator.

Fabrication of the equipment shall not commence until the Working Drawings have been accepted by the Contract Administrator.

Once fabrication of the equipment has commenced, materials and dimensions shown on the final accepted Working Drawings shall not be changed.

2479.05 MATERIALS

2479.05.01 Marking

A permanent non-corrosive nameplate shall be attached to the exterior of the luminaire and located so that the marking is clearly visible during relamping. The nameplate shall indicate the manufacturer's

name or trademark, catalogue number, electrical rating, input amperes, luminaire voltage, date of manufacture, and the vertical and horizontal beam distribution.

A permanent label shall be attached to the interior of the luminaire indicating the manufacturer's name or trademark, catalogue number, date of manufacture, and the American National Standards Institute (ANSI) or Illuminating Engineering Society (IES) photometric classification and distribution type; the suitable supply voltage and frequency; the lamp type; the lamp wattage; and the nominal operating voltage of the lamp so that it is clearly visible during maintenance operations.

A label including a wiring diagram shall be attached to each ballast showing the ballast schematic wiring diagram and shall be visible during maintenance operations.

For asymmetrical luminaires with adjustable optical systems, a permanent embossed identification mark shall be located on the luminaire that is clearly visible and identifiable as an orientation mark.

2479.07 PRODUCTION

2479.07.01 Ballast Assemblies

Ballast assemblies shall be factory pre-wired with all connections clearly marked and identified.

2479.07.02 Lamp Socket Positions

The lamp socket position shall be pre-set at the factory for the specified distribution.

2479.08 QUALITY ASSURANCE

2479.08.01 Inspection

The supplier shall notify the Owner of the date that the fabrication of the luminaires is to commence.

The Owner's representative shall have free access to the place of fabrication for the purpose of inspecting and examining plant records, certificates, materials used, fabrication process, and to make any tests as may be considered necessary, while the luminaires are being fabricated.

All luminaires are subject to an inspection by the Owner's representative prior to shipment.



Note: The PROV published in November 2017 replaces OPSS 2485 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR PHOTOELECTRIC CONTROLLERS

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2485.08	QUALITY ASSURANCE - Not Used

2485.01	SCOPE

This specification covers the requirements for electronic photoelectric controllers rated for 1,800 VA for use with 105 to 305 volt power supply at 60 Hz.

2485.02	REFERENCES

This specification refers to the following standards, specifications, or publications:

CSA Standards

C239-02 (R2011) Performance Standard for Dusk-to-Dawn Luminaires

American National Standards Institute (ANSI)

C136.10-2010 Roadway and Area Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacle - Physical and Electrical Interchangeability and Testing

2485.07 PRODUCTION

2485.07.01 General

Photoelectric controllers shall be electronic and according to CAN/CSA C239.

Photoelectric controllers shall be of weatherproof construction and operational within a temperature range of -40 to 65 °C.

Photoelectric controllers shall be factory preset at 16 lux switch-on light level and 50 lux switch-off light level.

2485.07.02 Electrical Requirements

Photoelectric controllers shall be provided with three locking type blades according to ANSI C136.10.

Photoelectric controllers shall be supplied with contacts normally closed at nighttime or under failure conditions. Photoelectric controllers shall have an internal lightning arrester with a minimum spark over of 2.0 kV. The power consumption of the photoelectric controller itself shall be 5 watts or less.

2485.07.03 Marking

A permanent type of identification shall be provided on the outside of the photoelectric controller indicating the manufacturer's name or trademark, catalogue number, voltage, VA rating, and date coding.



MATERIAL SPECIFICATION FOR CALCIUM CHLORIDE AND CALCIUM-MAGNESIUM CHLORIDE BLEND

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2501.09	OWNER PURCHASE OF MATERIAL
2501.01	SCOPE

This specification covers the requirements for calcium chloride and calcium-magnesium chloride blend for use as a dust suppressant or de-icer.

2501.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Canadian General Standards Board (CGSB)

15.1-92 Standard for Calcium Chloride

ASTM International

D1293-18 Standard Test Methods for pH of Water
E449-18 Analysis of Calcium Chloride

Pacific Northwest Snowfighters (PNS)

Test Method B Corrosion Rate as Conducted from the NACE Standard TM0169-95 (1995 Revision) and as Modified by the Pacific Northwest States *

Test Method C Percent Total Settleable Solids and Percent Solids Passing on a No. 10 Sieve *

* [Part of 2008 Pacific Northwest Snowfighters Snow and Ice Control Chemical Products Specifications and Test Protocols]

2501.03**DEFINITIONS**

For the purpose of this specification, the following definitions apply:

Calcium Chloride Solid means a granular form of anhydrous calcium chloride (CaCl_2) that may be applied directly or dissolved in water to form calcium chloride solution.

Calcium Chloride Solution means an aqueous solution of calcium chloride solid.

Calcium-Magnesium Chloride Blend means an aqueous solution containing predominantly calcium chloride with supplemental magnesium chloride (MgCl_2).

2501.05**MATERIALS****2501.05.01****Calcium Chloride Solid**

Calcium chloride solid shall be loose, dry, and according to CAN/CGSB 15.1, Type S:

- a) Grade 1, Class A;
- b) Grade 2, Class B; or
- c) Grade 3, Class B.

2501.05.02**Calcium Chloride Solution**

Calcium chloride solution shall be according to CAN/CGSB 15.1, Type L, Class 1, and shall be homogeneously mixed.

Calcium chloride solution used as a dust suppressant shall contain a minimum of 35% by mass of pure calcium chloride and shall meet the requirements shown in Table 1.

Calcium chloride solution used as a de-icer shall:

- a) Contain a minimum of 29% by mass of pure calcium chloride.
- b) Meet the requirements shown in Table 1.

2501.05.03**Calcium-Magnesium Chloride Blend**

Calcium-magnesium chloride blend used as a dust suppressant shall have a minimum of 27% by mass of calcium chloride, a minimum calcium chloride equivalence of 35% and shall meet the requirements shown in Table 2. Calcium-magnesium chloride blend shall exhibit no crystallization above 5 °C.

Calcium-magnesium chloride blend used as a de-icer shall:

- a) Contain a minimum of calcium chloride equivalence of 29% and shall meet the requirements shown in Table 2.
- b) Meet the requirements shown in Table 1.

2501.07**PRODUCTION****2501.07.01****Packaging and Delivery**

Calcium chloride solid shall be delivered in moisture-proof 20, 40, or 1,000 kg bags by railway hopper car or by truck and in a dry and useable condition.

Calcium chloride solution and calcium-magnesium chloride blend shall be delivered by railway tank car or truck tank.

2501.07.02 Labelling

2501.07.02.01 Calcium Chloride Solid and Calcium Chloride Solution

Labelling shall be according to CAN/CGSB 15.1 with each container legibly marked with the following:

- a) Cautionary information specified in CAN/CGSB 15.1.
- b) Manufacturer's or supplier's name.
- c) Date packaged (i.e., yyyy-mm-dd).
- d) Type, grade, and class.
- e) Concentration of pure calcium chloride.
- f) Unit size (mass or volume).
- g) Standard number (i.e., CAN/CGSB 15.1).

When bulk shipping is provided, the shipping manifest shall include the same information.

2501.07.02.02 Calcium-Magnesium Chloride Blend

The shipping manifest shall include the following information:

- a) Manufacturer's or supplier's name.
- b) Date shipped (i.e., yyyy-mm-dd).
- c) Words "Calcium-Magnesium Chloride Blend".
- d) Concentration of pure calcium chloride and percent calcium chloride equivalency.
- e) Unit size (volume).

2501.08 QUALITY ASSURANCE

2501.08.01 Sampling and Testing

2501.08.01.01 General

Calcium chloride solid, calcium chloride solution, and calcium-magnesium chloride blend may be subject to sampling and testing for conformity to the specified requirements. All materials that fail to meet the specified requirements shall be rejected.

2501.08.01.02 Sampling Calcium Chloride Solid

A minimum of three samples shall be selected by the Owner at random from the shipment. Samples shall be taken by the Owner by scraping aside the top layer of material to a depth of approximately 25 mm and taking a 0.5 kg representative sample by means of a sampling tube or other method. Precautions shall be taken during the sampling operation to avoid exposing the sample unduly to atmospheric moisture. Immediately after collecting the three samples, the individual samples shall be mixed thoroughly to form a composite sample of material, and then be stored and sealed in a suitable glass or plastic container.

2501.08.01.03 Sampling Calcium Chloride Solution and Calcium-Magnesium Chloride Blend

A minimum of three samples from each tank of the shipment shall be selected by the Owner. Each sample shall be representative of the contents of the tank. Precautions shall be taken during the sampling operation to avoid exposing the sample unduly to atmospheric moisture. Immediately after collecting the three samples, the individual samples shall be mixed thoroughly to form a composite sample of material, and then be stored and sealed in a suitable glass or plastic container.

2501.08.02 Certificate

Upon request, a manufacturer's certificate shall be provided stating that an independent laboratory has tested the product and found it to be according to this specification.

2501.09 OWNER PURCHASE OF MATERIAL

2501.09.01 Measurement and Payment

2501.09.01.01 General

Payment at the price specified in the purchasing order shall be for the supply of the calcium chloride solid, calcium chloride solution, or calcium-magnesium chloride blend delivered to the destination on the date and time specified.

The cost of all testing, except that performed in the Owner's laboratory, shall be included in the price.

2501.09.01.02 Calcium Chloride Solid

Measurement of calcium chloride solid shall be by mass in kilograms. Weighing shall be as specified in the purchasing order.

2501.09.01.03 Calcium Chloride Solution

Measurement of calcium chloride solution, at the concentration specified, shall be by one of the following methods:

a) Mass of solution in tonnes.

When shipped by railway tank car or when weighed at the source of supply, the mass of solution shall be substantiated by bills of lading in as many copies as the Owner may require. Railway scales shall be as specified in the purchasing order.

When weighing by truck tank, the mass of solution shall be determined as specified in the purchasing order.

b) Volume of solution in litres.

The volume of solution in litres shall be measured by means of a metering device as specified in the purchasing order.

When volumetric measurement is used, the Owner shall be provided with an invoice for each tank load of solution delivered. The invoice shall contain a note signed by the delivery person, as the official representative of the supplier of solution, indicating the total volume in litres of the delivery tanker and certifying the actual volume of solution in litres delivered in each tank load.

When calcium chloride solution is used as a dust suppressant, the mass of solution in tonnes may be converted to a mass of equivalent solid in kg. In converting the mass of solution to an equivalent mass in solid, a conversion factor for a 35% calcium chloride solution of 1 tonne of solution to 455 kg of solid shall be used.

The volume in litres of solution may be converted to an equivalent mass of solution in tonnes. In converting the volume of solution to an equivalent mass of solution, the following conversion factors shall be used:

- a) 1.357 kg/litre shall be used for a minimum 35% solution.
- b) 1.283 kg/litre shall be used for a minimum 29% solution.

2501.09.01.04 Calcium-Magnesium Chloride Blend

Measurement of calcium-magnesium chloride blend, at the concentration specified, shall be by one of the following methods:

- a) Mass of solution in tonnes.

When shipped by railway tank car or when weighed at the source of supply, the mass of solution shall be substantiated by bills of lading in as many copies as the Owner may require. Railway scales shall be as specified in the purchasing order.

When weighing by truck tank, the mass of solution shall be determined as specified in the purchasing order.

- b) Volume of solution in litres.

The volume of solution in litres shall be measured by means of a metering device as specified in the purchasing order.

When volumetric measurement is used, the Owner shall be provided with an invoice for each tank load of solution delivered. The invoice shall contain a note signed by the delivery person, as the official representative of the supplier of solution, indicating the total volume in litres of the delivery tanker and certifying the actual volume of solution in litres delivered in each tank load.

TABLE 1
Calcium Chloride Properties

Material/Property	Calcium Chloride Solution		Test Procedure
	Dust Suppressant	De-Icing	
Total Settleable Solids	-	<1% (Note 1)	PNS Test Method C
Corrosion Inhibitor	-	Minimum 70% less corrosive than Sodium Chloride	PNS Test Method B
pH (Note 2)	6 to 9	6 to 9	ASTM D1293
Notes: 1. 99% of the solids passing through a 2.00 mm sieve after being stored for 168 hours at -29 ± 1 °C. 2. Dilute 1 part product to 4 parts distilled water before attempting a reading.			

TABLE 2
Calcium-Magnesium Chloride Blend Properties

Material/Property	Calcium-Magnesium Chloride Blend		Test Procedure
	Dust Suppressant	De-Icing	
Calcium Chloride (CaCl ₂), % minimum by mass	27.0	22.0	ASTM E449
Magnesium Chloride (MgCl ₂), % minimum by mass	As required for total CaCl ₂ equivalence (Note 1)		ASTM E449
Total CaCl ₂ equivalence, % minimum by mass	35.0	29.0	(Note 1)
Other Alkali Chlorides: NaCl, KCl, % maximum by mass	2.0	1.75	ASTM E449
pH (Note 2)	6 to 9	6 to 9	ASTM D1293
Corrosion Inhibitor	-	Minimum 70% less corrosive than Sodium Chloride	PNS Test Method B
Notes: 1. Total CaCl ₂ equivalence = % CaCl ₂ + (% MgCl ₂ x 1.166). 2. Dilute 1 part of product to 4 parts distilled water prior to attempting a reading.			



MATERIAL SPECIFICATION FOR SODIUM CHLORIDE

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2502.09	OWNER PURCHASE OF MATERIAL
2502.01	SCOPE

This specification covers the requirements for the supply and delivery of sodium chloride.

2502.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

ASTM International

D632 - 12(2020)e1	Standard Specification for Sodium Chloride
D2216 - 19	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
E534 - 18	Standard Test Methods for Chemical Analysis of Sodium Chloride

2502.03 DEFINITIONS

Quality Assurance (QA) means a system or series of activities carried out by the Owner to ensure that materials received from the supplier meet the requirements as specified in the Contract Documents.

2502.04 DESIGN AND SUBMISSION REQUIREMENTS

2502.04.01 Submission Requirements

The supplier upon delivery, shall submit all test results in writing verifying the material is according to this specification.

2502.05 MATERIALS

2502.05.01 General Requirements

Sodium chloride shall be in a free-flowing state until used and shall be according to Table 1 and Table 2 or ASTM D632, Type I Grade 1.

2502.07 PRODUCTION

When delivery in bags is specified, sodium chloride shall be delivered in four-ply, asphalt-lined or polyethylene-lined bags in sound condition and containing 40 kg. The closures shall be sewn.

Each bag shall be marked with the following:

- a) Name of supplier/manufacturer.
- b) Net mass.
- c) Salt grade, (i.e., coarse crushed rock salt or fine crushed rock salt).

When delivery in bulk is specified, the sodium chloride shall be shipped by rail or truck, whichever is specified.

2502.08 QUALITY ASSURANCE

2502.08.01 General

A laboratory designated by the Owner shall carry out QA testing for purposes of ensuring that the sodium chloride used in the Work is according to the physical, chemical, and gradation requirements of this specification. Testing will be performed at the discretion of the Owner.

2502.08.02 Inspection, Sampling, and Testing

Inspection of sodium chloride shall be according to ASTM D632.

Sampling, testing methods, and procedures shall be as outlined in ASTM D632 and Table 1.

One of the QA samples shall be randomly selected for testing by the QA laboratory. The QA laboratory shall retain the remaining samples for referee testing, if required.

2502.08.03 Acceptance

The material shall be deemed acceptable if all the test results meet all applicable requirements of this specification.

Material that fails to meet the gradation requirements according to ASTM D632 shall be rejected. The supplier shall remove all rejected material as directed.

QA test results for a sample that is not according to Table 2 shall be rejected. The supplier shall remove all rejected material as directed.

2502.08.04 Referee Testing

The supplier may invoke referee testing by submitting a written request to the Owner, within 5 Business Days following notification that the sample representing the material does not meet the requirements of this specification.

Referee testing shall be carried out according to ASTM E534.

The retained duplicate QA samples shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the supplier.

If a lot is not accepted based on the referee test results, then the supplier shall be responsible for the cost of the referee testing of that lot. If a lot is accepted based on the referee test results, the Owner shall bear the cost of the referee testing.

2502.09 OWNER PURCHASE OF MATERIAL

2502.09.01 Measurement and Payment

Sodium chloride shall be measured by mass in tonnes as specified in the purchase order.

When shipped in bulk, sodium chloride shall be weighed at the source of supply and the mass shall be substantiated by bills of lading in as many copies as the Owner may require.

Payment at the price specified in the purchase order shall be for the supply of the sodium chloride delivered to the destination on the date and time specified.

The cost of all testing except that performed in the Owner's designated laboratory, shall be included in the price.

TABLE 1
Testing Methods and Procedures

Property	Test Method	Min. Mass Required
Moisture content	ASTM D2216	500g
Sodium chloride content, dry mass basis	ASTM D632	500g
Insoluble matter, dry mass basis	ASTM E534	500g

TABLE 2
Sodium Chloride Chemical Composition, by Mass

Characteristic	Per Cent
Moisture content	not more than 1.5
Sodium chloride content, dry mass basis	not less than 95.0
Insoluble matter, dry mass basis	not more than 4.0



**ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION**

**OPSS.PROV 2510
NOVEMBER 2017**
(Formerly OPSS 2510, November 2015)

Note: The PROV published in November 2017 replaces OPSS 2510 COMMON, November 2015 with no technical content changes.

**MATERIAL SPECIFICATION FOR
TALL OIL PITCH EMULSION**

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2510.08	QUALITY ASSURANCE
2510.09	OWNER PURCHASE OF MATERIAL

2510.01 SCOPE

This specification covers the requirements for tall oil pitch emulsion suitable for use as granular sealer.

2510.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standards Specifications, Material

OPSS 1004 Aggregates - Miscellaneous

ASTM International

D 244-09 Standard Test Methods and Practices for Emulsified Asphalts

Ontario Ministry of the Environment and Climate Change Publications

Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act

Protocol for Analytical Methods Used in the Assessment of Properties Under Part XV.1 of the Environmental Protection Act

Environmental Protection Act, Ontario Regulation 347, General - Waste Management - R.R.O. 1990

Environment Canada Publications

EPS 1/RM/13 Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout, Second edition, 2000 with May 2007 amendments

EPS 1/RM/14 Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to *Daphnia magna*, Second edition, 2000

Organisation for Economic Co-operation and Development (OECD) Publications

Method 301B Ready Biodegradability: CO₂ Evolution, OECD Guidelines for the Testing of Chemicals, 1992

Method 302B Inherent Biodegradability: Zahn-Wellens/EMPA Test, OECD Guidelines for the Testing of Chemicals, 1992

United States Environmental Protection Agency Publications

SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, July, 1992

Other

ISO/IEC 17025-2005 General Requirements for the Competence of Testing and Calibration Laboratories

2510.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Effluent means any liquid waste that may be discharged to the aquatic environment.

Tall Oil means a mixture of rosins and fatty acids produced from the processing of pulp and paper.

Tall Oil Pitch (TOP) means the residue formed during the distillation of tall oil. Major components consist of fatty acids, resin acids, esters, and neutral materials.

Tall Oil Pitch Emulsion (TOP emulsion) means a tall oil pitch homogeneously dispersed in a water-emulsifier solution.

2510.04 DESIGN AND SUBMISSION REQUIREMENTS

2510.04.01 Submission Requirements

Valid test results from an acceptable laboratory showing complete conformance of the TOP emulsion with the requirements of this specification shall be made available upon request.

2510.05 MATERIALS

2510.05.01 Tall Oil Pitch

TOP shall be produced from distilled tall oil from the processing of pulp and paper not associated with the use of chlorine-based chemical to bleach pulp for the production of white paper.

2510.05.02 Water

Water shall be clean and free of contaminants that could adversely affect TOP emulsion and the environment.

2510.05.03 Emulsifier

Emulsifier shall be according to the manufacturer's requirements.

2510.05.04 Tall Oil Pitch Emulsion

TOP emulsion shall meet the physical property requirements of Table 1 and the environmental testing requirements of Table 2.

Components used to produce the TOP emulsion shall not contain any petroleum based products, calcium chloride, magnesium chloride, lignosulphonate, or lignan derivatives.

Addition of any asphalt products, solvents, polymers, or other additives during or after the manufacture of TOP emulsion shall not be permitted.

TOP emulsion shall show no signs of separation.

2510.07 PRODUCTION

2510.07.01 Storage

Tall oil pitch emulsion that is to be stored longer than 7 Days shall be kept out of direct sunlight and maintained at a temperature of not less than 5 °C.

If stored more than 60 Days, the TOP emulsion shall be circulated prior to use using a low speed mechanical impeller or a pump rated at 5 hp or less. When a pump is used, the TOP emulsion shall be drawn from the bottom of the storage tank and fed to the top of the same tank with a submerged hose to avoid bubbling.

2510.07.02 Shipment

Tall oil pitch emulsion shall be shipped in sealed containers of a size that minimizes the air space between the surface of the liquid and the top of the container.

All shipping containers shall be clean and reusable. Reused containers shall be free of any form of contamination and, if required, cleaned prior to loading.

Tall oil pitch emulsion shall be protected from freezing.

A bill of lading or an invoice, as applicable, shall be supplied in as many copies as required by the Owner for each container of TOP emulsion delivered.

2510.07.03 Sampling and Testing

2510.07.03.01 General

Samples shall be collected, handled, prepared, and tested in accordance with the requirements of Table 1 and Table 2, except as noted below.

2510.07.03.01.01 Laboratory Requirements

Solids content testing of TOP emulsion shall be carried out in a laboratory that is acceptable to the Owner.

An acceptable laboratory for conducting environmental testing listed in Table 2, Section A, shall be one that has been certified by an organization accredited by the Standards Council of Canada in accordance with ISO/IEC 17025 and participates in mandatory proficiency testing programs for the applicable parameter in Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act.

An acceptable laboratory for conducting environmental testing listed in Table 2, Section B, shall be one that has been certified by an organization accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL) or by the Standards Council of Canada (SCC).

2510.07.03.01.02 Solids Content

Solids content shall be determined by measuring the mass of the residue remaining after drying a representative sample of TOP emulsion using the following procedure:

- a) Obtain a minimum 500 ml sample of TOP emulsion following thorough mixing or circulation of the contents of the shipping or storage container.
- b) Measure and record the mass of a suitable clean dry specimen container on a balance readable to 0.1 g and accurate to within 0.1% of the test load. A suitable container shall be one that is resistant to corrosion and change in mass upon heating, cooling, and exposure to materials of varying pH.
- c) Decant approximately 100 ml from the representative sample into the specimen container. Measure and record the mass of the container and TOP emulsion.
- d) Place the specimen and container in an oven maintained at $110\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and dry to a constant mass. Specimens may be dried at higher temperatures with a hot plate or burner provided that steam is allowed to escape freely.
- e) Allow the container and remaining residue to cool to room temperature. Measure and record the dried mass and container using the same balance as above.
- f) Calculate the percent solids as follows:

$$\text{Percent solids} = [(M_{\text{CR}} - M_{\text{C}}) / (M_{\text{CT}} - M_{\text{C}})] \times 100 = M_{\text{R}} / M_{\text{T}} \times 100$$

where: M_{C} = mass of container, *g*
 M_{CT} = mass of container and TOP emulsion, *g*
 M_{CR} = mass of container and residue, *g*
 M_{T} = mass of TOP emulsion specimen, *g*
 M_{R} = mass of residue, *g*

- g) Report the solids content as percent solids to the nearest 0.1%.

2510.07.03.01.03 Particle Charge

The particle charge of the TOP emulsion shall be determined according to ASTM D 244 in the same manner as required for an asphalt emulsion.

2510.07.03.01.04 Environmental Testing

2510.07.03.01.04.01 Sample Preparation

Sample preparation for *Daphnia magna*, and Rainbow Trout testing shall be as follows:

- a) Obtain a sufficient amount of inert, non-absorptive material for the substrate meeting the gradation requirements of 9.5 mm clear stone according to OPSS 1004.
- b) Prepare the substrate by applying the TOP emulsion at a rate of 1,000 ml per 1,000 g of substrate distributed evenly in 4 coats (i.e., 250 ml per 1,000 g substrate per coat).
- c) Stir the mixture after each coat has dried to ensure that substrate particles do not adhere to each other.
- d) Allow each coat of the TOP emulsion to dry completely prior to the application of the next coat.
- e) To prepare the effluent for testing, expose a maximum of 1,000 ml of dechlorinated tap water for each 100 g of prepared substrate for a minimum of 24 hours.
- f) Decant sufficient effluent as required for each test.

2510.07.04 Marking

Bill of lading or invoice, as applicable, shall be legibly marked with the following information:

- a) Product name.
- b) Name of the manufacturer.
- c) Date shipped (i.e., yyyy-mm-dd).
- d) Product type.
- e) Net content mass in tonnes or volume in litres, as applicable.
- f) Solids content in percent.
- g) Particle charge (i.e., cationic).

2510.08 QUALITY ASSURANCE

2510.08.01 Inspections, Sampling, Testing, and Acceptance

The Owner reserves the right to make inspections, take samples, and perform tests at times and locations as the Owner may consider necessary to ensure that the materials supplied are in accordance with this specification.

TABLE 1
Physical Requirements

Solids content, % Minimum	Particle Size, µm Maximum (Note 1)	Particle Charge
8 (Note 2)	5.0	Cationic or non-ionic
Notes: - As determined by a particle size analyzer capable of resolution below 10 µm. - When the TOP emulsion is supplied at a higher concentration, it may be diluted with water to meet the solids content of this specification.		

TABLE 2
Environmental Testing

Section	Test	Requirement	Test Method
A	Full Metal Scan	Less than or equal to the concentrations for Agriculture or Other Property Use shown in Table 1 of Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act.	As described in Protocol for Analytical Methods Used in the Assessment of Properties Under Part XV.1 of the Environmental Protection Act.
	Inorganic Anions		
	Polychlorinated Biphenyls (PCBs)		
	Dioxins and Furans		
	Polyaromatic Hydrocarbons (PAHs)		
	Acid / Base / Neutral Extractable Organics		
B	Inherent Biodegradability	Minimum 20% biodegradation in 28 Days	OECD Method 302B
	Ready Biodegradability	Maximum 60% ThCO ₂	OECD Method 301B
C	<i>Daphnia magna</i> LC50	No greater than 50% impairment or mortality after continuous exposure for 48 hours.	EPS 1/RM/14
	Leachate Testing: Metals Non-Metals, Metalloids	Less than the concentration shown in Schedule 4 of Ontario Regulation 347 as amended by Ontario Regulation 558/00, under the Environmental Protection Act	SW - 846, Toxicity Characteristic Leaching Procedure, Method 1311
	Rainbow Trout LC50	No greater than 50% impairment or mortality after continuous exposure for 96 hours.	EPS 1/RM/13



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REVISION INFORMATION SHEET

ONTARIO PROVINCIAL STANDARDS FOR ROADS AND PUBLIC WORKS

VOLUME 6 PROVINCIAL-ORIENTED MATERIAL SPECIFICATIONS

MANUAL REVISION No. 22

July 2023

UPDATING ONTARIO PROVINCIAL STANDARDS FOR YOUR USE

Each roads and public works owner (Owner) is responsible for determining implementation dates and directions for use of Ontario Provincial Standards; therefore, manual holders are cautioned about immediately discarding superseded and cancelled standards.

ACCESSING AND OBTAINING ONTARIO PROVINCIAL STANDARDS

Individual OPS standards, revision packages, and complete manuals are available for download, free of charge, in PDF format, from the [MTO Technical Publications](https://www.mto.gov.on.ca/technicalpublications/) website.

WAITING TO HEAR FROM YOU

Further news and information about the Ontario Provincial Standards organization can be obtained from the OPS website at www.ops.on.ca.

Questions should be directed by email to Ontario.Prov.Standards@ontario.ca

If you have a suggestion to revise a standard or you have a standard that works in your ministry, municipality, or area, send it to the OPS Administration, for review and possible inclusion into the Ontario Provincial Standards.

THIS MANUAL IS REVISED AS FOLLOWS:

Index Pages Volume 6

Remove the entire index and replace with the attached revised index.

Standard Specifications Volume 6

Changes to the OPSS.PROV template as detailed in the Summary of Revisions will be made to all OPSS.PROVs starting November 2017 and continuing until all OPSS.PROVs meet this new format.

Superseded/Cancelled (Remove)		Revised/New (Insert)		Remarks
OPSS.PROV	Dated	OPSS.PROV	Dated	
1212	Nov 2003	1212	July 2023	Material Specification for Hot Poured Rubberized Asphalt Joint Sealing Compound The specification was administratively converted to an OPSS from the delete and replace SSP 112S07.
1213	Mar 1998	1213	July 2023	Material Specification for Hot-Applied Rubberized Asphalt Waterproofing Membrane OPSS.PROV 1213 has been revised extensively. It is recommended that users read the entire specification, as there are major differences between this version of the specification and previous versions.
1215	Mar 1998	1215	July 2023	Material Specification for Protection Board OPSS.PROV 1215 has been revised extensively. It is recommended that users read the entire specification, as there are major differences between this version of the specification and previous versions.
		1216	July 2023	Material Specification for Primer for Hot-Applied Rubberized Asphalt Waterproofing Membrane New specification for Primer for Hot-Applied Rubberized Asphalt Waterproofing Membrane.
		1217	July 2023	Material Specification for Reinforcement Used With Hot-Applied Rubberized Asphalt Waterproofing Membrane New specification for Reinforcement Used With Hot-Applied Rubberized Asphalt Waterproofing Membrane.

Superseded/Cancelled (Remove)		Revised/New (Insert)		Remarks
OPSS.PROV	Dated	OPSS.PROV	Dated	
1712	Feb 1991	1712	July 2023	Material Specification for Organic Solvent Based Traffic Paint The PROV published in July 2023 replaces OPSS 1712 COMMON, February 1991 with no technical content changes.
1713	Feb 1991	1713	July 2023	Material Specification for Thermoplastic Pavement Marking Materials The PROV published in July 2023 replaces OPSS 1713 COMMON, February 1991 with no technical content changes.
1714	Feb 1991	1714	July 2023	Material Specification for Field Reacted Polymeric Pavement Marking Materials The PROV published in July 2023 replaces OPSS 1714 COMMON, February 1991 with no technical content changes.
1715	Feb 1991	1715	July 2023	Material Specification for Preformed Plastic Pavement Marking Tape The PROV published in July 2023 replaces OPSS 1715 COMMON, February 1991 with no technical content changes.
1716	Feb 1991	1716	July 2023	Material Specification for Water-Borne Traffic Paint The PROV published in July 2023 replaces OPSS 1716 COMMON, February 1991 with no technical content changes.
1750	Dec 1983	1750	July 2023	Material Specification for Traffic Paint Reflectorizing Glass Beads The PROV published in July 2023 replaces OPSS 1750 COMMON, December 1983 with no technical content changes.
2471	Nov 2016	2471	July 2023	Material Specification for Sectional Steel High Mast Lighting Poles The specification was administratively converted to an OPSS from the delete and replace SSP 124S01.

Superseded/Cancelled (Remove)		Revised/New (Insert)		Remarks
OPSS.PROV	Dated	OPSS.PROV	Dated	
2501	April 2015	2501	July 2023	Material Specification for Calcium Chloride and Calcium-Magnesium Chloride Blend The specification was administratively converted to a PROV from the April 2015 COMMON version with administrative updates, including title change and scope to include existing calcium-magnesium chloride blend identified within the 2015 version of the specification.