STANDARD TECHNICAL SPECIFICATION

OPG-M-582 R00

Cable, Control and Instrumentation, Multiple Conductor, Shielded Up to 600 V

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1. SCOPE OF WORK

1.1 General

This Technical Specification covers standard requirements for flame rated, shielded, Control and Instrumentation cables for use at Ontario Power Generation Inc. (OPG) generating stations. The cables are for use in protection systems control and instrumentation circuits at potentials up to and including 600 V.

The Technical Specification is intended to supplement the Canadian Standards Association (CSA), C22.2 No. 239, Control and Instrumentation Cables. All CAN/CSA C22.2 No. 239 requirements shall apply unless explicitly modified by this Standard Technical Specification.

The following sections apply to control and instrumentation cables unless explicitly stated.

1.2 Supplementary Specification

A Supplementary Specification OPG-M-582S and drawings for each specific project shall accompany, be read with and form part of this Technical Specification. The requirements of the applicable Supplementary Specification shall take precedence over the Technical Specification for the specific project under discussion.

All drawings supplied by the OPG Representative as part of the Supplementary Specification to the Contractor shall form part of this Technical Specification. The drawings and Specifications shall be deemed to be complementary to each other so that if anything is shown on the drawing but not mentioned in the Specification or vice versa, it shall be furnished and built as if specifically set forth in both. In case of conflict between the Technical Specification, Supplementary Specification and/or the drawings, the OPG Representative shall be consulted for clarification.

2. LAWS, STANDARDS, AND CODES

2.1 General

All work shall conform to:

- The laws and regulations of Canada, the Province of Ontario, or local municipalities.
- Specific standards listed in the sections below, their latest issues, amendments and supplements of which shall apply unless otherwise indicated in the contract documents.
- Any other standards mentioned elsewhere in this document or that apply in general to

this work.

The Contractor shall clearly state in its proposal any exceptions or deviations it intends to take to these standards and specifications.

Should any law, standard or code be revised, the Contractor and OPG will make each other aware of the revision to discuss adoption of the revision.

Should conflict occur between laws, standards or codes and the Technical Specification, the most stringent requirements shall govern.

2.2 Canadian Standards Association (CSA) Standards

- CAN/CSA C22.2 No. 0.3: Test Methods for Electrical Wires & Cables.
- CAN/CSA C22.2 No. 75: Thermoplastic-Insulated Wires and Cables.
- CAN/CSA C22.2 No. 239: Control and Instrumentation Cables.
- CAN/CSA C22.2 No. 2556: Wire and Cable Test Methods.
- CAN/CSA Z299.3: Quality Assurance Program – Category 3.

2.3 American Society for Testing and Materials (ASTM) Standards

- ASTM - B3: Standard Specification for Soft or Annealed Copper Wire.
- ASTM - B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, Soft.
- ASTM – D5423: Standard Specification for Forced Convection Laboratory Ovens for Evaluation of Electrical Insulation.
- ASTM – D2863: Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle Like Combustion of Plastics (Oxygen Index).

2.4 International Organisation for Standardisation (ISO) Standards

The Contractor shall be certified to ISO 9001 standard.

3. DEFINITIONS AND ABBREVIATIONS

The following definitions and abbreviations apply throughout this Specification:

Contractor	The party named in the contract to whom OPG has awarded the contract to design and supply the equipment (the Supplier, the Subcontractor, the supplier's personnel or any other person the

	Supplier or Subcontractor is responsible for at law).
OPG	Ontario Power Generation, Inc.
OPG Representative	Engineer, employed by or representing OPG, responsible for ensuring that the Contractor is adhering to the specification.
FT4	Vertical Flame Test Rating, per CSA C22.2 No. 239.
Jacket	A continuous non-metal covering.
CIC	Control and Instrumentation Cable
Instrumentation Cable	-Twisted paired or multi-paired conductors with overall shield used to connect instrument field devices such as flow, pressure, temperature transducers to control systems such as PLC, SCADA -Twisted triad or muti-triad conductors with overall shield used to connect Resistance Temperature Detectors (RTDs) to control systems
LAG	Low Acid Gas
FR	Flame Retardant

4. GENERAL REQUIREMENTS

4.1 Cable

Control and Instrumentation Cables (CICs) shall satisfy the requirements of CSA C22.2 No. 239 and this Technical Specification.

The insulation shall be rated for a continuous minimum operating temperature of 75ºC for insulation grade TW75. The cable shall pass a -30ºC cold bend test.

The overall cable shall meet the flammability FT4 rating. All non-metallic cable components shall meet the acid gas test requirements of Section 5.4 of this Specification.

If the cable, or any section of a cable, is directly exposed to sunlight, the cable shall be sunlight resistant rated. Refer to the Supplementary Specification for information on intended route of the cable and whether the cable will be exposed to sunlight.

4.2 Conductor

The Conductor shall be stranded annealed copper. Each wire of the stranded conductor shall be of uncoated (bare) copper and shall comply with the requirements of ASTM B3. Conductors shall comply with the requirements of ASTM B8 and CSA C22.2 No. 75.

The conductor size to be supplied shall be specified in the Supplementary Specification.

There shall not be a mixture of copper and aluminum circuit conductors in the same cable.

For control cable rated up to 300 V the size range of the conductor shall be No. 20 AWG to No. 14 AWG. For cable rated up to 600 V the size range of the conductor shall be No. 18 AWG to 4/0 AWG.

Instrumentation cable (paired or triad) shall be No. 18 AWG for reliability purposes and ease of termination. Larger AWG conductor size is acceptable if required. Refer to supplemental specification for cable size specified.

The number of strands in each conductor shall conform to ASTM B8, Class B, as a minimum.

4.3 Conductor Insulation

The insulation shall be of PVC and of grade TW75 as specified in CSA C22.2 No. 75, suitable for installation at -10 ºC.

4.4 Insulation Thickness

The average insulation thickness shall be in accordance with CSA C22.2 No. 239 Table 5 for the cable size required. The minimum insulation thickness at any point shall not be less than 90% of the average thickness shown in Table 5 of CSA C22.2 No. 239.

4.5 Insulated Conductor Assembly

Control cable conductors shall be assembled in concentric layers. The direction of lay of the layers shall be alternated. The overall cross-section of the finished cable assembly shall be as near circular as practicable.

Instrumentation cable shall be assembled as two or three conductors twisted together to form a pair or triad. Multiple pairs or triads can be assembled together, similar to the cabling of conductors in control cables, to form multi-pair or multi-triad cables.

Flat twin cable is unacceptable.

4.6 Binder Tape

Over the assembled insulated conductors, a polyethylene terepthalate tape or equivalent wrap shall be applied to prevent bonding between the conductor insulation and the inner protective covering.

4.7 Inner Protective Covering

Over the binder tape a PVC inner protective covering, meeting CSA C22.2 No 239 requirements (except thickness) for a 75 ºC thermoplastic jacket shall be extruded. The inner protective covering shall have a minimum thickness at any point of 0.68 mm. The inner protective covering is intended to provide additional insulation between the shield and the conductors as well as to provide protection to the conductors should the shield become deformed during bending of the cable.

4.8 Shields

A shield consisting of a corrugated, untinned, copper tape shall be applied longitudinally over the PVC inner jacket.

The copper tape overall shield specifications are as follows:

(1) The tape thickness shall be 0.13 mm nominal.

(2) Tape corrugations shall be:

a) At least 28 per 100 mm diameters**** up to and including 18.5 mm.

b) At least 32 per 100 mm for diameters**** above 18.5 mm.

****The diameters specified are those over the inner protective covering.**

(1) The radial distance between the outer surfaces of the inner and outer peaks of the corrugated tape shall be:

a) 0.65 ± 0.15 mm for diameters****** up to and including 18.5 mm.

b) 0.90 ± 0.15 mm for diameters****** above 18.5 mm.

**** The diameters specified are those over the inner protective covering.**

(2) There shall be a minimum tape overlap of 5 mm for all sizes of cable.

There is no OPG requirement for individual shielding of instrumentation cable as the overall corrugated copper shield provides adequate coverage. If individual shielding is required where electromagnetic interference is known to be high then this requirement will be detailed in the supplementary specification.

The individual shield for instrumentation cable when specified shall be shielded with 100% coverage aluminum/polyester tape with a seven strand tinned copper drain wire. The shielding tape shall provide total shield isolation from all other shields.

4.9 Jacket

The overall jacket shall consist of an extruded polyvinyl chloride (PVC) meeting the requirements of CSA C22.2 No. 239 for a 75 °C thermoplastic type.

The jacket colour shall be black. The jacket thickness shall be in accordance with Table 7 of

CSA C22.2 No. 239.

4.10 Conductor Identification

Conductors shall be identified by solid colours and by coloured tracers on the solid colours.

The material used for the coloured tracers and alpha numeric coding shall be such that there will be no mutual deterioration of the identification and the insulating compound such as to produce a change in the physical or electrical properties of the insulating compound, or to produce fading, cracking, blurring or similar deterioration of the identification.

The solid colour shall be distributed throughout the insulation. Colouring applied to the surface only, will not be accepted as a solid colour.

Each coloured tracer shall not be less than 1.5 mm wide and may consist of:

(3) A continuous spiral with a maximum lay of 50 mm; or

(4) Two longitudinal stripes approximately 180 degrees apart.

Individual conductor colour code of a two conductor control cable shall be identified by solid colours of black and white. For control cables with conductors in a 3 to 16 conductor cable shall be identified as shown in Table 2 of this Technical Specification. The colour coding for more than 16 conductors shall be white insulation with black ink numeric coding.

Paired conductors of an instrumentation cable shall be as per the colour code adopted by the industry for telephone exchange cable as shown in Table 3 of this Specification.

Individual conductor colour code of a triad cable shall be black, white and red. Multi-triad cables shall have alpha numeric coding printed on the white conductor.

The shade of the solid colours shall be such that they will maintain a definite contrast between each other and between the solid colour and tracer when illuminated by a source providing an illuminance of 100 dalx.

4.11 Product Identification

Marking and identification of the cable shall be durably and legibly surface ink-printed, on the outer jacket at intervals of not more than 1 m and product marking shall be in accordance with and include all marking items identified in CSA C22.2 No. 239.

4.12 Packaging and Package Marking

Cable shall be supplied in continuous lengths as specified in the Supplementary Specification

and the purchasing documents. Each cable length shall be packaged on a separate reel.

Cable ends shall be sealed to prevent the ingress of moisture.

Cable reels shall be constructed to ensure acceptance and safe delivery by a common carrier. Selection of proper reel size depends on the length and overall diameter of the cable supplied. A reel not matched to the weight of the cable wound on it may be damaged during shipment. The reel diameter shall take into account the minimum safe cable bending radius to prevent damage to the cable.

Marking and identification of the packaging shall be in accordance with and include all marking items identified in CSA C22.2 No. 239.

5. TYPE TESTS

5.1 General

Type tests are tests performed on a specific cable type to qualify the cable design. Once the design has been qualified, the manufacturer usually only performs the acceptance tests (see Section 6).

The tests shall be as specified in CSA C22.2 No 239 and as modified and supplemented by the requirements of this Specification. Certified test results submitted with previous tenders are acceptable, provided insulation, inner protective covering and jacket compounds, and production processes have been unchanged.

Certified test results shall be provided for each type of construction and size for all tests, except for the fire retardancy test. Qualification for the fire retardancy test are listed in Table 4 of this Specification.

5.2 Physical Properties of Insulation and Jacket after Aging

Only the air oven test is required. Oven aging shall be performed in a forced air ventilation oven described by the performance requirements for Type II ovens found in ASTM D5423.

5.3 Inner Protective Covering and Overall Jacket

Thermoplastic jackets used over insulations with a 75 ºC rating shall meet the physical requirements specified for the overall thermoplastic (PVC) covering in CSA standard C22.2 No. 239.

5.4 Tests for Fire Retardancy and Acid Gas Emission

5.4.1 Fire Retardancy

Vertical Flame test spread in grouped cables shall be performed as outlined in CSA C22.2 No. 2556 Clause 9.6.4.3 Method 2. The length of cable damage shall not exceed 1.5 m (i.e. the cable shall meet FT 4 rating).

5.4.2 Acid Gas Emission

This test shall be performed as outlined in CSA C22.2 No. 2556 clause 9.11.5 Method 1. The acid gas content shall not exceed 0.14 g per gram of material.

5.4.3 Oxygen Index

This test shall be performed on compound samples of the insulation, inner protective covering, and jacket materials taken prior to extrusion in accordance with ASTM D2863. The criteria for burning Type A specimen shall apply. The mean and standard deviation for ten samples each, of the insulation, inner protective covering, and jacket shall be quoted. The standard deviation shall not exceed 1.0. These results will be used for comparison purposes during acceptance testing of the cables.

5.5 Physical Tests

The following physical type tests shall be in accordance with CSA C22.2 No. 239 and in compliance with CSA C22.2 No. 0.3 or CSA C22.2 No. 2556.

5.5.1 Weathering (Sunlight Resistance)

A jacketed specimen of cable shall be subjected to exposure for 1000 h in a weatherometer, followed by exposure to a temperature of –30 ± 1 °C for 1 h. The jacket of the specimen shall show no cracks when wound one complete turnaround a mandrel having a diameter as shown in Table 21 of CSA C22.2 No. 239, while still at -30 °C. Compliance shall be as specified CSA C22.2 No. 0.3.

5.5.2 Cold Bend Test

Neither the insulation nor the jacket shall crack when a specimen of finished cable is bent 180 º around a mandrel as specified in Tables 19 and 20 of CSA C22.2 No. 239 after the specimen and mandrel have been subjected to -30 ± 1 ºC for 4 hours and while the specimen and mandrel are still at that temperature. Compliance shall be as specified CSA C22.2 No. 2556.

5.6 Cable Flexing Test

A sample of completed cable shall be flexed with a tensile force applied by either of the two methods shown in Figure 1 and Figure 2 of this Specification. A visual examination of the shield, of the sample tested, shall not reveal any fractures.

The required tensile force and number of flexing cycles shall be chosen from the following table:

Cable Diameter (millimeters)	Tensile Force (newtons)	Number of Flexing cycles
Up to 32.5	125	4
Over 32.5	250	2

6. ACCEPTANCE TESTS

6.1 General

Unless otherwise specified cables for acceptance shall be tested in accordance with the requirements of and tests given in CSA C22.2 No. 239 except that the air oven test is not required. The following sections outline additional tests required by Ontario Power Generation.

6.1.1 Insulation Tests

Thermoplastic insulation tests shall be in accordance with CSA C22.2 No. 75.

6.1.2 Oxygen Index

This test shall be performed on compound samples of insulation, inner covering and jacket materials in accordance with ASTM D2863 for a type A specimen, and Section 5.4.3 of this Specification. The production run will be acceptable with respect to oxygen index if the value of oxygen index determined is not more than one unit below the mean value determined during certification.

If a sample of insulation or inner protective covering compound fails to meet this requirement and the production run is used in a completed cable, samples (in accordance with Section 7.2.3 of this Specification) from the completed cable using these suspect compounds shall pass the full scale fire test in accordance with Section 5.4.1 of this Specification.

If a sample jacket fails of jacket compound fails to meet this requirement, samples (in accordance with Section 7.2.3 of this Specification) from the completed cable shall pass the full scale fire test in accordance with Section 5.4.1 of this Specification.

6.1.3 Tests for Fire Retardancy

The test outlined in Section 5.4.1 of this Specification shall be required by Ontario Power Generation, if the Oxygen Index results (Section 6.1.2 of this Specification) prove to be

unacceptable.

6.1.4 Acid Gas Emission

Every non-metallic component shall meet the acid gas requirements of Section 5.4.2 when tested in accordance with CSA C22.2 No. 2556.

6.2 Electrical Tests

The following electrical acceptance tests shall be in accordance with CSA C22.2 No. 239 and in compliance with test requirements specified in CSA C22.2 No. 2556.

6.2.1 Spark Test

Each individual conductor shall withstand the ac or dc spark test voltage shown in Table 17 of CSA C22.2 No. 239.

6.2.2 Insulation Resistance Test

The insulation resistance shall meet the requirements shown in Table 18 of CSA C22.2 No. 239.

6.2.3 Circuit Continuity Test

All individual conductors in every length of finished cable shall be tested to ensure continuity throughout the length of cable.

6.2.4 Dielectric Withstand Test

Each length of finished cable shall withstand the application of an ac voltage of 1000 V for 150 to 300 V cable and 2000 V for 600 V cable for 1 minute between each conductor and the adjacent conductors. The same test shall be applied between all conductors and the shield, the metallic covering if specified and the bonding conductor if specified. A dc test voltage equivalent to three times the ac level may be used as an alternative voltage source.

7. QUALITY ASSURANCE PROVISION

7.1 General

The Contractor shall:

(5) Have an implemented, certified and current quality management system to ensure that the product quality characteristics specified will be met. The minimum acceptable quality program shall conform to the International Organisation of Standardisation (ISO) 9001 and CAN/CSA-Z299.3 with a minimum of 3 years in good standing.

(6) Supply a certificate showing compliance with the acceptance tests in accordance with the Ontario Power Generation Technical Specification OPG-M-582 with each shipment.

(7) Failure of a representative sample to conform to the requirements of the Technical Specification OPG-M-582 shall constitute cause for rejection of the material represented.

(8) Ensure cable and packaging identification meet the requirements of the Technical Specification OPG-M-582.

7.2 Sampling

The quantity of cable ordered shall refer to a lot. Each lot shall consist of a length or lengths of cable of a discrete conductor size and a discrete number of conductors. Each cable length shall be on a separate reel.

A sub-supplier lot of material is defined as a batch of material provided to the cable manufacturer from one of the cable manufacturer's material supplier that has:

- The same lot number or batch number.
- Been manufactured at the same time by the sub-supplier so that the material is uniform throughout the sub-supplier lot.

7.2.1 Sample Selection

Sample selection for acceptance tests for all tests except oxygen index and fire retardancy shall be made in accordance with the following Table 1.

Table 1 – Sample Selection for Acceptance Tests except Oxygen Index and Fire Retardancy Tests

Number of Lengths of Samples			
Nominal Overall Diameter of Cable (mm)	Quantity of Completed Cable Ordered (m)	Number of Samples	Minimum Length of Each Sample (m)*
Less Than 25	Less Than 600	1	1
	600 to 15,000	1	2
	More Than 15,000; First 15,000	1	2
	Each Additional 15,000 or part thereof	1	2
>25 but<50	Less Than 300	1	1
	300 to 7500	1	1

	More Than 7,500; First 7,500	1	1
	Each Additional 7,500 or part thereof	1	1
>50	Less than 300	None	-
	300 to 7,500	2	0.6
	More Than 7,500; First 7,500	2	0.6
	Each Additional 7,500 or part thereof	2	0.6

* An additional 5 m sample length is required in each case for the acceptance dielectric strength tests.

7.2.2 Oxygen Index

The test outlined in Section 5.4.3 of this Specification shall be performed on specimens from the insulation, inner protective covering, and jacket compounds prior to extrusion onto the conductor or cable respectively. The samples shall be taken by the manufacturer at the start of each production run.

7.2.3 Fire Retardancy

When required the test outlined in Section 5.4.1 of this Specification shall be performed by the manufacturer on specimens of finished cable from each production run and from every 7500 m or less of cable length composing the production run.

Note:

For the purpose of the fire retardancy test, the production run referred to is the production run of insulating, inner protective covering or jacking compound that failed the oxygen index test.

7.3 Cable Acceptance

7.3.1 General

Failure of a sample to meet any acceptance test, other than oxygen index and fire retardancy shall require the testing of every reel composing the lot. Any reel from which samples do not meet the test requirements shall be rejected.

7.3.2 Oxygen Index and Fire Retardancy

If a sample of completed cable composed of compound of insulation or inner protective covering that fails the oxygen index test, fails the fire retardancy test, then all completed cable utilizing the production run of insulation compound or inner protective covering compound shall be

rejected.

If a sample of the completed cable composed of jacket compound that fails the oxygen index test, fails the fire retardancy test, then all completed cable utilizing the production run of jacket compound shall be rejected.

7.3.3 Spark Test

If a failure occurs during the spark tests, the insulation may be repaired.

8. SITE ACCEPTANCE

The cable shall be accepted at site if:

(9) A visual inspection confirms there is no damage or manufacturing defects to observable parts of the cable and packaging.

(10) The cable is shipped with a copy of the certificate of compliance.

(11) The cable complies with all aspects of this Technical Specification.

9. DOCUMENTATION REQUIREMENTS

The Contractor shall submit the following information with the proposal for the new cable. Absent, partial or missing information without explanation may render the submittal non-compliant and remove the Contractor from further consideration.

9.1 Drawings

The Contractor shall provide a cross sectional drawing of the cable, including dimensions for each proposal.

9.2 Documents

The following documentation shall be submitted along with the proposal:

(12) A completed copy of the “Information Exchange Table” provided in the Supplementary Specification that includes, but is not limited to, the following:

c) Voltage Class (volts).

d) Ampacity @ 30 ºC (amps).

e) Capacitance per unit length in picofarads per meter (pF/m).

f) Inductive reactance per unit length in ohms per kilometer (Ω/km).

g) Insulation thickness in millimeters (mm).

h) Inner protective cover thickness in millimeters (mm).

i) Average jacket thickness in millimeters (mm).

j) Type of conductor stranding.

k) Overall cable diameter in millimeters (mm).

l) Cable linear density in mass per unit length in kilograms per meter (kg/m).

m) Recommended minimum bending radii for the cable pulling in millimeters (mm).

n) Recommended maximum installation tension in both Newton (N) and kilograms Mass equivalent (kg).

o) Recommended minimum installation temperature in degrees Celsius (ºC).

p) Maximum continuous conductor temperature in degrees Celsius (ºC).

(13) The cable data sheet commonly used in the Contractor online documentation.

(14) An example of a certificate of compliance for a similarly manufactured cable.

10. WARRANTY

The Contractor shall guarantee that the cable supplied under this Technical Specification is free from inherent defects in design, workmanship and material.

If the cable supplied by the Contractor fails or becomes defective during the warranty period the Contractor shall correct the failure or defect to the satisfaction of OPG.

Warranty shall be for one (1) year commencing after energization at OPG. Coverage for warranty claims within one (1) year shall continue for one (1) additional year from date of replacement or repair.

The Contractor shall be the single point of contact for all in-service and warranty related issues, including material that the Contractor did not manufacture in whole or part that makes up the cable assembly.

Table 2 – Colour Sequence for Control Cable

CONDUCTOR NO.	BASE COLOUR	TRACER
1	BLACK	—
2	RED	—
3	BLUE	—
4	WHITE	—
5	YELLOW	—
6	BROWN	___
7	ORANGE	___
8	BLACK	WHITE
9	RED	WHITE
10	GREEN	WHITE
11	YELLOW	WHITE
12	RED	BLACK
13	GREEN	BLACK
14	YELLOW	BLACK
15	GREEN	RED
16	YELLOW	RED
17 >	WHITE	***

Note: For cables greater than 16 conductors the base colour shall be white with black numeric coding.

Table 3 – Colour Sequence for Instrumentation Cable

PAIR NO.	1ST CONDUCTOR	2ND CONDUCTOR
1	BLUE	WHITE
2	ORANGE	WHITE
3	GREEN	WHITE
4	BROWN	WHITE
5	***SLATE	WHITE
6	BLUE	RED
7	ORANGE	RED
8	GREEN	RED
9	BROWN	RED
10	***SLATE	RED
11	BLUE	BLACK
12	ORANGE	BLACK
13	GREEN	BLACK
14	BROWN	BLACK
15	***SLATE	BLACK
16	BLUE	YELLOW
17	ORANGE	YELLOW
18	GREEN	YELLOW
19	BROWN	YELLOW
20	***SLATE	YELLOW
21	BLUE	VIOLET
22	ORANGE	VIOLET
23	GREEN	VIOLET
24	BROWN	VIOLET
25	***SLATE	VIOLET

Note: ***Slate Conductor must be printed with the word *** “Slate”

Table 4 – Qualification of Cables with Respect to Fire Retardancy Requirements of Ontario Power Generation

Cable Type	Size AWG	No. of Cond.	Group No.
Instrumentation	No. 18 **	6 pr	3
		25 pr	4
		50 pr	5
Control	No. 16	2	1
		4 5 6 7	2
		12 16	3
	No. 12	2 3 4	2
		5 7 9 12	3
		16	4
	No. 8	2	2
	No. 6	2	3
		3	
		4	
		6	4
	No. 4	4	4
	No. 2	4	4
		6	

Note ** Larger Size Instrumentation Cable may also be specified.

The cables in each conductor size have been grouped according to their overall diameters as follows:

Group	Overall Diameter in millimetres
1	Up to 13
2	Over 13 up to 20
3	Over 20 up to 30
4	Over 30 up to 45
5	Over 45 up to 65

Table 4 of this Specification should be used as follows for the qualifying cables using the same insulation and jacket.

Criteria No. 1

In each cable size (AWG) a fire tests on a specific cable type (no of cond.) qualifies all other cable types for that cable size in the same group.

Criteria No. 2

A fire test on a specific cable size and type (no. of cond.) in addition qualifies all larger sizes of cable of the same type (no. of cond.).

eg:

(15) A successful fire test on a No. 14 AWG, 3 conductor cable qualifies the following cables:

- - No. 14 AWG, 2, 3 and 4 conductor (meets criteria No. 1) and
- - No. 12 AWG to No. 4/0 AWG, 3 conductor (meets criteria No. 2).

(16) A successful fire test on a No. 10 AWG, 4 conductor cable qualifies the following cables:

- No. 10 AWG, 4, 6 conductor (meets criteria No. 1) and
- No. 10 AWG to No. 4/0 AWG, 4 conductor (meets criteria No. 2)

(17) The following fire tests will qualify all cables listed in Table 4 of this Specification:

- No. 14 AWG, 2 ,7, 12, 40 conductor and

  No. 12 AWG, 3, 9 conductor and

  No. 8 AWG, 6 conductor
- No. 14 AWG, 2 ,3, 7, 12, 40 conductor and

  No. 12 AWG, 4, 7, conductor and

No. 10 AWG, 6 conductor

- No. 14 AWG, 2, 3 and 4 conductor (meets criteria No. 1) and
  No. 12 AWG to No. 4/0 AWG, 3 conductor (meets criteria No. 2).

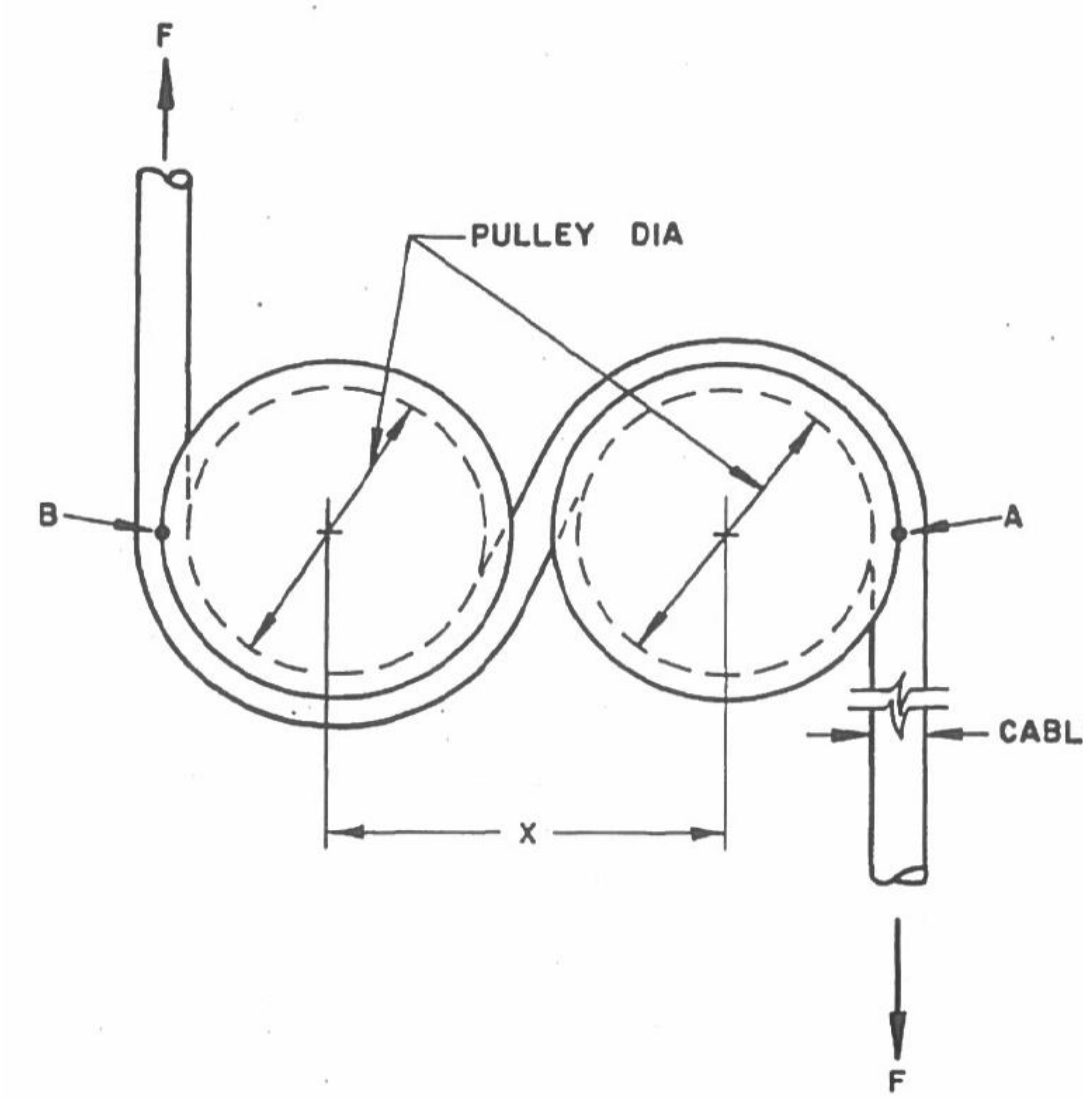


Figure 1 - Cable Flexing Test Under a Constant Load, METHOD 'A'

NOTES:

1. The value of the tensile force F should be obtained from the table in Section 5.5 of this Specification
2. One cycle is complete when: Point 'A' moves to point 'B' or
   Point 'A' moves to point 'B' or
   Point 'B' Moves to Point 'A'
3. Ratio of Pulley Diameter: Cable diameter not more than 14:1
4. X = (Pulley Dia. + [3 x Cable Dia.] Max

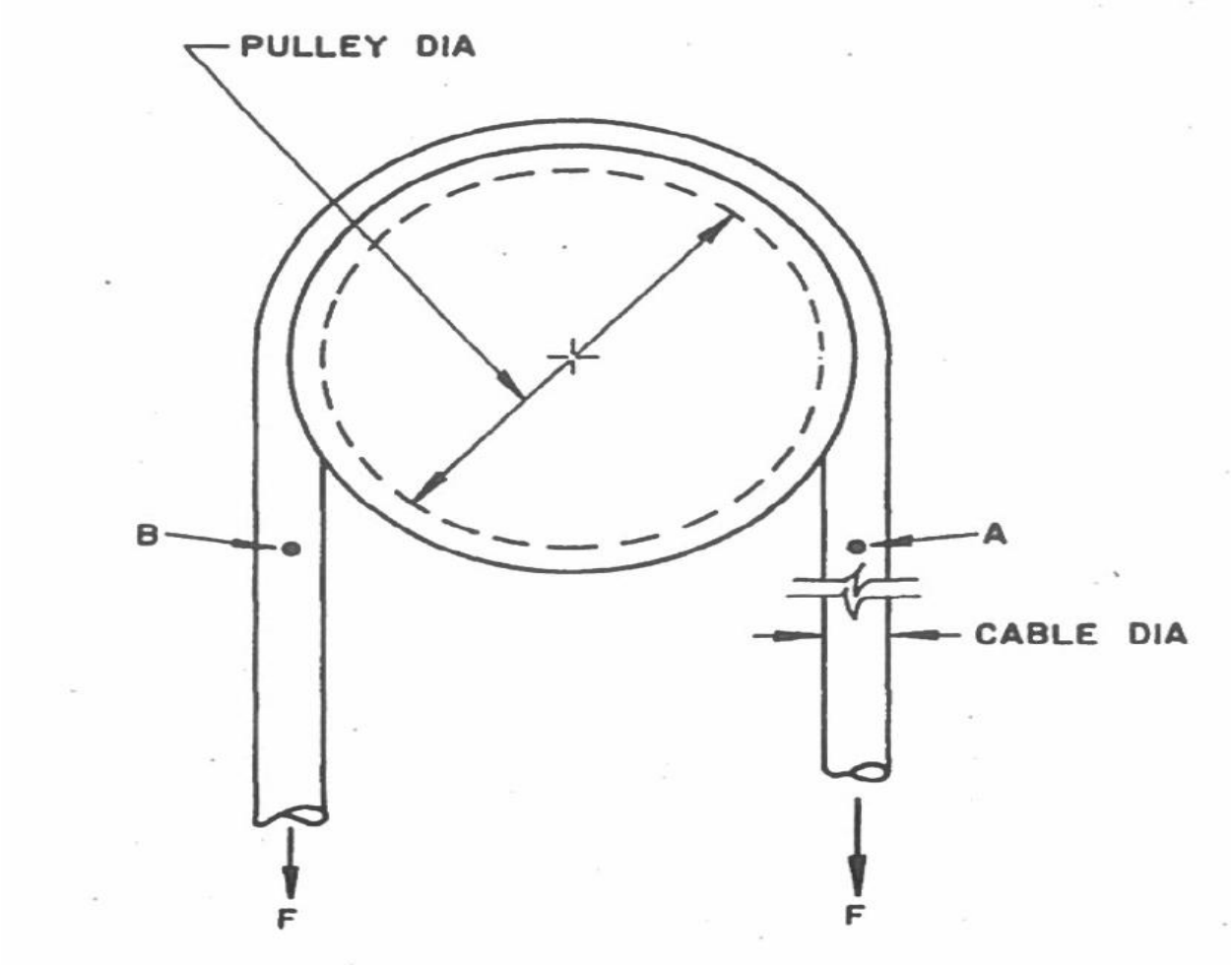


Figure 2 - Cable Flexing Test Under a Constant Load, METHOD 'B'

NOTES:

1. The Value of the tensile force shall be obtained from the table in Section 5.5 of this Specification.
2. The following constitutes one flexing cycle:
   I. Pull 'A' to point 'B', Clear of pulley
   II. Remove tensile force and turn cable through 180º so that part of the cable previously on the outside of the bend is now in contact with the pulley
   III. Reapply the force and pull point 'B' through to point 'A'

   (The cable does not have to be turned through 180º after the completion of one flexing cycle and the beginning of the next.
3. Ratio of Pulley Diameter: Cable Diameter not more than 14:1.