WEBINAR

Installations 101

January 27, 2022

By: Wissam Geahchan, Applications Engineer

Nexans
ELECTRIFY THE FUTURE

ATTENTION

AUDIENCE PARTICIPATION

- Questions can be asked at any time using the chat function on the webinar screen
- Any unanswered questions will be followed up through email
- This presentation, a recording of the webinar and a brief survey will be emailed to all registrants

Nexans
ELECTRIFY THE FUTURE

ABOUT ME

Wissam Geahchan

Applications Engineer, Nexans Canada

- Electrical Engineering graduate from the University of Toronto
- Active member of CSA and UL standards committees
- Experience applying the Canadian Electrical Code in a variety of applications
- LEED Green Associate
- Soccer coach

Nexans
ELECTRIFY THE FUTURE

Installations 101: 2-Part Series

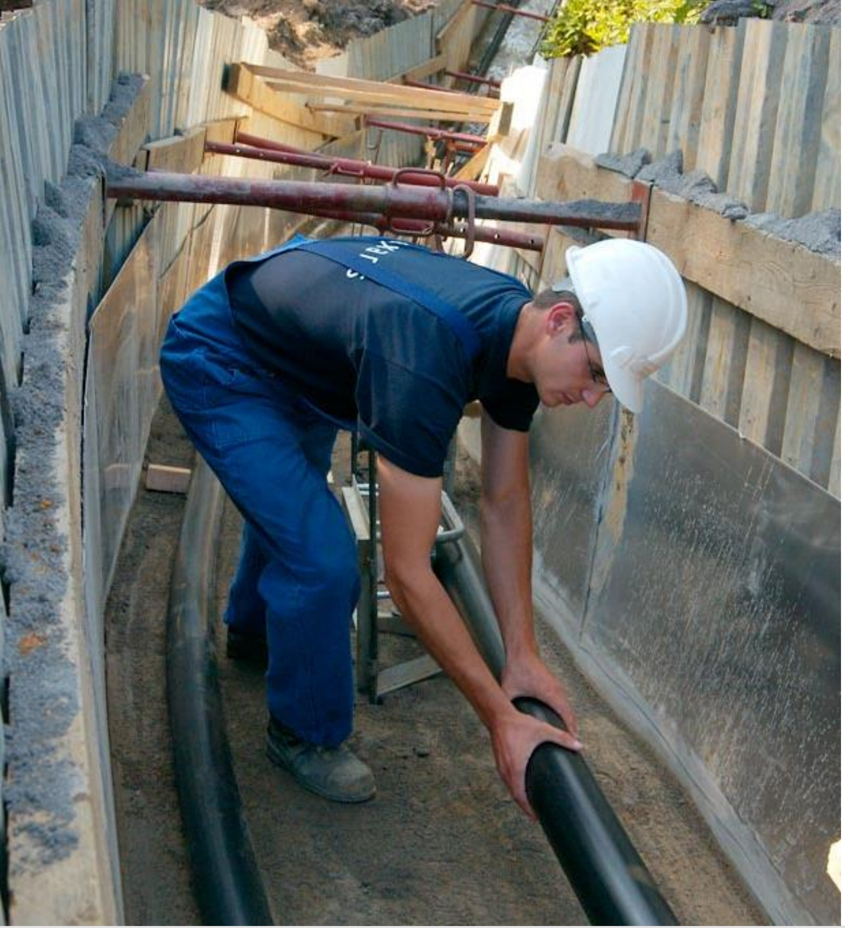
Part 1:

- Industry standards & guides
- Installation Types & Considerations:
  - Exposed / Concealed
  - Raceway
  - Cable Tray
  - Low Temperature
- Field Testing Cables
  - Installation Testing – LV Megger and MV DC High Potential

Part 2:

- Industry standards & guides
- Installation Types & Considerations
  - Underground / Overhead / Underwater
- Field Testing Cables
  - Installation Testing – Very Low Frequency, Tan Delta, Partial Discharge

Nexans
ELECTRIFY THE FUTURE



AGENDA

- Industry standards and guides governing installation
- Installation Types and Considerations
- Field Testing Cables
- Key Takeaways
- Q&A

Nexans
ELECTRIFY THE FUTURE

DISCLAIMER

"Cable" Installations 101

This presentation is not meant to be a comprehensive “How-To” presentation.

Only qualified personnel who are familiar with the processes and associated safety precautions shall install cable and perform field testing.

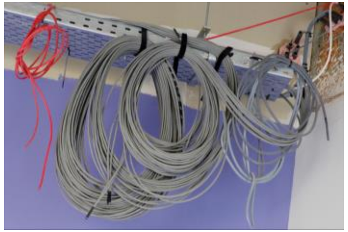
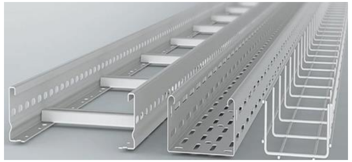
Tailored to the North American market (more towards Canada)

Industry Standards and Guides

1. **CSA C22.1 Canadian Electrical Code, Part 1 (CEC)**
2. **NFPA 70, National Electrical Code (NEC)**
3. **Provincial Electrical Safety Codes**
    1. Ontario Electrical Safety Code - OESC
    2. BC Safety Standards Act
    3. Alberta Electrical Utility Code, 5th Edition, 2016
4. **Municipal Electrical Safety Codes**
5. **Local Authorities Having Jurisdiction (AHJ)**
    1. Electrical Safety Authority - ESA (Ontario)
    2. Technical Safety BC
    3. Alberta Safety Codes Authority
6. **National, Provincial, Municipal Building Codes**
    1. National Building Code (NBC)
    2. Ontario Building Code (OBC)
7. **NEMA WC26 / EEMAC 201 - Binational Wire & Cable Packaging Standard**
8. **NEMA WC70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy**
9. **NEMA WC71 - Standard for Non-shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy**
10. **NEMA TCB 2-2017 – Guidelines for the Selection and Installation of Underground Non-metallic Raceways**
11. **NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems**
12. **EPRI EL-3333, Volume 2 - Maximum Safe Pulling Lengths for Solid Dielectric Insulated Cables – Cable User's Guide**
13. **IEEE 635 - Guide for Selection and Design of Aluminum Sheaths for Power Cables**
14. **IEEE 400 - Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5kV and above**
15. **IEEE 510 - Recommended Practices for Safety in High Voltage and High-Power Testing**
16. **IEEE 525 – Guide for the Design and Installation of Cable Systems in Substations**
17. **IEEE 576 - Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications**
18. **IEEE 835 – Power Cable Ampacity Tables**
19. **ICEA S-94-649 Concentric Neutral Cables Rated 5 thru 46kV**
20. **ICEA S-97-682 Utility Shielded Power Cables Rated 5 thru 46kV**
21. **IEC 60364-1, Low-voltage electrical installations**
22. **Megger "A Stitch in Time" – The Complete Guide to Electrical Insulation Testing**

Nexans
ELECTRIFY THE FUTURE

Installation Types

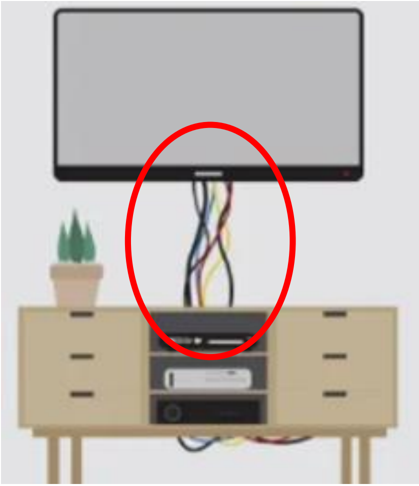
Exposed / Concealed	Raceway	Cable Tray	Low Temperature
			

Nexans
ELECTRIFY THE FUTURE

Concealed / Exposed

Concealed*
rendered permanently inaccessible by the structure or finish of the building.

Exposed*
(as applied to wiring methods)
not concealed.

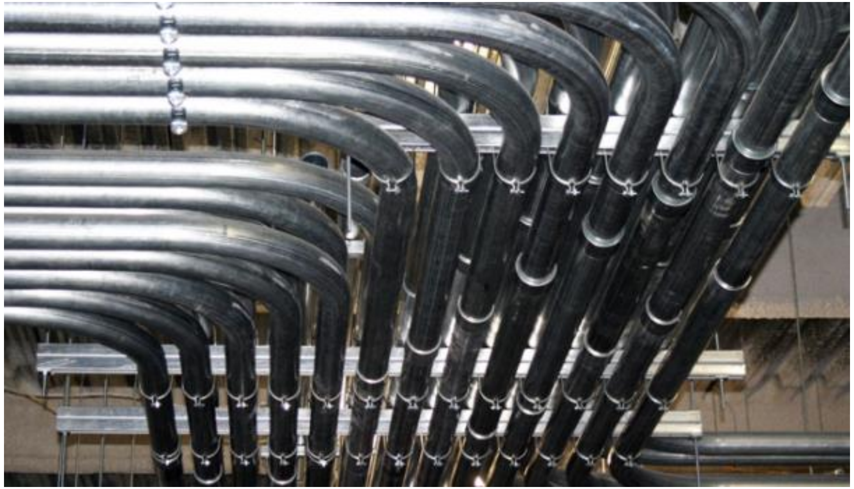


*as defined in CSA C22.1 Canadian Electrical Code, Part 1

Nexans
ELECTRIFY THE FUTURE

Raceway

Raceway* - any channel designed for holding wires, cables, or busbars, and unless otherwise qualified in the Rules of this Code, the term also includes conduit (rigid and flexible, metal and non-metallic), electrical metallic and non-metallic tubing, underfloor raceways, cellular floors, surface raceways, wireways, busway, and auxiliary gutters.



Four types of raceways:

1. Conduit (or tubing)
2. Busways
3. Surface raceways
4. Underfloor raceways

*as defined in CSA C22.1 Canadian Electrical Code, Part 1

Raceway – Conduit

Metallic: galvanized steel or aluminum

Four main types:

1. Rigid Metal Conduit (**RMC**):
   Thickest & stiffest and requires special tools to bend.

2. Electrical Metallic Tubing (**EMT**):
   Thinner & can be bent, cut and installed without many special tools.

3. Intermediate Metal Conduit (**IMC**):
   Thinner RMC but thicker and more rigid than EMT.

4. Flexible Metal Conduit (**FMC**):
   Helically wound and flexible tube, often made of aluminum.

Non-metallic: typically PVC

Three main types:

1. **Rigid PVC**: schedule 40 or schedule 80 PVC pipe. Used mostly for outdoor or underground applications.

2. **Liquid-tight flexible non-metallic conduit (LFNC)**: Flexible, waterproof, and resistant to UV rays making it safe for outdoor use. Easy to bend and cut.

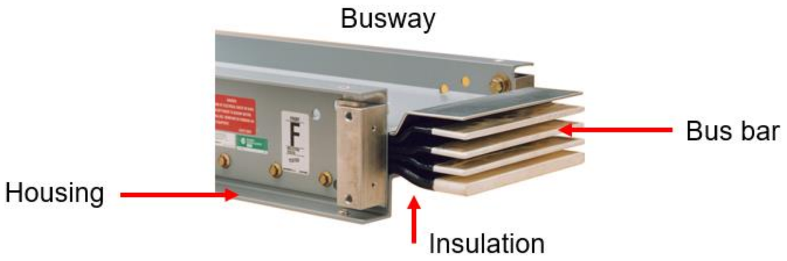
3. **Electrical non-metallic tubing (ENT):**
   Corrugated, flexible PVC tubing, lightweight & easy to handle and cut. Used indoors and in dry locations.

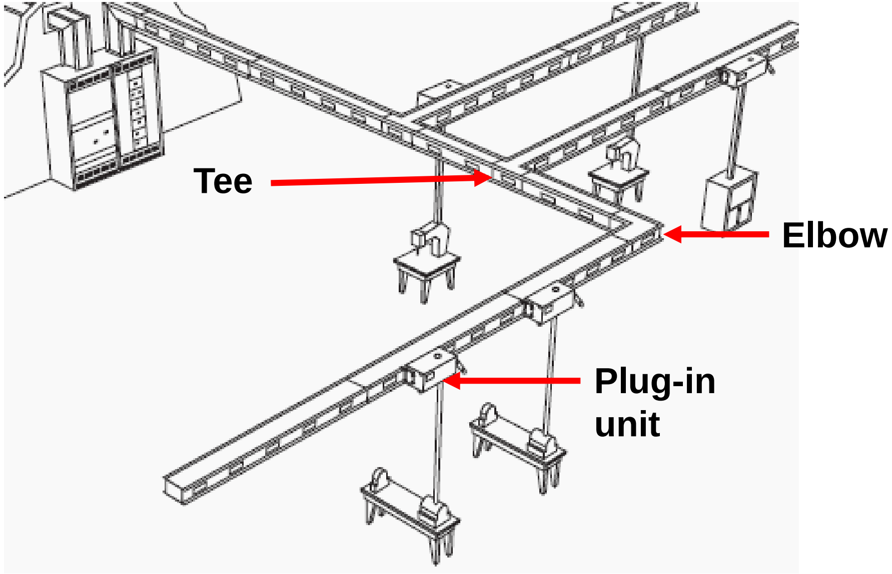
Nexans
ELECTRIFY THE FUTURE

Raceway – Busway

Busway* - a raceway consisting of metal troughing (including elbows, tees, crosses, and straight runs) containing conductors that are supported on insulators.

In other words, it is a prefabricated electrical distribution system consisting of ***bus bars*** in an enclosure. It includes fittings, accessories and other plug-in units that help facilitate distribution and protection.





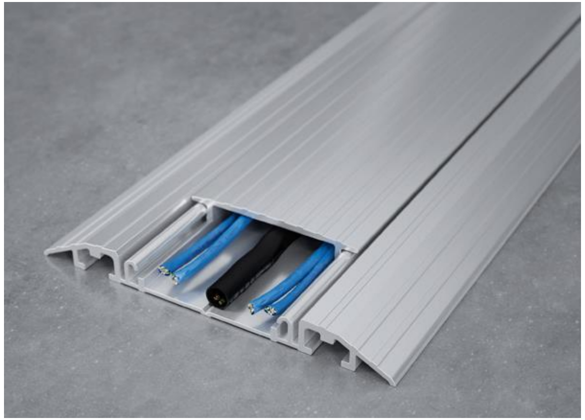
Example busway system in a machine shop

*as defined in CSA C22.1 Canadian Electrical Code, Part 1

Raceway – Surface

- Used to route wires and cables along a wall/floor
- Conceal and protect the cables
- Integrate with the aesthetic of the room/space

Source - Connectrac – a brand of Legrand



Source - Connectrac – a brand of Legrand

Nexans
ELECTRIFY THE FUTURE

Raceway – Underfloor

An **underfloor raceway** is designed for installation beneath or flush with the surface of a floor.

Source - Connectrac – a brand of Legrand

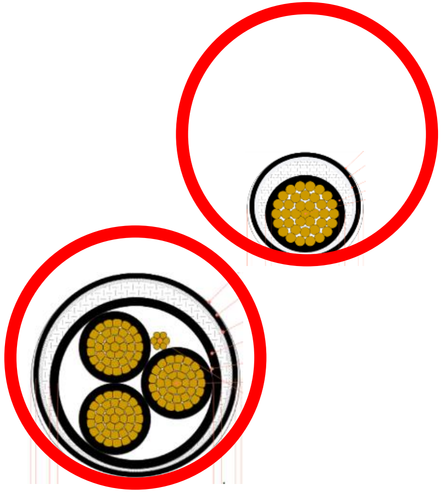
Inst. Considerations – Conduit Fill

The maximum number of insulated conductors or multi-conductor cables in one conduit or tubing shall be such that the conductor or cable will not result in a greater **conduit fill** than that specified in Table 8. Tables 6 and 9 will also help us with this.

CEC, Part 1 – Table 8

Table 8
Maximum allowable per cent conduit and tubing fill
(See Rules 12-902, 12-910, and 38-032.)

	Maximum conduit and tubing fill, %				
	Number of insulated conductors or multi-conductor cables				
	1	2	3	4	Over 4
Insulated conductors or multi-conductor cables (not lead-sheathed)	53	31	40	40	40
Lead-sheathed single conductor cables or multi-conductor cables	55	30	40	38	35



All conductors, including the bonding conductor, are included in the conduit fill calculation.

Inst. Considerations – Conduit Fill

CEC, Part 1 - Tables 6A-6K

Δ

Table 6A
Dimensions of single conductors and cables for calculating conduit and tubing fill
(See Rule 12-910 and Appendix B.)

R90XLPE, RW75XLPE, RW90XLPE UNJACKETED 600 V																					
CONDUCTOR CHARACTERISTICS			NUMBER OF CONDUCTORS																		
Conduc-tor size, AWG or kcmil	Class B		1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
	Dia mm	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2	Area mm^2
STRANDED CONDUCTORS																					
14	3.36	8.87	8.87	17.73	26.6	35.47	44.33	53.2	62.07	70.93	79.8	88.67	177.34	266.0	354.67	443.34	532.01	620.68	709.35	798.01	886.68
12	3.84	11.58	11.58	23.16	34.74	46.32	57.91	69.49	81.07	92.65	104.23	115.81	231.62	347.44	463.25	579.06	694.87	810.68	926.49	1042.31	1158.12
10	4.47	15.69	15.69	31.39	47.08	62.77	78.46	94.16	109.85	125.54	141.24	156.93	313.86	470.79	627.72	784.65	941.58	1098.51	1255.44	1412.37	1569.3
8	5.99	28.18	28.18	56.36	84.54	112.72	140.9	169.08	197.26	225.44	253.62	281.8	563.6	845.4	1127.21	1409.01	1690.81	1972.61	2254.41	2536.21	2818.02
6	6.95	37.94	37.94	75.87	113.81	151.75	189.68	227.62	265.56	303.49	341.43	379.37	758.73	1138.1	1517.47	1896.83	2276.2	2655.57	3034.94	3414.3	3793.67
4	8.17	52.42	52.42	104.85	157.27	209.7	262.12	314.55	366.97	419.4	471.82	524.24	1048.49	1572.73	2096.98	2621.22	3145.47	3669.71	4193.96	4718.2	5242.45
3	8.88	61.93	61.93	123.86	185.8	247.73	309.66	371.59	433.52	495.46	557.39	619.32	1238.64	1857.96	2477.28	3096.61	3715.93	4335.25	4954.57	5573.89	6193.21
2	9.7	73.9	73.9	147.8	221.69	295.59	369.49	443.39	517.29	591.18	665.08	738.98	1477.96	2216.94	2955.92	3694.91	4433.89	5172.87	5911.85	6650.83	7389.81
1	11.23	99.05	99.05	198.1	297.15	396.2	495.24	594.29	693.34	792.39	891.44	990.49	1980.98	2971.47	3961.95	4952.44	5942.93	6933.42	7923.91	8914.4	9904.88

Inst. Considerations – Conduit Fill

CEC. Part 1 - Tables 9A-9H

Δ

Table 9A
Internal diameter and cross-sectional areas of various trade conduit and tubing
(See Rule 12-910 and Table 8.)

Nominal trade size	Internal diameter and cross-sectional areas of rigid metal conduit		Internal diameter and cross-sectional areas of flexible metal conduit		Internal diameter and cross-sectional areas of rigid PVC conduit		Internal diameter and cross-sectional areas of rigid Type EB1 PVC conduit and rigid Type DB2/ ES2 PVC conduit		Internal diameter and cross-sectional areas of metallic liquid-tight flexible conduit		Internal diameter and cross-sectional areas of non-metallic liquid-tight flexible conduit		Internal diameter and cross-sectional areas of electrical metallic tubing		Internal diameter and cross-sectional areas of electrical non-metallic tubing	
		100%		100%		100%		100%		100%		100%		100%		100%
Dia	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²	ID mm	Area mm²
12	—	—	9.52	71	—	—	—	—	12.29	119	12.07	114	—	—	—	—
16	16.05	202	15.88	198	14.57	167	—	—	15.8	196	15.49	188	15.4	186	14.58	167
21	21.23	354	20.62	334	19.77	307	—	—	20.83	341	20.45	328	20.5	330	19.66	304
27	27.0	573	25.4	507	25.4	507	—	—	26.44	549	25.91	527	26.2	539	25.37	506
35	35.41	985	31.75	792	31.75	792	—	—	35.05	965	34.54	937	34.6	940	33.73	894
41	41.25	1336	38.1	1140	38.1	1140	—	—	40.01	1257	40.01	1257	40.5	1288	39.57	1230
53	52.91	2199	50.8	2027	50.8	2027	50.8	2027	51.31	2068	51.69	2098	52.1	2132	51.18	2057
63	63.22	3139	63.5	3167	61.3	2951	—	—	62.99	3116	—	—	69.4	3783	—	—
78	78.49	4839	76.2	4560	76.2	4560	76.2	4560	77.98	4776	—	—	85.2	5701	—	—
91	90.68	6458	88.9	6207	88.4	6138	88.4	6138	88.9	6207	—	—	97.4	7451	—	—
103	102.87	8311	101.6	8107	100.1	7870	100.1	7870	101.6	8107	—	—	110.0	9503	—	—
129	128.85	13 039	—	—	125.85	12 439	126.35	12 538	—	—	—	—	—	—	—	—
155	154.76	18 811	—	—	149.75	17 613	149.75	17 613	—	—	—	—	—	—	—	—
200	—	—	—	—	199.39	31 225	—	—	—	—	—	—	—	—	—	—
275	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
325	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Conduit, tubing, and fitting trade sizes

Inches	Metric designator
3/8	12
1/2	16
3/4	21
1	27
1-1/4	35
1-1/2	41
2	53
2-1/2	63
3	78
3-1/2	91
4	103
5	129
6	155
8	200

Cable Tray

*A supporting means consisting of troughing/fittings constructed so that insulated conductors and cables may be readily installed or removed after the cable tray has been completely installed, without damage either to the conductors or their covering.

Three main categories:

Ladder Cable Tray

- Easy access to the cables from top or bottom
- Provides convenient anchors for tying down the cables

Non-ventilated Cable Tray

- Used mainly for fiber-optic cable installations where there is a concern for electromagnetic & radio-frequency interference protection

Ventilated Cable Tray

- Provides more cable support than the ladder-type
- Typically used for telecom and fiber-optic cables.

*as defined in CSA C22.1 Canadian Electrical Code, Part 1

Inst. Considerations – Cable Tray

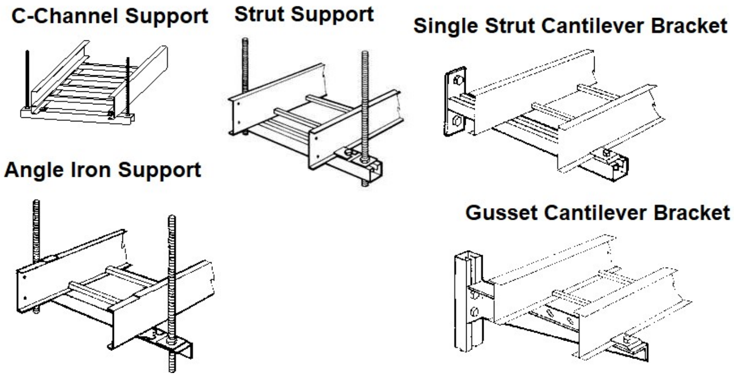
- Must be installed as a complete system BEFORE the conductors/cables are installed
- Maximum design load and support spacing shall not exceed the load/span ratings of the cable tray
- Appropriate clearances as outlined in CEC - *Section 12-2200* must be kept
- Cables shall be fastened by straps at certain intervals throughout the run

Nexans
ELECTRIFY THE FUTURE

Inst. Considerations – Cable Tray

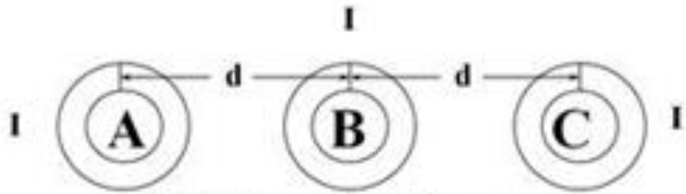
Supports

Cable trays are typically installed and fastened to the underside of a Unistrut channel.



Forces

Magnetic forces are generated on adjacent current carrying conductors. The below formula can be used to calculate the “jump” caused by EMF.



RMS Symmetrical Current
3Φ Asymmetrical Fault

A or CΦ Maximum $F = 34.9 \frac{I^2 x 10^{-7}}{d}$ lbs./ft.

BΦ Maximum $F = 37.5 \frac{I^2 x 10^{-7}}{d}$ lbs./ft.

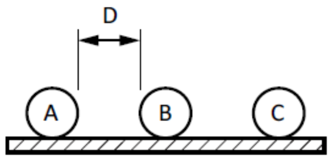
Inst. Considerations – Cable Spacing

Cable spacing makes a difference.

The lower the spacing, the lower the allowable ampacity must be to account for *mutual heating* between the cables.

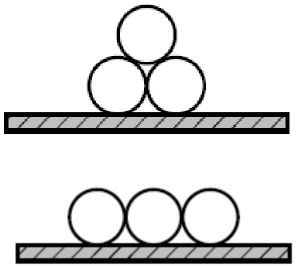
A simple example follows …

Inst. Considerations – Cable Spacing



Note: *D = diameter of one conductor.*

Size, AWG or kcmil	Concentric ground wire or concentric neutral wire size	Allowable ampacity — Indoor installation*			
		5 kV to 15 kV		25 kV to 46 kV	
		Copper	Aluminum	Copper	Aluminum
2	Full	215	169	—	—
1	Full	245	194	245	193
1/0	Full	278	222	278	221
2/0	Full	317	255	316	253



Size, AWG or kcmil	Concentric ground wire or concentric neutral wire size	Allowable ampacity — Indoor installation*			
		5 kV to 15 kV		25 kV to 46 kV	
		Copper	Aluminum	Copper	Aluminum
2	Full	172	135	—	—
1	Full	197	154	202	158
1/0	Full	225	176	231	181
2/0	Full	260	204	265	208

Note: *Cables are in contact or spaced less than one diameter apart.*

* Excerpt from CSA C22.1 Canadian Electrical Code, Part 1 – Appendix D

Nexans
ELECTRIFY THE FUTURE

Low Temperature Installations

- Cables must meet certain design and testing criteria for cold bend and cold impact (typically @ -40C)
- These tests are conducted under carefully controlled laboratory conditions
- These cables may be handled and installed at temperatures lower than -10°C, but appropriate care must be taken, which includes:
  a. minimize flexing of the conductor;
  b. when flexing the conductor, bend the conductor slowly; and
  c. work with an increased minimum bend radius.

Nexans
ELECTRIFY THE FUTURE

Low Temperature Installations

- It is recommended that wherever possible, keep the cable in a warm environment prior to installation.
- Once a conductor is installed in a fixed position, it may operate safely at much lower ambient temperatures.
- LV cables can be marked "-25C" or “-40C” on the cable's jacket.
- MV cables can be marked "LTDD" or "LTGG" as noted in CSA C68.5 and C68.10.

Table 25 *
Low-temperature marking
(See Clauses 10.2.1.1, 11.7.2, and E.1.)

Test temperature, °C	Prefix	Cold impact test indicator	Cold bend test indicator
–25	LT	D	D
–40	LT	G	G
–45	LT	H	H
–50	LT	I	I

Nexans ELECTRIFY THE FUTURE

* Table 25 from CSA C68.5

Other Installation Considerations

Some of the previously mentioned installation types require the pulling of cable into conduit or trays.

These installations require careful planning and execution.

Nexans recommends that, wherever possible, cables be pulled by means of the conductors, aided with a basket-type grip over the inner jacket, armour and outer jacket (if present). This ensures all cable components are pulled as a unit.

Line pulling swivels may also be used to minimize the buildup of back twist.

Basket-type pulling grip

Line pulling swivel

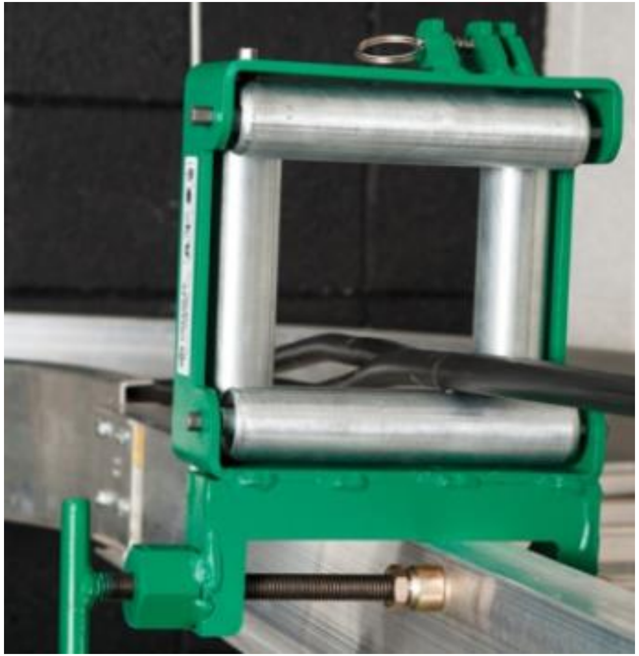
Nexans
ELECTRIFY THE FUTURE

Other Installation Considerations

For the installation of cable in trays, **rollers** are normally used.

Using well lubricated rollers and large radius sheaves at bends will result in a lower coefficient of dynamic friction when compared to duct.

For long pulls, with bends, it may be necessary to install assist pullers to reduce the risk of damage from excessive Sidewall Bearing Pressure (SWBP).



Nexans
ELECTRIFY THE FUTURE

Other Installation Considerations

Pulling Tension

The maximum pulling tension on a cable, where pulled by means of the conductor(s) using pulling eyes, should not exceed:

For copper conductors:
T_{max}= 70 x n x A

For aluminum conductors:
T_{max} = 50 x n x A

where:
T_{max} = maximum pulling tension when the copper conductors are under tension (N)

n = 1 for single conductor cable;
= 1.5 for 2c cable;
= 2 for 3c cable (triplexed);
= 3 for 4c cable; or
= The number of conductors multiplied by 0.8, rounded down to the nearest whole number, for cables with more than 4 conductors (ex. 4 for 5c cable, 4 for 6c cable, 5 for 7c cable).

A = cross-sectional area of one conductor (mm2)

Nexans
ELECTRIFY THE FUTURE

Pulling Tension in Duct Calculation

The tension resulting from a given duct installation is calculated as follows:

a. Tension developed in a **straight** section:

$$T = 9.8 \times L \times W \times f$$

where:
T = pulling tension (N)
L = length of duct section (m)
W = linear mass of cable (kg / m)
f = coefficient of dynamic friction, typically, 0.35

b. Tension developed in a **bend**:

$$T = T_1 \times e^{fa}$$

where:
T = tension coming out of bend (N)
T_1 = tension at bend entrance (N)
e = 2.71828
f = coefficient of dynamic friction
a = angle of bend (radius)
e^{fa} = tension multiplier for bend angle and friction

Coefficient of Dynamic Friction with Lubricant

Duct Type	Conductor or Cable Outer Covering			
	PVC or Nylon		XLPE	
	One Cable Per Duct	Three Cables Per Duct	One Cable Per Duct	Three Cables Per Duct
PVC	0.50	0.60	0.40	0.60
PE	0.30	0.45	0.45	0.55
Fiber	0.40	0.45	0.30	0.65
Transite	0.70	0.70	0.70	0.70
Steel	0.65	0.65	0.60	0.65

Note: A coefficient of dynamic friction of 0.15 can be used when calculating pulling tension using rollers.

Nexans
ELECTRIFY THE FUTURE

Other Installation Considerations

Sidewall Bearing Pressure (SWBP)

Consideration must be given to SWBP when pulling cable through a bend. The SWBP is calculated as follows:

$$SWBP = \frac{T}{r}$$

where:

SWBP = sidewall bearing pressure (N/m)
T = pulling tension on cable end exiting bend (N)
r = radius of the conduit bend (m)

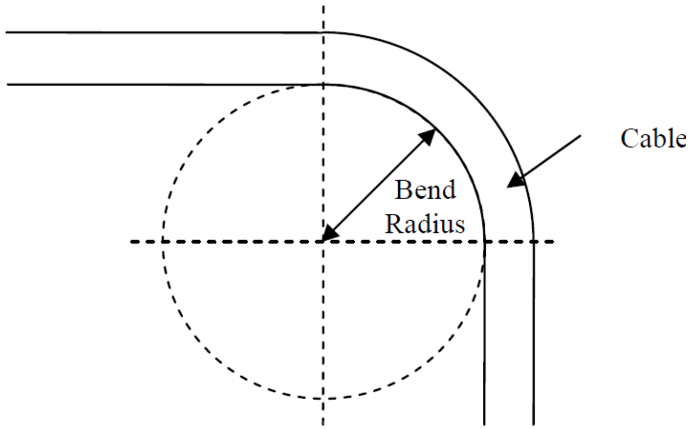
- For **unarmoured cables**, Nexans recommends a maximum SWBP of **7290 Newtons per meter** of bend radius (500 lbf/ft).
- For **interlocked armoured cables**, Nexans recommends a maximum SWBP of **4400 Newtons per meter** of bend radius (300 lbf/ft).
- For **corrugated aluminum sheath armoured cables**, Nexans recommends a maximum SWBP of **7290 Newtons per meter** of bend radius (500 lbf/ft).

Other Installation Considerations

Bend Radius

The smallest radius the cable is allowed to be bent around.

Measured from the inner surface of the cable at the bend



Bend Radius

During installation of the cable, it is recommended that the radius of bends be **1.5x** that of the minimum bending radius for the final training.

Minimum Bend Radius – Unarmoured Cables

Cable Type	Minimum Bend Radius			
	Overall Cable Diameter 25.4 mm (1") or Less		Overall Cable Diameter Greater than 25.4 mm (1")	
	Under Tension	Final Training	Under Tension	Final Training
CANADEX® or HEATEX® NMD90	6x	4x	7.5x	5x
SUPERVEX® NMWU	6x	4x	7.5x	5x
TW(-40C), TW75 and TWU(-40C)	6x	4x	7.5x	5x
INSTAGLIDE® T90 Nylon / TWN75	6x	4x	7.5x	5x
RW90 and RWU90	6x	4x	7.5x	5x
RPV90 and RPVU90	6x	4x	7.5x	5x

Minimum Bend Radius – Armoured Cables

Cable Type	Minimum Bend Radius	
	Under Tension	Final Training
AC90 and ISO-BX	10.5x	7x
ACWU90	10.5x	7x
FIREX®-II TECK90	10.5x	7x
CORFLEX® RA90	14x (sheath diameter)	9x (sheath diameter)
DRIVERX® VFD RA90	14x (sheath diameter)	9x (sheath diameter)

Note: The minimum bending radius factor is applied to the overall cable diameter unless otherwise stated. These values are based on NEMA WC70, WC71, and the Canadian Electrical Code (CSA C22.1)

Nexans
ELECTRIFY THE FUTURE

Field Testing Cables

- 4 main types of tests for wire and cable :
  1. Type test / qualification test / conformance test
  2. Factory test
  3. Installation test
  4. Maintenance test

"Field Testing" falls under these two. Will only discuss #3 in today's presentation.

- Field tests should be made as soon as possible after installation
- Only qualified persons should perform field testing
- Before applying test voltages, the cable being tested must be disconnected completely from all other equipment

Nexans
ELECTRIFY THE FUTURE

Field Testing Cables

We will discuss two main types of installation tests:

1. **LV cable insulation resistance tests**
    a. for voltages < 5 kV

2. **MV cable insulation resistance tests (also called dielectric withstand tests)**
    a. for voltages between 5 – 69 kV

Other types of field tests: (discussed in the next presentation)

i. Very low frequency tests (VLF)
ii. Tan delta
iii. Partial discharge tests (PD)

Insulation Resistance (IR) Test

- Test performed on low voltage cables (rated < 5kV)
- Commonly referred to as “megger” or “Go / No Go” test
- The minimum acceptable insulation resistance value is calculated using the following formula:

$$R_{Insulation} = (V_{Rated} + 1) \bullet \left(\frac{304.8}{L} \right)$$

Where:

$R_{Insulation}$ is the minimum acceptable insulation resistance value, in mega-ohms;

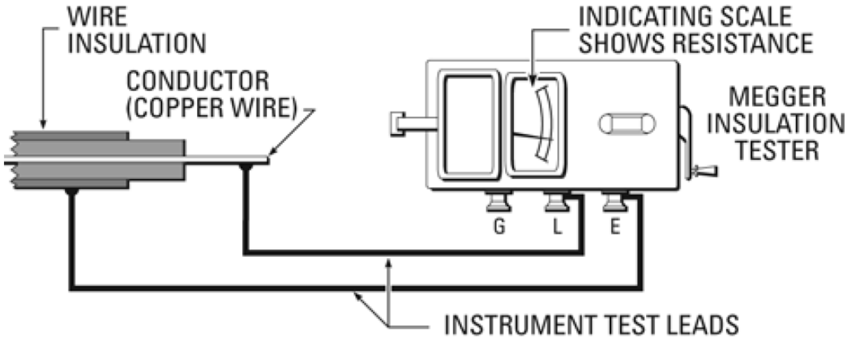
V_{Rated} is the rated voltage of the cable (typically printed on the cable), in kilovolts; and

L is the length of the cable, in meters (if the cable length is in feet, replace the number 304.8 with 1000).

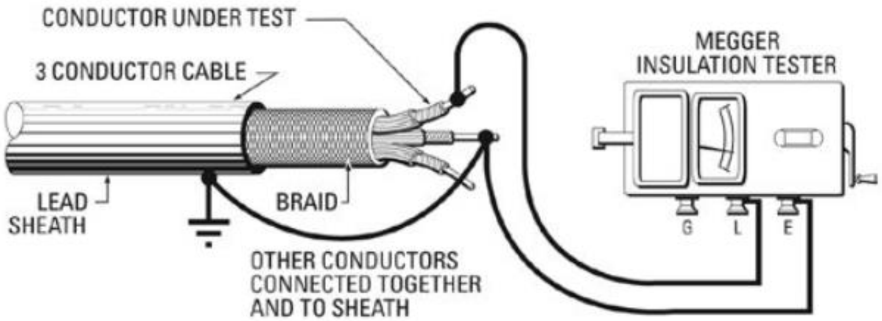
Nexans
ELECTRIFY THE FUTURE

IR Test – Typical Set-up

Single conductor cable



Three conductor cable



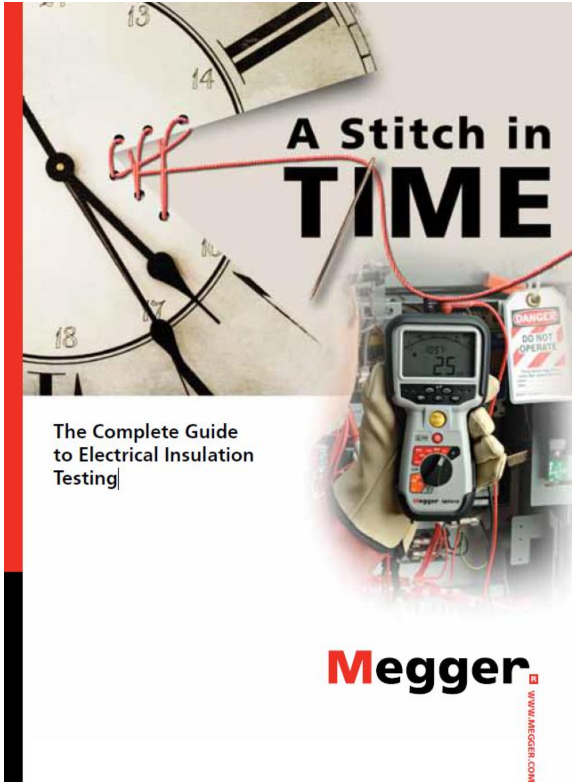
Nexans
ELECTRIFY THE FUTURE

IR Test – Megger

Megger's **The Complete Guide to Electrical Insulation Testing** is a good reference.

You can download it [here]

If you have specific questions about your installation, do not hesitate to contact your cable's manufacturer.

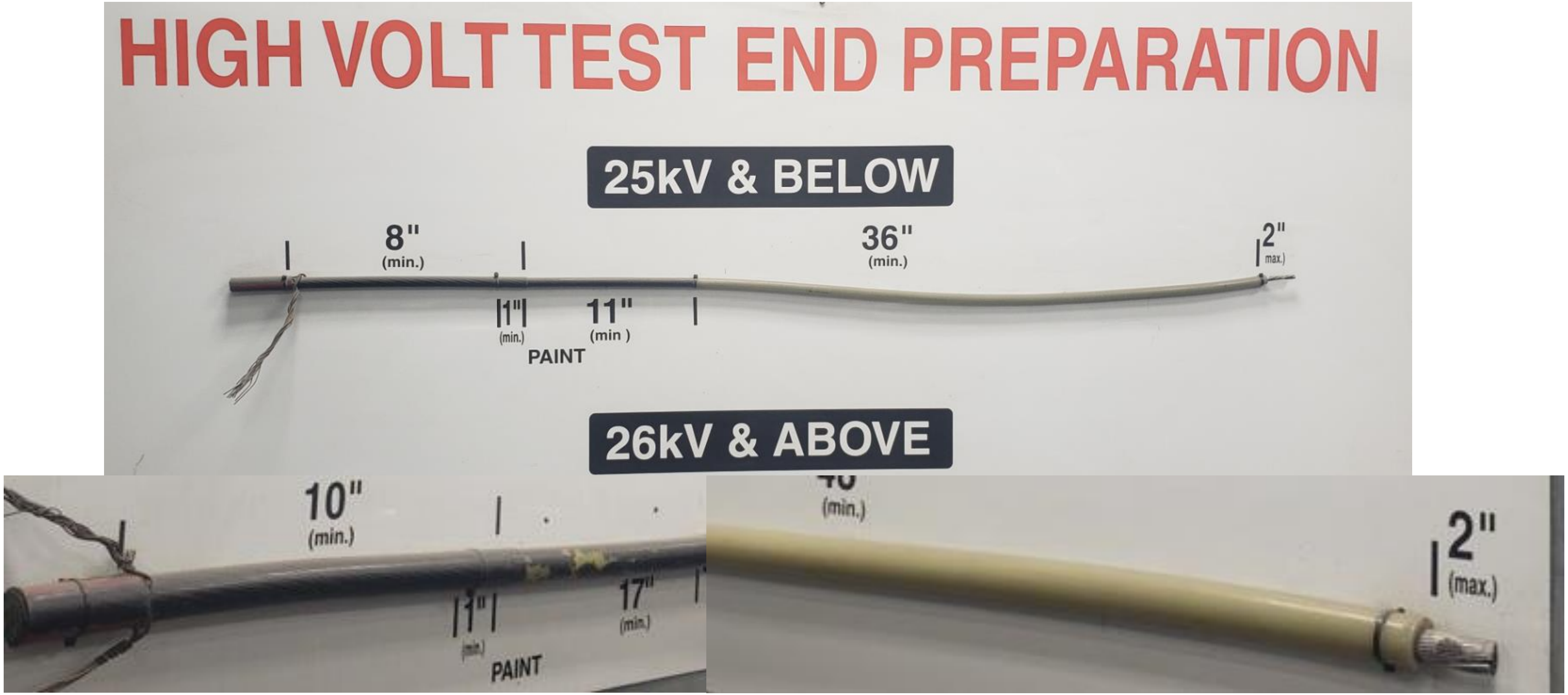


High Potential DC Test

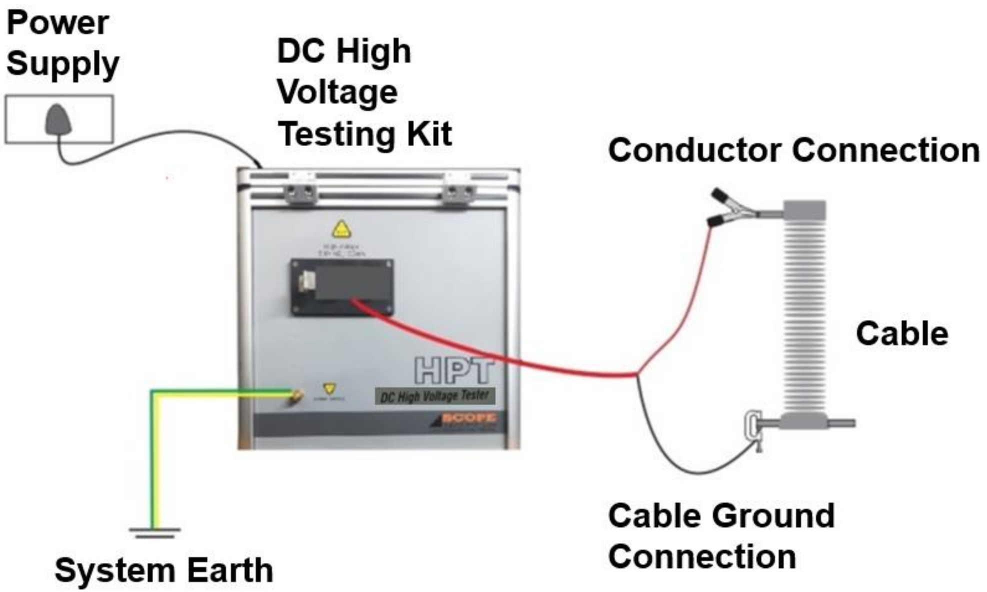
- Test performed on medium voltage cables (rated 5 – 69 kV)
- Commonly referred to as “DC Hipot” test
- Involves applying an overvoltage to the cable system for a short duration to verify the dielectric integrity of the system.
- In most cases, it is a pass/fail test.
- A DC Hipot testing unit is:
  - Easy to control
  - Provides accurate leakage data
  - Small & lightweight

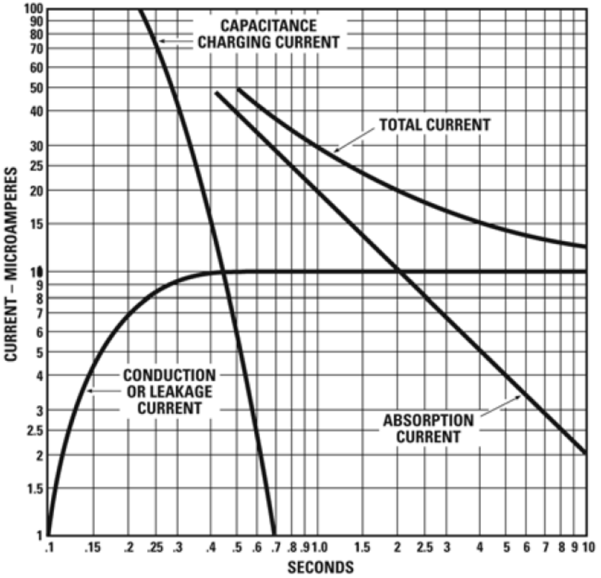
Nexans
ELECTRIFY THE FUTURE

DC Hipot – Cable Ends Prep



DC Hipot – Typical Set-up





Components of current measured during DC testing of insulation.

DC Hipot Test: Key Points

- Applied to reveal gross problems such as improperly installed accessories or mechanical damage
- Not expected to reveal deterioration due to aging in service
- DC leakage can be affected by external factors such as heat, humidity, wind, and water level if unshielded and in ducts or conduits

For more information, refer to IEEE 400 - *Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5kV and above*

Field Testing

There continues to be much debate in the industry on what test methods and equipment are the best.

Ultimately, it comes down to:

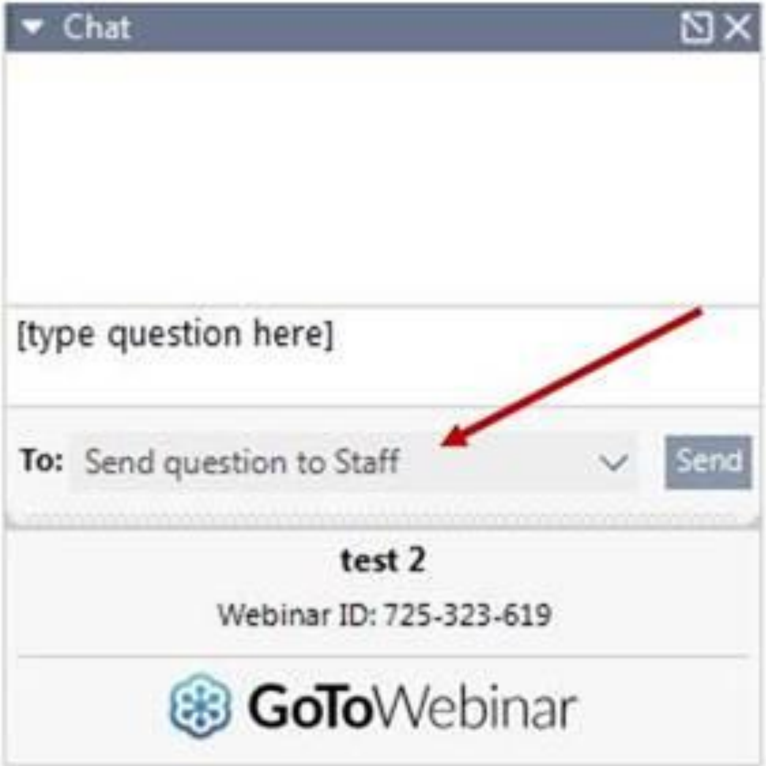
- what cable types are being tested
- what the voltage level is
- what information you are trying to obtain.

Key Takeaways

1. Discussed the different standards and industry guides that govern the installation of cable.
2. Discussed 4 types of cable installation methods
    a. Concealed/Exposed
    b. Raceways
    c. Cable Tray
    d. Low Temperature
3. Reviewed the factors that need to be considered to make these installations safe, efficient, and compliant.
4. Discussed 2 types of field installation testing
    a. LV - Insulation resistance
    b. MV – High Potential DC

Nexans

Q & A


Chat
[type question here]
To: Send question to Staff
Send
test 2
Webinar ID: 725-323-619
GoToWebinar

Contact:

Wissam Geahchan
Applications Engineer, Nexans Canada
wissam.geahchan@nexans.com

www.nexans.ca

Nexans
ELECTRIFY THE FUTURE