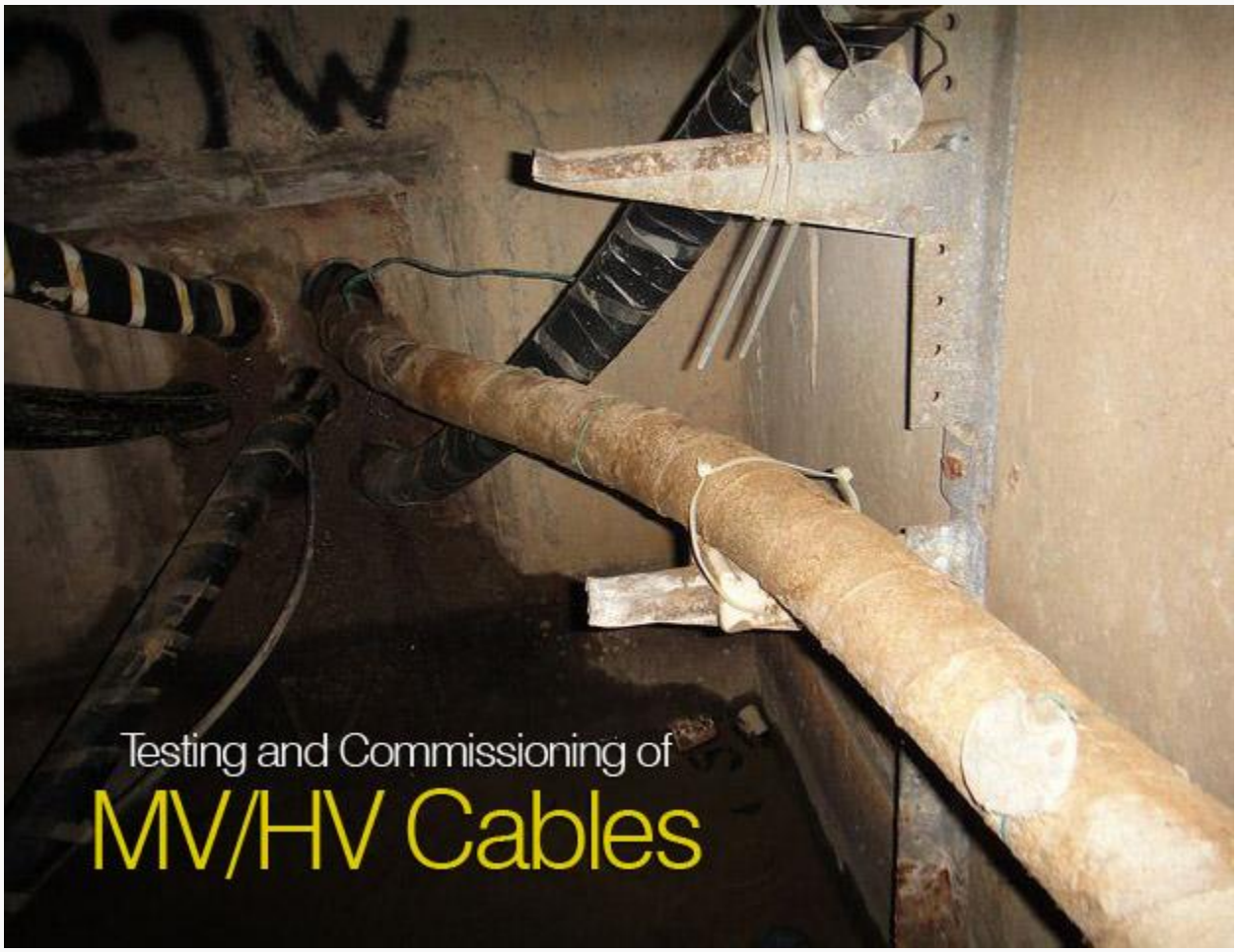
Testing and Commissioning of MV/HV Cables



Example of asbestos paper insulation wrap on high-voltage cable inside an underground cable vault. Several layers of the soft and friable insulation are wrapped around the cable in long, wide strips. Originally, pure white, the discoloration is from sediment mud after formerly being submerged in the once flooded vault; some water leakage is still present.

1. Visual and Mechanical Inspection

1. Compare **cable data** with drawings and specifications.
2. Inspect exposed sections of cables for ***physical damage***.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1. Use of a low-resistance ohmmeter in accordance with ***Section 1.2*** above.
    2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or ***Table 100.12***.

3. Perform a ***thermographic survey***.
   (***NOTE:*** Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.)
4. Inspect compression-applied connectors for correct cable match and indentation.
5. Inspect shield grounding, cablesupports, and terminations.
6. Verify that visible cable bends meet or exceed ICEA and manufacturer's minimum published bending radius.
7. Inspect fireproofing in common cable areas. (**)
8. If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
9. Inspect for correct identification and arrangements.
10. Inspect cable jacket and **insulation condition**.

***** Optional test***

2. Electrical Tests

1. Perform ***resistance measurements*** through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with ***Section 1.1***.
2. Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use ***Table 100.1***.
3. Perform a ***shield-continuity test*** on each power cable.
4. In accordance with ***ICEA, IEC, IEEE*** and other power cable consensus standards, testing can be performed by means of direct current, power frequency alternating current, or very low frequency alternating current. These sources may be used to perform**insulation-withstand tests**, and baseline diagnostic tests suchas partial discharge analysis, and power factor or dissipation factor. The selection shall be made after an evaluation of the available test methods and a review of the installed cable system.

   Some ofthe available test methods are listed below:

   1. ***Dielectric Withstand:***
      1. Direct current (DC) dielectric withstand voltage
      2. Very low frequency (VLF) dielectric withstand voltage
      3. Power frequency (50/60 Hz) dielectric withstand voltage
   2. ***Baseline Diagnostic Tests:***
      1. ***Power factor/ dissipation factor (tan delta):***
         1. Power frequency (50/60 Hz)
         2. Very low frequency (VLF)
      2. ***DC insulation resistance:***
      3. ***Off-line partial discharge:***

1. Power frequency (50/60 Hz)
2. Very low frequency (VLF)

3. Test Values

3.1 Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by ***more than 50 percent of the lowest value***.
2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use ***Table 100.12***.
3. Results of the thermographic survey.
   (***NOTE:*** Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.)
4. The minimum ***bend radius*** to which insulated cables may be bent for permanent training shall be in accordance with ***Table 100.22***.

3.2 Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use ***Table 100.1***.Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
3. Shielding shall exhibit continuity. Investigate **resistance values** in excess of ***ten ohms per 1000 feet of cable***.
4. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
5. Based on the test methodology chosen, refer to applicable standards or manufacturer's literature for acceptable values.

Tables

Table 100.12.1

Bolt-Torque Values for Electrical Connections

- US Standard Fasteners (a)
- Heat-Treated Steel – Cadmium or Zinc Plated (b)

Grade	SAE 1&2	SAE 5	SAE 7	SAE 8
Head Marking				
Minimum Tensile (Strength) (lbf/in^2)	64K	105K	133K	150K
Bolt Diameter (Inches)	**Torque (Pound-Feet)**			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

Table 100.12.1 - Bolt-Torque Values for Electrical Connections

a) Consult manufacturer for equipment supplied with metric fasteners.
b) Table is based on national coarse thread pitch.

Table 100.12.2

- US Standard Fasteners (a)
- Silicon Bronze Fasteners (b, c)

Torque (Pound-Feet)

Bolt Diameter (Inches)	Nonlubricated	Lubricated
5/16	15	10
3/8	20	15
1/2	40	25
5/8	55	40
3/4	70	60

Torque (Pound-Feet)

a) Consult manufacturer for equipment supplied with metric fasteners.
b) Table is based on national coarse thread pitch.
c) This table is based on bronze alloy bolts having a minimum tensile strength of 70,000 pounds per square inch.

Table 100.12.3

- US Standard Fasteners (a)
- Aluminum Alloy Fasteners (b, c)

Torque (Pound-Feet)

Bolt Diameter (Inches)	Lubricated
5/16	10
3/8	14
1/2	25
5/8	40
3/4	60

Torque (Pound-Feet) - Aluminum Alloy Fasteners

a) Consult manufacturer for equipment supplied with metric fasteners.
b) Table is based on national coarse thread pitch.
c) This table is based on aluminum alloy bolts having a minimum tensile strength of 55,000 pounds per
square inch.

Table 100.12.4

- US Standard Fasteners (a)
- Stainless Steel Fasteners (b, c)

Torque (Pound-Feet)

Bolt Diameter (Inches)	Uncoated
5/16	15
3/8	20
1/2	40
5/8	55
3/4	70

Torque (Pound-Feet) - Stainless Steel Fasteners

a) Consult manufacturer for equipment supplied with metric fasteners.
b) Table is based on national coarse thread pitch.
c) This table is to be used for the following hardware types:

- Bolts, cap screws, nuts, flat washers, locknuts (18-8 alloy)
- Belleville washers (302 alloy).

Tables in 100.12 are compiled from Penn-Union Catalogue and Square D Company, Anderson Products Division, General Catalog: Class 3910 Distribution Technical Data, Class 3930 Reference Data Substation Connector Products.

Table 100.1

Insulation Resistance Test Values Electrical Apparatus and Systems

Nominal Rating of Equipment in Volts	Minimum Test Voltage, DC	Recommended Minimum Insulation Resistance in Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

Table 100.1 - Insulation Resistance Test Values Electrical Apparatus and Systems

In the absence of consensus standards dealing with insulation-resistance tests, the Standards Review Council suggests the above representative values. Test results are dependent on the temperature of the insulating material and the humidity of the surrounding environment at the time of the test.

Insulation-resistance test data may be used to establish a trending pattern. Deviations from the baseline information permit evaluation of the insulation.

Table 100.22

Minimum Radii for Power Cable

Single and Multiple Conductor Cables with Interlocked Armor, Smooth or Corrugated Aluminum Sheath or Lead Sheath

Cable Type	Overall Diameter of Cable					
	inches 0.75 & less	mm 190 & less	inches 0.76 to 1.50	mm 191 to 381	inches 1.51 & larger	mm 382 & larger
	Minimum Bending Radius as a Multiple of Cable Diameter					
Smooth Aluminum Sheath Single Conductor Nonshielded, Multiple Conductor or Multiplexed, with Individually Shielded Conductors	10		12		15	
Single Conductor Shielded	12		12		15	
Multiple Conductor or Multiplexed, with Overall Shield	12		12		15	
Interlocked Armor or Corrugated Aluminum Sheath Nonshielded	7		7		7	
Multiple Conductor with Individually Shielded Conductor	12/7 [a]		12/7 [a]		12/7 [a]	
Multiple Conductor with Overall Shield	12		12		12	
Lead Sheath	12		12		12	

Table 100.22 - Minimum Radii for Power Cable

ANSI/ICEA S-93-639/NEMA WC 74-2000, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy, Appendix I – Recommended Bending Radii for Cables and Table I1 – Minimum Radii for Power Cable.

a. 12 x individual shielded conductor diameter, or 7 x overall cable diameter, whichever is greater.

Resource: *STANDARD FOR ACCEPTANCE TESTING SPECIFICATIONS for Electrical Power Equipment and Systems (NETA 2009)*

Source:

http://electrical-engineering-portal.com/testing-and-commissioning-of-mvhv-cables