



Design Standard

Medium Voltage Power Systems

Detailed specifications follow.

PART 1 MEDIUM-VOLTAGE CABLE

1.1 Shielded MV105 Cable

- A. Provide medium-voltage shielded power cables that are NTRL-listed as Type MV105 for use in raceways, trays, underground ductbanks, manholes, vaults, and within switchgear and equipment of sufficient interior dimensions to allow for the proper bending & and termination of shielded cables.
- B. Comply with the NEC®, IEEE C2™, ICEA S-93-639 / NEMA WC-74, and UL 1072.
- C. Select voltage ratings for power cables and terminations based on the operating voltage of the medium-voltage distribution system as follows:

Distribution System Operating Voltage	Power Cable Nominal Voltage Rating
4,160 volts	5kV
5,000 volts to 15,000 volts	15kV
25,000 volts	25kV
35,000 volts	35kV

- D. Specification
 - 1. Conductor: Single uncoated annealed copper conductor with Class B stranding. Aluminum conductors may be allowed in some circumstances with prior UES approval. If aluminum is approved standard sizes below shall be increased to meet equal or greater ampacity.
 - 2. Strand Screen: Extruded semi-conducting ethylene-propylene rubber (EPR).
 - 3. Insulation: 133% EPR 140 mils thick for 5kV & 220 mils for 15kV.
 - 4. Insulation Screen: Extruded semi-conducting thermoset (TS) EPR.
 - 5. Shielding: Copper tape 5 mils thick helically applied with a minimum of 12.5% overlap.
 - 6. Jacket: Sun Resistant PVC
 - 7. Continuous Operating Temperature: 90°C
Note: Operating temperature is limited to 90°C because PVC power ducts are listed for 90°C conductors.
 - 8. Emergency Temperature Rating: 105°C
 - 9. Short-Circuit Rating: 250°C
 - 10. Conductor Sizes (for 15kV copper conductor only): AWG Nos. 1, 1/0, 4/0, &



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500kcmil. Feeders from between 15 kV Switches shall be minimum 500kcmil

1.2 Non-shielded MV105 Power Cable

- A. Use non-shielded medium-voltage power cables only for short jumpers within switchgear or transformer enclosures where it is not feasible to install shielded cables due to inadequate space for bending or terminating shielded cables.
- B. Use non-shielded medium-voltage transformer cable with 133% EPR/140 mils thick for 5kV and 133% EPR/220 mils thick for 15kV insulation, Sun Resistant PVC Jacket.
- C. Conductor AWG Sizes (for 15kV only): 1, 1/0, 4/0, & 500kcmil.
- D. Obtain approval from the Owner for each installation of non-shielded medium-voltage cable
- E. Acceptable Manufacturers:
 - 1. General Cable Prysium
 - 2. Okonite
 - 3. Southwire

1.3 Medium-Voltage Cable Terminations

- A. Terminating materials must be compatible with the cable supplied.
- B. Submit proof of the acceptability by the cable manufacturer of any splicing or terminating materials.
- C. Separable Insulated Connectors: Specify pre-molded EPDM-type, submersible, fully shielded, separable insulated connectors for use with MV105 power cable as specified above. Connector system components shall comply with IEEE Std 386, *Separable Insulated Connector Systems for Power Distribution Systems Above 600V*.
- D. Match voltage-class ratings of cable at 5kV, 15kV, or 25kV voltage-class. Provide 200A-rated load break elbow connectors for outdoor terminations at medium-voltage transformers and switchgear with switch-ways rated at 200A continuous, and 600A-rated dead break elbow connectors for terminations at medium-voltage switchgear with switch-ways rated at 600A continuous.
- E. Indoor Terminators: Silicone rubber, cold shrink, tubular or skirted.
- F. Outdoor Terminator: Silicone rubber, cold shrink, skirted.
- G. Acceptable Manufacturers:
 - 1. Elastimold
 - 2. RTE
 - 3. 3M

1.4 Medium-Voltage Cable Testing

- A. Upon completion of the installation, the Owner shall secure and pay for the services of a qualified, independent testing firm to conduct a test of all medium-voltage cable, including



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- terminations, as part of the electrical acceptance test project phase.
- B. The testing firm shall perform a high-potential proof test using a non-destructible DC testing device such as a “Kenotron” Westinghouse “High-Pot Tester,” or approved equal, capable of generating approximately 100,000 VDC under normal leakage conditions of acceptable cable.
 - C. All cables shall be tested in place with all splices and pothead terminations made up but not connected to switchgear or any other equipment, load device, or dead-end seal. Cables with dead-end seals shall be temporarily opened and then re- sealed.
 - D. In case of failure during the test, the Contractor shall locate the faulty splice, termination, or cable section and notify the Owner before making any repairs.
 - E. The testing firm shall submit to the Project A/E five copies of all test reports for review by the Engineer-of-Record. Should the test reports indicate, in the opinion of the Owner, that the condition of the new cable is unsatisfactory, the Contractor shall make all repairs and/or replacements to the satisfaction of and no additional cost to the Owner.
 - F. Additional tests using the same testing firm shall also be made at the Contractor’s expense on all repaired sections.
 - G. The Owner will not accept any cable installations until satisfactory certified proof test reports are obtained.

PART 2 RACEWAY SYSTEMS FOR MEDIUM-VOLTAGE CABLES

2.1 Design Guidance

- A. Perform calculations to determine pulling tensions and sidewall pressures for all duct or conduit runs of medium-voltage power cable.
- B. Design raceway systems so that the calculated pulling tensions and sidewall pressures will not exceed the cable manufacturer’s recommendations
- C. Lacking manufacturer’s recommendations use the following maximum values:
 - 1. Cable tension:
 - a. 0.008 lb./cmil for up to 3 conductors, not to exceed 10,000 pounds.
 - b. 0.0064 lb./cmil for more than 3 conductors, not to exceed 10,000 pounds.
 - c. 1000 lbs. per basket grip
 - 2. Sidewall pressure: 500 lbs./ft
- D. The maximum length of raceways between cable pulling points shall be the lesser of 400 feet or a maximum of 90° in total horizontal bends between cable pulling points.

2.2 Above ground Installations

- A. Within the perimeter of buildings, install aboveground medium-voltage cables in rigid metal conduit.
- B. In areas protected with fire sprinklers, terminate conduits entering equipment enclosures



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from above with water sealing fittings.

- C. Install voltage markers on all conduits containing medium-voltage cables.

PART 3 MEDIUM-VOLTAGE SWITCHGEAR

3.1 Design Criteria

- A. For facility-level medium-voltage switchgear lineups and unit substation switchgear, provide metal-enclosed interrupter switchgear conforming to IEEE C37.20.3, Standard for Metal-Enclosed Switchgear, with current-limiting E-rated power fuses conforming to IEEE C37.46, Standard Specifications for Power Fuses and Fuse Disconnecting Switches.
- B. For facility-level medium-voltage switchgear applications that either exceed the current capacity of fused equipment or require complex or high-speed switching operations, use metal-clad switchgear with vacuum circuit breakers conforming to:
 - 1. IEEE C37.20.2, *Standard for Metal-Clad and Station-Type Cubicle Switchgear*
 - 2. IEEE C37.04, *Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*
 - 3. ANSI C37.06, *Standard for Switchgear – AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities* IEEE C37.09, *Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*
- C. Provide 5kV medium-voltage switchgear having the following minimum ratings:
 - 1. 60Hz one-minute withstand voltage at mean sea level: 22kV; this rating may be obtained through insulation coordination with surge arresters.
 - 2. BIL at mean sea level: 75kV; this rating may be obtained through insulation coordination with surge arresters.
 - 3. Short-circuit rating: Greater than the available short-circuit current.
- D. Provide 15kV-class medium-voltage switchgear with the following minimum ratings:
 - 1. 60Hz one-minute withstand voltage: 42kV at mean sea level; this rating may be obtained through insulation coordination with surge arresters.
 - 2. BIL at mean sea level: 95kV; this rating may be obtained through insulation coordination with surge arresters.
 - 3. Short-circuit rating: Provide equipment with a short-circuit rating greater than the available short-circuit current and not less than 25kA RMS symmetrical.
- E. Provide intermediate-class, metal-oxide surge arresters in 15kV-class medium-voltage switchgear conforming to IEEE Std C62.11, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits*. Apply arresters in accordance with IEEE Std C62.22-1991, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems* or as recommended by the arrester manufacturer.
- F. Switchgear shall come complete from manufacture with controls. All breaker Remote controls shall be wired to relay to support remote breaker control. Relay shall be model currently in use on campus and be fully compatible with campus SCADA for seamless



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integration. Controls shall include:

1. Statuses: Breaker Open, Breaker Closed, Breaker Racked in, in local, in remote, Bus 86 tripped, Trip coil monitor.
2. Remote Controls: Open Breaker, Close Breaker
3. Local Controls: Open Breaker, Close Breaker, Local/Remote switch (43)
4. Local/Remote Switch shall completely disable remote controls while in local and completely disable Local controls while in remote, Local/Remote Switch shall not block trips from breaker.
5. All relays shall be wired to common Communication and programmable control hub. Such as an SEL RTAC. Communication hub shall be model currently in use on campus and be fully compatible with campus SCADA.

PART 4 OUTDOOR MEDIUM-VOLTAGE PAD MOUNTED SWITCHGEAR

4.1 All 15kV switches shall meet either “15kv Switches - Pad Mounted” or “15kv Switches – Underground” Texas A&M UES’ standards.

4.2 Pad Mount Switches

A. Description

1. For purposes of this Section, “padmount switches” are understood to consist of a single self-supporting enclosure containing interrupter switches.
2. Padmount switches are restricted to outdoor use. A padmount switch may include power fuses and accessory compartments.

B. Application

1. Padmount switches are typically used for sectionalizing applications in the medium-voltage distribution system.

Note: Within the limitations of their current-carrying capability, interrupting duty and available configurations, padmount switches typically offer the lowest-cost switching solution.

2. Install padmount switches atop or immediately adjacent to manholes.
3. Route cables to padmount switches through manholes.
4. Pre-cast, concrete vaults with 18” minimum depth shall be used as vault foundations. Vault foundations shall include ground ring around interior wall of vault, as well as two 3/4” diameter 10’ long ground rods.

C. Clearances

1. Design installations of padmount switches to permit maintenance access.
2. Design the installation of padmount switches to ensure 10 feet of clear working space in front of the switch enclosure doors for the full width of the enclosure

Note: In areas where vehicle parking may be possible, bollards, curbs or other structures should be installed to keep vehicles out of the working space. The sides of switches without doors or auxiliary compartments containing electrical control or instrumentation devices do not need working space greater than 30 inches for



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personnel access. For switches with side-mounted accessories such as fuse storage compartments or crank-type switch operators, this access space is to be measured from the outer face of the accessory or the end of the crank handle.

3. Auxiliary compartments with electrical control or instrumentation devices must be provided with working space in conformance with NESC Rule 125

PART 5 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

5.1 5.1 Description

- A. For purposes of this Section, “metal-enclosed interrupter switchgear” is understood to be equipment consisting of interrupter switches housed in individual steel compartments. Switching devices are fixed (not draw out). Busses are typically exposed when the compartment door is open. The switchgear may include fuses, sensing and metering devices and control equipment, but not power circuit breakers.
- B. Metal-enclosed interrupter switchgear is available with enclosures suitable for indoor or outdoor installation.
- C. Metal-enclosed interrupter switchgear shall be manufactured in accordance with IEEE C37.20.3.

5.2 5.2 Application

- A. Metal-enclosed interrupter switchgear differs from padmount switches in its higher continuous current and interrupting rating, and wider availability of custom features. Metal-enclosed interrupter switchgear is commonly used as the primary disconnecting means for unit substations.
- B. For application of metal-enclosed interrupter switchgear, consultation with the equipment vendors is recommended.
- C. Manufacturers’ ratings do not take into consideration the effect of solar radiation on metal-enclosed interrupter switchgear installed outdoors. Use IEEE Standard C37.24 to calculate the derating of the continuous current rating of switchgear exposed to the sun.

PART 6 METAL-CLAD SWITCHGEAR

6.1 Description

- A. For purposes of this Section, “metal-clad switchgear” is understood to be equipment consisting of individual steel compartments with draw-out switching devices. Switching devices may be load-break interrupter switches or power circuit breakers. The switchgear may include fuses, sensing and metering devices and control equipment.
- B. Metal-clad switchgear is available with enclosures suitable for indoor or outdoor



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installation.

- C. Metal-clad switchgear shall be manufactured in accordance with IEEE C37.20.2.

6.2 Equipment

- A. Specify Powell Power/Vac vacuum metal-clad circuit breaker elements for use on
- B. 15kV-class systems.

Note: The requirement for GE Power/VAC equipment is not intended to unreasonably limit the market for the supply of switchgear equipment. The limitation extends only to the interrupter devices (the vacuum bottles) and the removable circuit breaker mechanism (the breaker” truck”). The switchgear control systems, buswork, and enclosures may be assembled by a qualified fabricator other than General Electric.

6.3 Application

- A. Metal-clad offers the most flexible means of control and protection for power systems. Sophisticated protective relay schemes are readily applied to metal-clad switchgear. Of the three available types of switchgear, metal-clad is the most expensive.
- B. For application of metal-enclosed interrupter switchgear, consultation with the equipment vendors is recommended.
- C. Specify outdoor installations of metal-clad switchgear with walk-in aisle-type enclosures.
- D. Provide ventilation (and air conditioning if required) as necessary to ensure that interior temperatures do not exceed 95°F.
- E. Manufacturers’ continuous current ratings do not take into consideration the effect of solar radiation on metal-clad switchgear installed outdoors. Use IEEE Standard C37.24 to calculate the derating of the continuous current rating of switchgear exposed to the sun.

PART 7 MEDIUM-VOLTAGE TRANSFORMERS

- 7.1 Specify dry-type units for locations inside the building and oil-filled pad mounted-type units for locations outdoors.

- A. Only the use of new copper wound, loop fed transformers are permitted for use in the 12.5kV Texas A&M electrical distribution (aluminum wound transformers are not acceptable for use).
- B. Transformer Capacity: Base transformer capacity on load calculations per the requirements in NEC[®] and this Chapter and loading guidance in the following IEEE standards as applicable:
 1. IEEE C57.91-1981, *Guide for Loading Mineral-Oil-Immersed Overhead and Pad-Mounted Distribution Transformers Rated 500 kVA and Less with 65°C or 55°C Average Winding Rise.*
 2. IEEE C57-92-1981, *Guide for Loading Mineral-Oil-Immersed Overhead and Pad-Mounted Distribution Transformers Up to and Including 100 MVA with 65°C or 55°C*



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Average Winding Rise.

3. IEEE C57-91-1995, *Guide for Loading Mineral-Oil-Immersed Transformers.*
4. IEEE C57.96, *Guide for Loading Dry-Type Distribution and Power Transformers.*

Note: The IEEE C57-91-1995 Guide combines the data previously issued in the IEEE Guides C57.91-1981, C57.92-1981, and C57.115-1991 (re-designated as Std. 756). It also updates the data and presents equations that approximate the empirical data previously presented in tabular form. The designer may apply either method.

- C. All transformer shall come with complete set of “Routine Test” from manufacture as listed in IEEE C57 and sub standards, Transformers shall also be tested on site to NETA standards with the exceptions and additions as follows:
1. Outdoor Padmount transformers shall be proof tested using high potential test to manufactures standards.
 2. Outdoor Padmount transformers shall not need Oil sample test provided, transform comes sealed from manufacture with oil test report, and seal remains intact.
 3. Outdoor Padmount transformers shall not need power factor test provided, test comes from manufacture and transformer has not sustained any damage between test and commissioning.
 4. All testing shall be with equipment list for test and equipment with current certified calibrations.
All testing shall be schedule minimum 14 days prior to, and all allowances made so as to be witness tested by Texas A&M or appointed agency.

7.2 Indoor Dry-Type Medium-Voltage Transformers

- A. Use dry-type transformers conforming to IEEE Std C57.12.01, Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings, where liquid containment is not practical. Use dry-type transformers having an 80°C winding temperature rise over a 30°C average, 40°C maximum ambient. Use cast epoxy resin transformers to serve critical loads or where the transformer is in a dirty environment. Use vacuum pressure impregnated or cast epoxy resin transformers to serve non-critical loads and where the transformer is in a clean environment. Specify copper windings only.
- B. Install medium-voltage dry-type transformers indoors only.
- C. Install indoor transformers in vaults or rooms with a fire-resistance rating of not less than 2 hour.
- D. Doors in transformer vaults or rooms shall be fire-rated and swing outward in the direction of egress.
1. Equip doors with panic hardware.
 2. Fire rating of doors shall match fire rating of room or vault.
 3. Provide door opening adequate for moving largest equipment in the room or vault.
- E. Locate transformers a minimum of 36 inches from building walls.
- F. Provide ionization type smoke detectors and automatic sprinkler protection for indoor



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medium-voltage transformer vaults or rooms. Connect ionization-type smoke detectors to the building fire alarm system.

- G. Provide automatic sprinkler protection system with a discharge density of not less than 0.20 gpm/sq. ft. over floor area of the transformer vaults, rooms, or spaces.
- H. Provide mechanical cooling or ventilation powered from a reliable source to maintain transformer vaults or rooms within temperature limits appropriate for transformer operation.
- I. Provide power ventilation system from an emergency or standby power source if available.
- J. Specify primary overcurrent protection devices to provide through-fault protection of transformer in accordance with IEEE Std 242™.
- K. Select distribution-class, gapless-type metal-oxide surge arresters for connection to the primary side of the transformer to provide additional protection against abnormally high voltage transients. Specify the maximum continuous operating voltage (MCOV) of the arrester according to its voltage-class rating. Apply arresters in accordance with IEEE Std C62.22, *IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems* or as recommended by the arrester manufacturer.

7.3 Outdoor Oil-Filled Pad Mounted Medium-Voltage Transformers

- A. Install oil-filled medium-voltage transformers outdoors only.
- B. Provide outdoor, pad-mounted, mineral oil-insulated, self-cooled medium-voltage transformers with integral dead-front loop-feed primary and live-front radial secondary cable terminating compartments. Windings shall be copper; aluminum windings are not acceptable.
- C. Transformers shall be designed, constructed, and tested in conformance with IEEE C57.12.22™, Requirements for Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers (High Voltage, 16340 Volts and Below; 2500 KVA and Smaller).
- D. Transformers shall be designed to operate at a 65 °C average winding temperature rise over a 30 °C average, 40 °C maximum ambient temperature.
- E. Furnish each transformer with the following accessories:
 - 1. Oil-immersed, load-break, bayonet fuse-holders with expulsion style fuses.
 - 2. Oil-submersible protector with current-limiting fuses rated for 50kAIC. Current-limiting fuses shall be placed in series with expulsion style fuses.
 - 3. Distribution-class, metal-oxide varistor elbow (MOVE) type surge arresters
 - 4. Two 2-1/2% above and two 2-1/2% below rated-voltage, full-current-rated for



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changing under no load. Include externally-mounted handle for tap-changer.

F. Acceptable Manufacturers

1. ABB
2. Cooper
3. Square D
4. GE

G. Installation

1. Design a concrete foundation for the transformer. If required, provide an oil-containment system integral to the foundation in accordance with EPA regulations.
2. Install in accordance with the NEC[®] and the Factory Mutual Insurance Company Loss Prevention Data Sheet 5-412.

H. Determining Transformer Capacity

1. Use the following loading factors to determine transformer capacity:
 - a. Average 24-hour ambient temperature
 - i. Use the highest historical average (mean) daily temperature recorded at the University campus or at a location nearest the campus for which accurate data are available, such as the nearest airport or city. This data may be obtained from the National Weather Service at <http://www.nws.noaa.gov> or other source with similar reliable and/or official data. Refer to the appropriate sections in the ANSI/IEEE standards referenced above for further guidance concerning the determination of ambient temperature for use in the selection of the "Peak Load Per Unit" or peak load factor presented in the series of tables in both publications.
 - ii. According to Weather.com, the highest 24-hour average temperature for College Station, TX (zip code 77843) is 30°C and occurred on August 4 and 5.
 - b. Elevation: Determine actual site elevation according to the United States Geological Survey (USGS) 1:25000 topographic map. The USGS website is at <http://www.usgs.gov>
 - c. Rated average winding temperature rise: 65°C per IEEE Standard C57.12.00-2006, Paragraph 5.11.1.1.
 - d. Transformers serving facilities having a significant daily load cycle may be operated with the peak load above the transformer nameplate rating as long as normal transformer life expectancy is maintained; refer to the IEEE transformer-loading guides listed above.
2. For single-ended services, the calculated load using the NEC[®] plus future load growth shall not exceed the calculated transformer self-cooled peak loading capability.

Example 1 – For building or facility located on a campus in College Station with a significant daily load cycle: 685kVA calculated load per the NEC[®] plus 137kVA



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future load growth of 20% = 822kVA.

3. Select a pad-mounted transformer with a standard base rating equal to or greater than
 $822\text{kVA}/1.68^* = 489\text{kVA}$, or 500kVA, and a 2-hour peak loading capability of approximately $500\text{kVA} \times 1.68^* = 840\text{kVA}$ based on Table 6 in IEEE C57.91-1981
 - a. The peak load factor (per unit) assuming an ambient temperature of 30°C.
 - b. Base the secondary service conductors on the 822kVA calculated load.
4. For double-ended services, the calculated closed-tie load using the NEC[®] plus future load growth shall not exceed the calculated forced-air cooled peak loading capability of either transformer.

PART 8 TESTING

- 8.1 All equipment shall be undergo a full NETA acceptance test. Test values of gear shall come from manufacture of equipment. Exceptions and alterations to test noted in this Standard shall apply.
 - A. Existing Cable – Where projects receive permission from UES to reuse existing primary cables, cable must be pass a retesting. See UES cable splicing SOP for further details.
 - B. Existing transformers – Where projects receive permission from UES to reuse existing transformers. Transformer must undergo full NETA test with no exceptions. If transformer is moved, even temporarily. a power factor test shall be perform prior to move and again before being reenergized.
 - C. Gear with buswork – All gear contain buss work, such as bus duct, switchgear, panelboards, resister and capacitor banks, etc. Shall at minimum have receive a 10% spot check of torque on all bolts of buss work. This is in addition to using the resistive test spelled out in NETA to verify buswork.