



# **FACILITY CONNECTION REQUIREMENTS**

**NERC TO-FAC-001-0**

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# FACILITY CONNECTION REQUIREMENTS

(NERC TO-FAC-001-0)

## ***Introduction***

This document describes the methodology Denton Municipal Electric (DME) presently uses to comply with the North American Electric Reliability Corporation (NERC) Facilities Design, Connections and Maintenance standard FAC-001-0. Facility connection and performance requirements are established to avoid adverse impacts on reliability. These requirements address connection requirements for generation facilities, transmission facilities, and end-user facilities.

## ***Procedures for Coordinated Joint Studies***

The following procedures apply to all three types of facilities:

- 1) generation facilities
- 2) transmission facilities
- 3) end-user facilities

DME is a member of the Electric Reliability Council of Texas (ERCOT). One of the many functions of the ERCOT is to coordinate joint studies of new facilities and their impacts on the interconnected transmission system. DME actively participates in this process.

## ***Procedures for Notification***

The following procedures apply to all three types of facilities:

- 1) generation facilities
- 2) transmission facilities
- 3) end-user facilities

Any additions or modifications to existing facilities that have the potential to affect a transmission interconnection require the customer to notify DME's Engineering Division well in advance. DME's Engineering Division will review documentation to study and assess the potential impact of the modifications, consult with DME's Operations Division, and then contact the appropriate affected parties. The significance of any impact has the potential to vary over a broad range. Changes that could affect the operating limits on the interconnected system may require engineering studies and the involvement of numerous ERCOT committees. The most significant impacts will trigger the joint study processes described in the previous heading. Less significant changes that still impact reliability will be forwarded to the ERCOT Reliability Coordinator. All potential interconnection Facility Connection inquiries shall be directed to Brent A. Heath, P.E. at [brent.heath@cityofdenton.com](mailto:brent.heath@cityofdenton.com) and Chuck Sears at [chuck.sears@cityofdenton.com](mailto:chuck.sears@cityofdenton.com). Additional contact information and requirements for interconnection facility connections are provided on DME's website, [www.dmepower.com](http://www.dmepower.com).

## ***Covers Generator, Transmission, and End-User***

It is the responsibility of the facility owner (customer) to provide all devices necessary to protect the customer's equipment from damage by abnormal conditions and operations that might occur on the interconnected power system. The facility owner shall protect its generator and associated equipment from overvoltage, undervoltage, overload, short circuits (including ground

fault conditions), open circuits, phase unbalance, phase reversal, surges from switching and lightning, off-nominal frequency conditions, and other injurious electrical conditions that may arise on the interconnected system. It is the responsibility of the facility owner to provide for the orderly re-energization and synchronizing of their high-voltage equipment to other parts of the electric system while providing electric utility industry accepted load protection operations. Appropriate operating procedures and equipment designs are needed to guard against out-of-sync closure or uncontrolled energization. Each owner is responsible to know and follow all applicable regulations, industry guidelines, safety requirements, and accepted practice for the design, operation and maintenance of the facility. DME shall be notified of all intended actions that have the potential of affecting DME's electrical system prior to the action occurring.

### ***Voltage Level, Voltage Support, MW and MVar Capacity or Demand***

The following requirement applies to all three types of facilities:

- 1) generation facilities
- 2) transmission facilities
- 3) end-user facilities

After the customer supplies DME with the approximate geographic location and the desired megawatt (MW) and megavolt-amp reactive (MVar) capacities at the point of interconnection, DME will exercise engineering judgment and the results of engineering studies to determine appropriate voltage levels, interconnection points, and system capabilities, since the most practical voltage and interconnection points are site and project-specific.

### ***Breaker Duty - Surge Protection***

All facilities and equipment must equal or exceed the fault duty capability necessary to meet system short-circuit requirements as determined through short-circuit analysis and should fully comply with the latest American National Standards Institute (ANSI)/Institute for Electrical and Electronics Engineers (IEEE) C37 collection of standards for circuit breakers, switchgear, substations, and fuses. In order to maintain transmission reliability, each fault-interrupting device must be rated for full fault-interrupting capability to satisfy the short-circuit level requirements at the point of interconnection. Full fault-interrupting capability is per the latest IEEE C37 and C57 collections of standards. As a general rule, neither party should depend on the other for the protection of their respective equipment.

## ***System Protection and Coordination***

### ***Generation, Transmission, and End-User Protective Relaying***

Protective relaying systems and associated communications systems for all facility interconnections shall be planned, designed, constructed, and maintained in accordance with applicable NERC, ERCOT and DME service standards. Utility grade protective relays and fault clearing systems are to be provided on the interconnected power system. All protective relays shall meet or exceed ANSI/IEEE Standard C37.90. Adjoining power systems may share a common zone of protection between two parties. The design must provide coordination of speed and sensitivity in order to maintain power system security, stability, and reliability. The protection system (relay, control, and communications equipment) arrangement selected by the

customer must be compatible with the protection system used by DME to protect the transmission grid. Compatible relaying equipment must be used for a given zone of protection. Compatibility includes protection application, redundancy, operating speed, communication type, and communication medium. A power source for tripping and control must be provided for the protection system by a DC storage battery. The battery is to be sized with enough capacity to operate all tripping devices after eight hours without a charger, per IEEE standards. An undervoltage alarm must be provided for remote monitoring by the facility owners, who shall take immediate action to restore power to the protective equipment. Mechanical and electrical logic and interlocking mechanisms are required between interconnected facilities to ensure safe and reliable operation. These include, but are not limited to, breaker and switch auxiliary contacts, synch-check relays, and physical locking devices. The facility owner (generator, transmission, and end-user) is responsible for providing a protection system that will protect its equipment against disturbances on DME's system and minimize the effects of disturbances from its facilities on DME's equipment and transmission system. Entities connecting to the DME transmission system shall investigate and keep a log of all protective relay actions and misoperations, as required by NERC and ERCOT. In addition, the interconnecting entities must have a maintenance program for their protection systems in accordance with ERCOT. Documentation of the protection maintenance program shall be supplied to DME, ERCOT, TRE or NERC upon request. As outlined in the maintenance program, test reports are to be made available for review by DME. At intervals described in the documented maintenance program and following any apparent malfunction of the protection equipment, the entity shall perform both calibration and functional trip tests of its protection equipment as outlined by ERCOT.

### ***Generator Protection Requirements***

Generators connecting to the DME transmission system are responsible for protecting those facilities from electrical faults and other hazardous conditions. Generator interconnections must be equipped with circuit breakers or other appropriate interrupting devices to protect those facilities. The generator owner must provide and own the primary circuit breaker or other interrupting device that protects the facility and disconnects it from the DME transmission system.

The primary purpose of this interrupting device is to protect the generating plant facility. Synchronous or wind turbine generators connected to the DME transmission system shall be able to withstand certain temporary excursions in voltage, frequency, reactive and real power output without tripping. A system impact study will determine if additional reactive devices are required to maintain the generation during the temporary excursions. Maintaining the generation is required to support the grid and avoid cascading events. Generation protection and control shall be set in accordance with all applicable NERC and ERCOT requirements to coordinate with excitation limiters.

It is recognized that certain circumstances may exist that necessitate the imposition of performance criteria that is considered more stringent than the default criteria specified above. Such circumstances shall be identified during the conduct of the System Impact Study or operational study for each particular generator.

## ***Transmission Protection Requirements***

All transmission power systems shall have a dual primary protective relaying scheme that provides backup coverage of the remote bus. Communications-aided tripping through the use of a dedicated communications channel may be required based on system stability determination. Communications redundancy may be required depending on critical clearing time. A transfer trip may be required for backup protection and islanding schemes. Backup protective systems should provide additional coverage for breaker and relay failure outside the primary zone. Specific breaker failure protection schemes shall be applied as required to meet NERC requirements, and, where local/remote backup does not provide adequate sensitivity or speed, specific relay failure backup shall also be provided. Backup systems shall operate for failures on either side of an interconnection point. Time and sensitivity coordination must be maintained to prevent misoperations. Fiber optics is the preferred means of relay communications. Each fault-interrupting device must be rated for full fault-interrupting capability to satisfy the short-circuit level requirements at the point of interconnection. Neither party shall depend on the other for the protection of their respective equipment.

## ***Metering and Telecommunications***

### ***Generation Energy Metering***

At the customer's expense, DME will specify, design, install, own, and maintain all metering and metering devices (including instrument transformers) used to measure the delivery and receipt of energy for payment purposes. Metering shall be required for each point of delivery at each point where customer facilities interconnect with DME facilities. Meter accuracy will be maintained within +/- 0.3%. DME will test meters on an annual schedule; the customer will receive notification of test scheduling and copies of test results upon request. Requests for additional unscheduled testing will be honored at the expense of the requester unless the meters are found to be out of tolerance.

### ***Generation Energy Metering Communications***

The customer, at its expense, shall provide and maintain a dedicated voice telephone extension at each point of delivery dedicated for the purpose of accessing DME's dial-up energy metering equipment. An internet connection point could also be required at the customer's expense.

Typical metering requirements include the following:

1. 15-minute load profile data for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received
2. Total accumulative registers for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received

### ***Sale for Resale Energy Metering***

At the customer's expense, DME will specify, design, install, own, and maintain all metering and metering devices (including instrument transformers) used to measure the delivery and receipt of energy for payment purposes. Metering shall be required for each point of delivery at each point where customer facilities interconnect with DME facilities. Meter accuracy will be maintained within +/- 0.3%. DME will test meters on an annual schedule; the customer will receive notification of test scheduling and copies of test results upon request. Requests for additional unscheduled testing will be honored at the expense of the requester unless the meters are found to be out of tolerance.

Typical metering requirements include the following:

1. 15-minute load profile data for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received
2. Total accumulative registers for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received

### ***Transmission Interconnection Energy Metering***

DME will specify, design, install, own, and maintain all metering and metering devices (including instrument transformers) used to measure the delivery and receipt of energy for payment purposes. Meter accuracy will be maintained within +/- 0.3%. DME will test meters on an annual schedule; the interconnecting utility will receive notification of test scheduling and copies of test results upon request. Requests for additional unscheduled testing will be honored at the expense of the requester unless the meters are found to be out of tolerance.

Metering equipment should be provided as close to the interconnection point as practicable.

Typical metering requirements include the following:

1. 15-minute load profile data for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received
2. Total accumulative registers for:
  - kWh or MWh delivered to the customer
  - kWh or MWh received from the customer
  - kVar or MVar - hours delivered and received
  - kW or MW - delivered and received

## ***Supervisory Control and Data Acquisition (SCADA)***

### ***Generation Interconnection SCADA***

DME may require a Remote Terminal Unit (RTU) for the purpose of gathering customer load and equipment status information needed by DME for Engineering and Operations center use. When required, DME shall own and maintain the SCADA devices at the customer's expense. The customer shall provide, at its expense, a dedicated telecommunications data circuit to the operations center as designated by DME. DME shall specify the communications protocol for this data circuit(s). Instantaneous bi-directional analog real power and reactive power flow information must be telemetered directly to the location(s) specified by DME.

Typical data requirements include the following:

- Status of interrupting devices
- MW flow
- MVar flow
- Voltage at interconnection point
- Annunciation of alarms both electrical related and intrusions

### ***Transmission Interconnection SCADA***

For the purpose of gathering interconnection load and equipment status information needed at DME's appropriate operations center, DME shall own and maintain the SCADA devices. The customer shall provide, at its expense, a dedicated telecommunications data circuit to the operations center as designated by DME. DME shall specify the communications protocol for this data circuit(s). Instantaneous bi-directional analog real power and reactive power flow information must be telemetered directly to the location(s) specified by DME.

Typical data requirements include the following:

- Status of interrupting devices
- MW flow
- MVar flow
- Voltage at interconnection point
- Annunciation of alarms both electrical related and intrusions

## ***Grounding and Safety Issues***

A safe grounding design must accomplish two basic functions:

1. Ensure that a person in the vicinity of grounded structures and facilities is not exposed to critical levels of step or touch potential, and
2. Provide a path for electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting the continuity of service.

Accordingly, each electrical facility must have a grounding system or grid that solidly grounds all metallic structures and equipment in accordance with the standards outlined in ANSI/IEEE 80, IEEE Guide for Safety in AC Substation Grounding, ANSI/IEEE C2,

National Electrical Safety Code (NESC). Testing must be performed to ensure safe step and touch potential parameters have been met in accordance with IEEE 80. When various switching devices are opened on an energized circuit, its ground reference may be lost if all sources are not effectively grounded. This situation may cause over voltages that can affect personnel safety and damage equipment. This is especially true when one phase becomes short-circuited to ground. Therefore, the interconnected transmission power system is to be effectively grounded from all sources. This is defined as  $X0/X1 < 3$  and  $R0/X1 < 1$ . Interconnected generators should provide for effective system grounding of the high-side transmission equipment by means of a grounded high-voltage generation step-up transformer.

### ***Covers Generator, Transmission, and End-User Facilities***

Safety is of utmost importance. Strict adherence to established switching, tagging, and grounding procedures is required at all times for the safety of personnel. Any work carried out within a facility shall be performed in accordance with all applicable laws, rules, and regulations and in compliance with Occupational Safety and Health Administration (OSHA), NESC, and good utility practice. Automatic and manual disconnect devices are to be provided as a means of removing all sources of current to any particular element of the power system. Only trained operators are to perform switching functions within a facility under the direction of the responsible dispatcher or designated person as outlined in the NESC.

### ***Insulation and Insulation Coordination***

Insulation coordination is the selection of insulation strength. Insulation coordination must be done properly to ensure electrical system reliability and personnel safety. Basic switching surge levels (BSL), surge arrester, conductor spacing and gap application, substation and transmission line insulation strength, protection, and shielding shall be documented and submitted for evaluation as part of the interconnection plan. Interconnection facilities to be constructed in areas with salt spray contamination or other types of contamination shall be properly designed to meet or exceed the performance of facilities not in a contamination area with regard to contamination-caused outages. Equipment basic impulse levels (BIL) shielding and surge protection shall be designed to meet the latest IEEE C62 standards, and DME standards.

### ***Voltage, Voltage Support, Reactive Power, and Power Factor Control***

#### ***Generation Facilities***

DME's voltage, voltage support, reactive power, and power factor control requirements for generators are described in its generator interconnection agreements. The requirements for generators both larger and smaller than 20 MW are listed in DME's Electric Service Standards. A copy of DME's Electric Service Standards can be found on DME's website, [www.dmepower.com](http://www.dmepower.com).

#### ***Transmission Facilities***

The transmission system must be capable of moving electric power from areas of generation to areas of load under a wide variety of expected system conditions. Adequate reactive power

supplies are of paramount importance to the capability of the transmission system to reliably support a wide variety of transfers. Transmission facilities must be designed to minimize excessively high voltages during light transmission loading conditions, yet have adequate reactive supplies to support system voltage during heavy transmission loading conditions.

### ***End-User Facilities***

DME strives to supply end-user facilities with voltage that is +/- 5% from nominal. End-user facilities connected directly to the transmission system shall plan and design their systems to operate at as close to unity power factor as possible, to minimize the reactive power burden on the transmission system.

## ***Power Quality Impacts***

### ***Interconnection Requirement for Harmonic Levels***

#### ***Generation Facilities***

Generation facilities shall not have harmonic current distortion levels exceeding the levels recommended in most recent revision of IEEE-519, *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*. Generation facilities must meet the stated current limits specified for generators as presented in the Current Distortion Limits tables for the applicable voltage levels. Generation facilities shall not cause the harmonic voltage distortion levels to exceed the voltage distortion limits recommended in the most recent revision of IEEE-519.

#### ***Transmission Facilities***

Transmission facilities shall not have harmonic current distortions levels exceeding the levels recommended in the most recent revision of IEEE-519.

#### ***End-User Facilities***

End-user facilities shall not have harmonic current distortion levels exceeding the levels recommended in the most recent revision of IEEE-519. End-user facilities must meet the stated current limits specified in the Current Distortion Limits tables for the applicable voltage levels.

## ***Interconnection Requirement for Flicker***

### ***Transmission Facilities and End-User Facilities***

Transmission facilities and end-user facilities are required to limit voltage fluctuations to the limits specified in the most recent revision of IEEE-1423.

## ***Equipment Ratings***

All circuit breakers and other fault-interrupting devices shall be capable of safely interrupting fault currents for any fault they may be required to interrupt. Application of circuit breakers shall be in accordance with the ANSI/IEEE C37 collection of standards. All current-carrying equipment and devices shall be designed to carry the maximum loads that are predicted and used

in load flow analysis. Loads exceeding nameplate or normal design capacities are acceptable only when allowed by manufacturers' design documentation or standard industry practices. Equipment BILs, shielding, and surge protective device application must meet requirements as determined by the latest IEEE C62 standards. DME will provide the BIL for the system in the interconnection area. Equipment must meet all applicable ANSI/IEEE standards and specifications communicated by DME during pre-interconnection correspondence and meetings.

### ***Synchronizing of Facilities***

Synchronizing facilities consisting of potential transformers and associated protective relaying / controls are required at the point of interconnection on transmission facilities where energy can be sourced on both sides of an interconnection circuit breaker. These facilities verify that the voltages on both sides of a circuit breaker fall within certain tolerances of both magnitude and phase angle as established by system conditions, supervise the closing and automatic reclosing of the circuit breaker, and prevent the closing of the circuit breaker when the two systems are out of synchronism. Voltage magnitudes, phase angles, and frequency constraints shall be determined on a case-by-case basis depending on system characteristics, conditions, interconnection location, etc.

### ***Generation Facilities***

Live line, dead bus (LLDB) control is used in the interconnection circuit breaker reclosing scheme when generation facilities are connected to transmission facilities. In summary, the circuit breaker cannot be closed unless the generation side has essentially zero voltage. The transmission facility interconnection circuit breaker shall not be used to synchronize a generator to the transmission system. Instead, the generation facilities shall have their own synchronizing facilities to synchronize to the system. In addition, the generation facility shall remain disconnected from DME's system until system voltage and frequency are within an established range should a generation facility become disconnected from DME's system. Exceptions to this requirement may be considered on a case-by-case basis depending on the specific applications and planned operation.

### ***Maintenance Coordination***

#### ***Covers Generator, Transmission, and End-User Facilities***

The maintenance of facilities is the responsibility of the owner of those facilities. Adjoining facilities on the interconnected power system are to be maintained in accordance with accepted industry practices and procedures. Each party is to have a documented maintenance program ensuring the proper operation of equipment. DME will have the right to review maintenance reports and calibration records of equipment that could impact the DME system if not properly maintained. DME is to be notified as soon as practicable about any out-of-service equipment that might affect the protection, monitoring, or operation of interconnected facilities. In accordance with NERC Reliability Standard TOP-003, each Generator Operator shall provide outage information daily to DME operations for scheduled generator outages planned for the next day for any generator greater than 50 MW. Maintenance of facilities interconnected to the DME transmission system shall be done in a manner that does not place the reliability and capability of the DME transmission system, or other portions of the ERCOT transmission system, at risk. Planned maintenance must be coordinated and scheduled with DME.

## ***Operational Issues (Abnormal Frequency and Voltages)***

### **Covers Generator, Transmission, and End-User Facilities**

Operational procedures are to be established in accordance with all applicable U.S. Nuclear Regulatory Commission (NRC), NESC, OSHA, ERCOT, and NERC requirements. Each party shall designate operating representatives to address and document the following:

- Lines of communications and appropriate contact personnel
- System advanced Planning and coordination
- Maintenance coordination
- Actions to be taken after de-energization of interconnected facilities
- Other required operating and administrative policies

All parties are to be provided with current station operating diagrams. Common, agreed-upon nomenclature is to be used for naming stations, lines, and switches. Updated diagrams are to be provided when changes occur to interconnected facilities.

The operator of facilities interconnecting to the DME transmission system will not perform any switching that energizes or de-energizes portions of the DME transmission system or that may adversely affect the DME transmission system without prior notice to DME or its designated operating representative. Operators of facilities interconnecting to the DME transmission system will notify DME, or its designated operating representative, before performing any switching that would significantly affect voltages, power flows, or reliability in the DME transmission system. During emergency conditions, the facility operator shall raise or lower generation, adjust reactive power, switch facilities in or out, or reduce end-user load as directed by DME's System Operations dispatch personnel or supervisor.

## ***Inspection Requirements for Existing or New Facilities***

### **Covers Generator, Transmission, and End-User Facilities**

Each party to the interconnection agreement shall perform routine inspection and testing of its facilities and equipment in accordance with good utility practice and regulatory requirements to ensure the continued interconnection of the facilities with DME's transmission system.

Each party shall, at its own expense, have the right to observe the testing of any of the other party's facilities and equipment whose performance may reasonably be expected to affect the reliability of the observing parties' facilities and equipment. Each party shall notify the other party in advance of facility and equipment testing, and the other party may have a representative attend and be present during such testing. If a party observes any deficiencies or defects on (or becomes aware of a lack of scheduled maintenance and testing with respect to) the other party's facilities and equipment that might reasonably be expected to adversely affect the observing party's facilities and equipment, the observing party shall provide notice to the other party that is prompt under the circumstance, and the other party shall make any corrections required in accordance with good utility practices and as required by regulatory agencies.

## ***Communications and Procedures During Normal and Emergency Operating Conditions***

### ***Covers Generator, Transmission, and End-User Facilities***

Complete, precise, and timely communication is an essential element for maintaining reliability and security of a power system. Under normal operating conditions, the major link of communication with various interconnects shall be via telephone lines and then followed up through electronic documentation. DME and its customer shall maintain communications that shall include, but not be limited to:

- system paralleling or separation
- scheduled or unscheduled shutdowns
- equipment clearances
- periodic load reports
- maintenance schedules
- tagging of interconnection interrupting devices
- meter tests
- relay tests
- billing
- other routine communication

In case of emergency or abnormal operating conditions, various communication channels may be used. Emergency telephone numbers should be agreed upon by both parties prior to the actual connect and energize date.

## ***System Restoration***

### ***Covers Generator, Transmission, and End-User Facilities***

In case of emergency or abnormal operating conditions such as during a system restoration, each Generator, Transmission, or End-User shall stay in contact with DME's System Operations dispatch personnel. It is imperative that any requested action(s) by DME Operations personnel be performed in a safe but expedient manner, to assist with system restoration.

## *Glossary of Definitions*

**ANSI** - American National Standards Institute  
**BIL** - Basic Impulse Level  
**BSL** - Basic Switching Surge Level  
**DLLB** - Dead line, live bus  
**ERCOT** - Electric Reliability Council of Texas  
**FAC** - Facilities  
**IEEE** - Institute of Electrical and Electronics Engineers  
**DME** - Denton Municipal Electric  
**kVar** - Kilovolt-Amp Reactive  
**kV** - Kilovolt  
**kW** - Kilowatt  
**kWh** - Kilowatt-hour  
**LLDB** - Live line, dead bus  
**LLDB/DLLB** - Live line, dead bus / dead line, live bus  
**MVar** - Megavolt-Amp Reactive  
**MW** - Megawatt  
**MWh** - Megawatt Hour  
**NERC** - North American Electric Reliability Corporation  
**NESC** - ANSI / IEEE C2, National Electrical Safety Code  
**NRC** - U.S. Nuclear Regulatory Commission  
**OSHA** - Occupational Safety and Health Administration  
**POTT** - Permissive overreaching transfer trip  
**RTU** - Remote Terminal Unit  
**SCADA** - Supervisory Control and Data Acquisition  
**TRE** - Texas Reliability Entity

*Brent A. Heath*

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*3-16-11*

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Date