



Electrical Bonding of CSST Systems

**A Guide for the Design and Installation of Electrical Bonding
For CSST Natural and LP Gas Piping Systems
Revision 1**

September 2008



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1.0 General User Warnings

This guideline document must be used in conjunction with all applicable product standards and building, fuel gas and electrical codes. In the event that there is a conflict between this guideline and local code, the more stringent requirement will take precedence.

While this document is intended to provide all the necessary instructions for the electrical bonding of any CSST system, this guideline must also be used in conjunction with the current Design & Installation Guide published by each CSST manufacturer and any active Technical Bulletins. These documents are available from each manufacturer.

Neither Cutting Edge Solutions LLC or Rising Tide Consulting LLC make any representations or warranties (either expressed or implied), and nothing contained in this document shall imply that this guideline contains the best or the only approved method for bonding corrugated stainless steel piping systems or that the contents of this document are appropriate for all circumstances. Performance of accessory devices (such as bonding clamps) should be confirmed by contacting the manufacturer of the accessory device and reviewing the latest technical data on its listing, installation practices and performance.

Proper bonding and grounding is an important component in reducing the risk of injury, damage and fire due to electrical fault and/or lightning strike. Lightning is a well known destructive natural force that can act upon any structure or its contents. Lightning strikes acting on or near a structure can cause significant damage to the structure, its contents or the inhabitants including structural fire and electrocution. These guidelines are intended to reduce the risk of damage to the CSST system based on indirect lightning strikes only.

In order to maximize protection of the entire structure from lightning damage, and depending on factors that vary based on the type and location of the structure, consideration must also be given to the installation of a lightning protection system in accordance with NFPA 780 and/or other lightning protection standards that go beyond the scope of this manual.

The bonding techniques outlined within this guideline are recommended practice for generic applications. These practices must be reviewed for compliance with all applicable fuel gas, electrical and building codes. It would be impossible for this guideline to anticipate and cover every possible variation in building configurations, construction styles, appliance types and code requirements. Therefore, there may be applications that will not be covered by this guideline. For applications that are outside the coverage contained within this guideline, the installer should exercise sound technical judgment and apply generally accepted engineering principles and practices. Contact Cutting Edge Solutions or Rising Tide Consulting for engineering assistance for issues not addressed in this document or for clarifications.

While every effort has been made to prepare this document in accordance with all regional model codes in effect at its printing, there is no guarantee that the local administrative authority will accept the most recent version of these codes. It is the ultimate responsibility of the installer to determine suitability and local acceptance of any building component including gas piping. Neither Cutting Edge Solutions nor Rising Tide Consulting assumes any responsibility for labor or material used for installations made without first securing the acceptance of the local code authority.



2.0 Direct Bonding Requirements

2.1 General

CSST used in either natural gas or LP gas systems shall be directly bonded to the premise electrical ground system. The term “direct” bonding is intended to mean the use of a dedicated conductor and appropriately listed clamps to make an electrical connection between the piping and the grounding electrode system in the shortest and most straightforward path practical. Bonding shall be required for all new CSST installations and for any existing gas piping system that is either modified or expanded using one or more runs of CSST.

2.2 Definitions

Section 250.90 of the NEC provides guidance on the general purpose of bonding. It states: *Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault currents likely to be imposed.* The 2008 edition of the NEC goes on to define the term bonded as: *Connected to establish electrical continuity and conductivity.*

2.3 Model Code Requirements

The National Electric Code (NFPA 70) stipulates the requirements for the bonding of gas piping systems in *NEC Section 250.104(B) Other Metal Piping*.

The National Fuel Gas Code (NFPA 54) also requires the bonding of gas piping systems as stipulated in *Section 7.13 Electrical Bonding and Grounding*. The 2009 edition of NFPA 54 is expected to state the following requirements in *Section 7.13.2*:

CSST gas piping systems shall be bonded to the electrical service grounding electrode system at the point where the gas service enters the building. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent.

The International Fuel Gas Code (IFGC) and the Uniform Plumbing Code (UPC) have mandatory extraction policies (with AGA and NFPA) relative to this section of the NFGC. Therefore, the relevant gas piping bonding language from the National Fuel Gas Code will appear in the 2009 edition of both the IFGC and the UPC.

2.4 Manufacturer's Requirements

The installation instructions of each commercially available CSST system (six US manufacturers) require the direct bonding of the CSST system. This document provides additional information on the pertinent location, sizing and installation requirements. However, CSST installation requirements, including those for bonding, are affected by differences in the listed accessories/components specified by each manufacturer. It is the responsibility of the installer to review the manufacturer's latest instructions and to check their websites (see Section 6.0 for web addresses) for new or updated Technical Bulletins to insure that any manufacturer-specific practices are followed.

2.5 Installer and Inspection Requirements

The bonding of CSST shall be performed by a qualified contractor recognized by the Authority Having Jurisdiction as capable of performing such work. It is the responsibility of the installer to be familiar with the installation requirements contained within the D&I Guide of the chosen CSST manufacturer and with both the national and local electrical code requirements for bonding.

The bonding of CSST shall be inspected as required by the Authority Having Jurisdiction.

3.0 Required Installation Practices

3.1 General

CSST used in either natural gas or LP gas systems shall be bonded to the premise electrical ground system using dedicated clamps and bonding conductor.

The bonding connection to the gas piping system will be made in an exposed and accessible location near the gas service entrance (to the building), but not directly on the corrugated tubing. See **Section 3.2 Connection to Gas Piping System** for specific requirements and techniques.

The bonding connection to the electrical system shall be made directly to the grounding system for that electrical system. See **Section 3.3 Connection to Grounding System of the Premise Wiring System** for specific requirements and techniques.

The bonding conductor shall be appropriately sized and routed. See **Section 3.4 Bonding Conductor** for specific requirements and techniques.

CSST shall be bonded per these requirements whether or not the connected gas appliances are electrically powered or are incorporated into the electrical system. CSST must not be in direct contact with other electrically conductive metallic systems including copper water pipe, electric power cables, air conditioning and heating ducts, and communications/coax cable. CSST must not be directly supported on or by structural steel beams or joists unless it is electrically insulated and/or isolated from these beams and joists.

3.2 Connection to Gas Piping System

Direct bonding requires a single point of attachment to the gas piping system. The point of attachment can be located either on a section of rigid pipe or a piping component such as a nipple, fitting or manifold (provided it is manufactured from an appropriate and code-listed material) using a bonding clamp listed (per UL 467 or other acceptable national standard) for such use as shown on Figure 1.



Figure 1 - Bond Clamp on Rigid Pipe

The installation of a bonding clamp directly onto a CSST fitting (as shown on Figure 2) shall only be permitted if the bonding clamp is so listed for use in that manner. Pipe components used as attachment points must be made from a listed material including steel, galvanized steel, black iron, malleable iron, copper and/or brass. The clamp must make metal-to-metal contact with the piping, pipe component or CSST fitting component. Additional bonding connections are permitted when required by another system such as lightning protection.

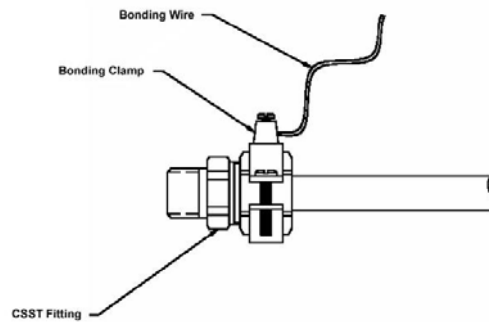


Figure 2 - Bond Clamp on CSST Fitting

Caution: Under no circumstances is a bonding clamp to be attached to or a bonding connection to be made directly on the corrugated tubing. Install clamp on CSST fitting only if clamp is listed for this condition.

The bonding connection shall always be installed downstream of the gas utility owned meter on the piping near the gas service entrance to the building (either indoors or outdoors). For propane systems without meters, the bonding connection shall be made downstream of the underground piping from the storage tank and the second stage pressure regulator. In general, the length of the bonding conductor should be as short as practical within the physical constraints of the installation. The most effective bonding connection to the gas piping system is a location upstream of the first CSST fitting within the system.

Exception: When upgrading the bonding of an existing CSST system, locating the bonding connection near the gas service entrance could result in the need to remove or modify extensive portions of the existing structure to permit the installation of the bonding conductor. When confronted with this type of situation, the bonding connection may be made at another suitable location (within the piping system) closer to the point of connection to the electrical grounding system.

The bonding connection to the gas piping shall be accessible, and shall remain so after all construction is completed.

3.3 Connection to Grounding System of the Premise Wiring System

The bonding conductor shall be attached to the grounding system of the premise electrical system in one of the following locations: (See Figure 3)

- a. The electrical system grounding electrode(s) with an appropriate ground clamp
- b. The foundation rebar when the electrical system employs an Ufer ground through the foundation as defined by *NEC Section 250.52 (A)(3) Electrodes Permitted for Grounding – Concrete-Encased Electrode*.
- c. The electrical system grounding electrode conductor if it is of sufficient size.
- d. The electrical panel (or sub-panel in multi-family buildings) at the grounded conductor or the ground/bond bus. Appropriate connectors for use inside the panel must be selected.
- e. The copper water piping (near the building entrance) with appropriate ground clamp **only** if the underground water pipe is a primary grounding electrode as defined by *NEC Section 250.52 (A)(1) Electrodes Permitted for Grounding – Metal Underground Water Pipe*.

Caution: As it can be difficult to verify that the underground water pipe is a primary grounding electrode for the electrical system, the other connection locations should be given a higher priority.

- f. Other grounding electrodes (e.g. lightning protection system) only when these electrodes are integrated into the existing electrical system ground. This requires the bonding together of all grounding electrodes as per *NEC Section 250.50 Grounding Electrode System*.

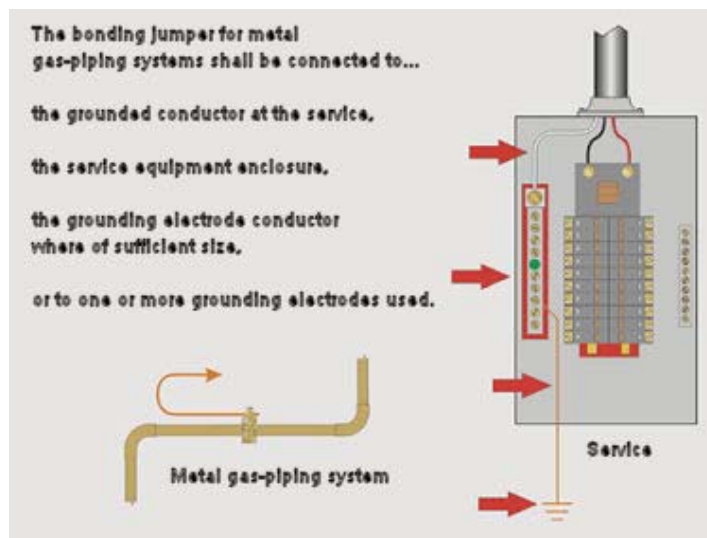


Figure 3 – Bonding Jumper Attachment Locations

The grounding system, and all grounding electrodes shall comply with the applicable requirements of *NEC Section 250 Grounding and Bonding*, particularly *Section 250.52 Grounding Electrodes*, and *Section 250.53 Grounding Electrode System Installation*. Connections to a grounding electrode shall comply with *NEC Section 250.70 Methods of Grounding and Bonding Conductor Connection to Electrodes* and shall include a listed clamp, listed lug, an exothermic weld or a listed pressure connector. The mechanical connection to a concrete-encased or buried grounding electrode is not required to be accessible.

3.4 Bonding Conductor and Sizing

The bonding conductor shall be a minimum of 6 AWG copper wire or equivalent. The bonding jumper shall be sized in accordance with Table 250.66 based on the size of the service-entrance conductor or feeder supplying the house (or each individual occupancy in a multi-family) and as permitted in 250.66(A), (B) and (C). Where a rod, pipe or plate is used as the grounding electrode, the bonding conductor is not required to be larger than a 6 AWG copper wire. When the bonding conductor is connected to a concrete encased electrode, the bonding conductor is not required to be larger than a 4 AWG copper wire.

The bonding conductor can be bare or coated. The bonding conductor shall be installed and routed in such a manner as to minimize the length of wire from the gas piping connection to the point of attachment to the electrical ground system while conforming to the requirements of 3.2 Connection to the Gas Piping System. When the bonding conductor length exceeds 125-ft, the size of the conductor must be increased one gauge size.

The bonding conductor should not be in direct contact with other metallic piping, duct systems, or electric wiring. Other metallic systems may be bonded in series with the CSST (i.e. daisy-chain), but the other metallic systems may not be used as the bonding conductor. Bonding conductors shall be installed in one continuous length without a splice except as permitted in *NEC Section 110.14 (B) Electrical Connections – Splices*.

The bonding conductor shall be protected as required by *NEC Section 250.64 (B) Grounding Electrode Conductor Installation – Securing and Protection Against Physical Damage*. The bonding conductor shall be either concealed (free from physical damage) or shall be run along the surface of the building construction and securely fastened to the construction. The bonding conductor can be installed above or below grade along the perimeter of the foundation or through the structural elements of the building.

4.0 Applications

4.1 Single Family Construction

Single family construction consists of a single gas meter, piping system and electrical system within one building. This type of construction commonly uses driven rod type grounding electrodes or a concrete-encased electrode system or Ufer ground. The requirements and installation techniques stated within this document can be directly applied in the majority of cases. Bonding of the gas piping system is complicated when the gas meter is located on an opposite side of the house from the electric meter location. This situation can create the need for the bonding conductor to run, either above or below grade, along the perimeter of the foundation, and may result in a relatively long conductor length.

4.2 Multi-Family Construction

Multi-family construction consists of any type of building with more than one dwelling. This includes the range of buildings from duplexes to high-rise apartment buildings. Due to this wide range of possible construction environments, this document does not cover all possible installation instances. Installations must follow generally accepted engineering principles and comply with the intent of these guidelines. Multi-family construction can include multiple gas meters installed in a central meter bank, one master gas meter with multiple sub-meters installed throughout the building, a main electrical panel with sub-panels for each domicile or one main electrical panel directly feeding the entire building.

When there is a master electrical panel in conjunction with a master gas meter or a meter bank, it is desirable to perform the bonding of the gas piping between these two points. In the case of a meter bank, it is likely that each gas meter is electrically isolated with a dielectric union from the main gas line or meter bar. For this reason, each individual meter must be bonded. This can be accomplished with one or more “daisy-chained” bonding conductor(s) as shown in Figure 4.

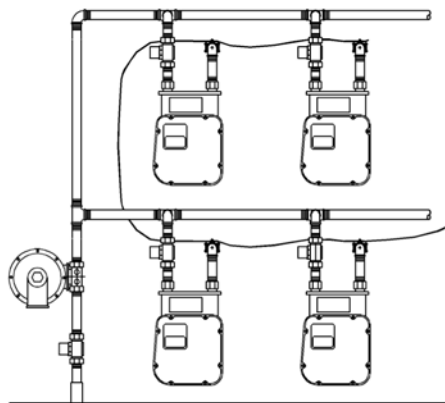


Figure 4 - Multi-Meter Bonding

If multiple bonding conductors are required, they shall be spliced into the main bonding conductor that is then routed to the electrical grounding system. The size of the main bonding conductor must be evaluated to determine if it requires any upsizing. Splices of the bonding conductor shall comply with ***NEC Section 110.14 (B) Electrical Connections – Splices.***

It is recommended that bonding for high-rise, multi-family applications be designed by an engineer knowledgeable in electrical system design and the local electrical code. In the case of an engineered building, it is also recommended that the engineer of record for the gas piping system and/or electrical system be consulted for the proper bonding methods used to meet these requirements. The engineer may require upsizing of the bonding conductor due to a higher panel rating common in large-scale multi-family construction. If conductor upsizing is required, the use of ***NEC Section 250.66 Size of Alternating-Current Grounding Electrode Conductor*** for selecting bonding conductor size is recommended.

4.3 Commercial Buildings

Commercial buildings may employ any of the electrical panel and gas meter configurations covered in Section 4.2. However, it is common for a commercial building to have much larger gas and electrical loads, and thus larger meters/panels. Regardless of this fact, the bonding requirements and techniques detailed above may still be applicable and sufficient.

It is recommended that bonding for large, commercial applications be designed by an engineer knowledgeable in electrical system design and the local electrical code. In the case of an engineered building, it is also recommended that the engineer of record for the gas piping system and/or electrical system be consulted for the proper bonding methods used to meet these requirements. The engineer may require upsizing of the bonding conductor due to the high panel rating common in commercial construction. If conductor upsizing is required, the use of ***NEC Section 250.66 Size of Alternating-Current Grounding Electrode Conductor*** for selecting bonding conductor size is recommended.

5.0 Lightning Protection Systems

When a lightning protection system is installed, the bonding of the gas piping shall meet the requirements of a nationally recognized lightning protection system standard (such as NFPA 780, UL 96A or LPI-175), and the requirements of this document.

Bonding required by the lightning protection system standard shall be connected to the gas piping system using one of the connection methods detailed in Section 3.2. Where a bond is required at a location where there is no CSST fitting or rigid pipe, a coupling may be installed within the CSST run to provide a bonding point. A qualified CSST installer shall insert this fitting or piping segment for the bonding connection point.

Under no circumstances is a bonding clamp to be directly connected to the CSST itself or is the jacket to be removed other than as required by the fitting connections.

6.0 References

CSST industry Internet links:

- www.wardmfg.com
- www.gastite.com
- www.tracpipe.com
- www.parker.com/parflexsystem
- www.tru-flex.com
- www.metalfab.com

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