SUPPLEMENT 2

Update on the Design and Installation Requirements for CSST Gas Piping Systems

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Editor's Note: *Requirements for the corrugated stainless steel tubing (CSST) system of piping for fuel gases in buildings have been included in the National Fuel Gas Code since 1988, and this system continues to be popular with plumbers, mechanical contractors, and other installers of gas piping systems. CSST provides another piping option in addition to steel pipe and copper tubing that has advantages in many installations. This supplement was revised for the 2006 edition to update the user with current information on CSST.*

Special thanks are extended to the Institute for Gas Technology, formerly Gas Research Institute, which funded the research program that identified CSST and sponsored demonstration projects.

Corrugated stainless steel tubing (CSST) is commonly used throughout the United States to distribute natural and LP-Gases inside all types of residential and commercial buildings. The design, sizing, and installation of CSST are covered in NFPA 54, *National Fuel Gas Code,* which references ANSI/LC-1, *Standard for Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*. In the 2009 edition of the *National Fuel Gas Code,* sizing tables have been updated and new installation practices for the electrical bonding of these systems have been added.

TUBING TECHNOLOGY

CSST is commercially available in a variety of sizes ranging from 0.375 in. to 2 in. (9.5 mm to 50.8 mm) internal diameter. The tubing is packaged in long coils on spools, which facilitate the dispensing of the tubing, and they vary in length from 100 ft to 500 ft (30 m to 150 m) depending on the tubing diameter. Special mechanical fittings are provided to connect the tubing with other components within the overall gas distribution network. The tubing can be easily cut and field assembled with the mating fittings using standard hand tools. Although each manufacturer's fitting attaches to the tubing in a unique fashion, all fittings are required to incorporate standard pipe threads for connection to conventional plumbing components and appliances.

One of the unusual characteristics of CSST is the unique shape of each manufacturer's tubing profile. No two profiles are alike. Therefore, a special designation was developed to denote the flow capacity of each tubing size rather than use the internal diameter dimension. An Equivalent Hydraulic Diameter (EHD) designator is assigned to each new CSST product by the certifying agency in accordance with the requirements of the ANSI LC-1 standard. Table S2.1 summarizes the currently available CSST products listed by manufacturer and EHD designator. It is important to note that not every manufacturer makes a full range of sizes. The system designer must exercise care

***TABLE S2.1** Availability of CSST Product by Manufacturer*

EHD Value	*13*	*15*	*18*	*19*	*23*	*25*	*30*	*31*	*37*	*39*	*46*	*48*	*60*	*62*
Nominal Diameter (inch)	3/8	3/8	1/2	1/2	3/4	3/4	1	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2
CSST Manufacturer														
Ward		X		X		X	X		X			X		X
Gastite	X		X		X			X	X		X		X	
Omegaflex		X		X		X		X	X		X			X
Parker	X		X		X			X		X				X
Tru-Flex		X	X			X		X	X					
Metal-Fab		X		X		X		X	X					

when making a tubing selection using the standard sizing tables to ensure that the size chosen is available from the chosen supplier of the CSST product. If the selected size is not available, then the next higher value of EHD must be used. In addition, CSST is used for retrofit applications, especially for the installation of additional appliances to an existing steel pipe system. This application results in a piping system comprised of two different materials. In these situations, the line sizing for the new tubing must be chosen and the size for the old piping must be recalculated to ensure that it has adequate capacity to carry the new load without excessive pressure reduction.

The lack of a mandatory standard for the tubing shape has created a situation where CSST from different manufacturers are not identical even though they are of the same nominal size. Thus, a fitting from one manufacturer cannot be assembled on the CSST from another. In other words, the fittings are not interchangeable. This discrepancy has raised concerns regarding future modifications and/or repairs to existing CSST systems. These concerns have been addressed in two ways. Although not interchangeable, CSST fittings can be interconnected through standard pipe components, such as couplings, elbows, and tees, because each CSST fitting terminates in an NPT threaded nipple. Should it become necessary to either extend an existing CSST run or replace a damaged section, a CSST fitting from another manufacturer can be used in conjunction with the existing termination fitting that is already installed at the end of the run. The repair is completed using a malleable iron pipe coupling and the two fittings as shown in Exhibit S2.1. The installer sometimes has the option of abandoning the existing line (if practical) and installing a completely new run of CSST and fittings from another manufacturer. Starting from the same port on the manifold (by removing the old fitting), new tubing is installed in parallel with the abandoned appliance run and connected to the appliance with a new fitting. The installer must ensure that the new run of CSST is at least of equal or greater EHD value than the line being replaced or repaired.

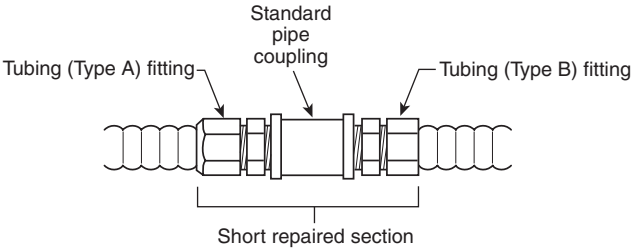

***EXHIBIT S2.1** Repair Method for Damaged CSST Tubing Run. (Courtesy of Foster-Miller, Inc.)*

LIGHTNING AND CSST

The protection of structures and equipment from both direct and indirect lightning strikes is considered outside the scope of the various building codes, including the electrical, fuel gas, and plumbing codes. However, all gas piping materials and equipment are susceptible to damage from lightning strikes. Based on anecdotal data gathered from plumbing contractors and forensic investigations, it is known that lightning energy will cause pipe dope to flow inside threaded pipe joints, burn perforations through CSST and flexible connectors, and result in seal failures in gas meters, regulators, and equipment controls.

Corrugated stainless steel is more vulnerable to arcing damage than other gas piping materials because of its thinner wall thickness. NFPA 54 was revised in the 2009 edition to address this, based on a number of incidents that became apparent after a class action lawsuit was settled. Section 7.13, Electrical Bonding and Grounding, has been revised to require that all CSST systems be bonded to the electrical service ground where the gas service enters the building using at least a 6 AWG copper conductor or

equivalent. This bond is intended to divert much of the lightning energy directly to earth before it can jump to another nearby electrically conductive pathway, such as copper water pipe or electrical wiring. Lowering the voltage level impressed on the CSST and minimizing the difference in electrical potential between conductive pathways will significantly reduce the magnitude and/or the occurrence of arcing.

CSST installation instructions have been revised to include similar requirements. These new practices require the installation of bonding clamps and a bonding conductor at the service entrance between the gas piping and the grounding electrode, grounding electrode conductor, or the service panel enclosure. NFPA 54 requires that CSST be installed in accordance with the manufacturer's installation instructions in 7.2.8.

BONDING OF GAS PIPING

Effective grounding of the electrical system depends on a low-resistance electrical pathway to the earth. The pathway to ground is affected by the resistance within the electrical system, the grounding electrode(s), and the soil conditions. While *NFPA 70®*, *National Electrical Code®* (*NEC®*), does not require a minimum resistance for the connection of a grounding electrode system that consists of metallic water pipes or concrete-encased electrodes, it does require that the electrical resistance of the connection to ground for ground-rod and plate-type electrodes must be 25 ohms or less. If this resistance is not achieved, an additional grounding electrode must be installed. In addition, Section 250.4(A) (1) of the *NEC* states:

> **(1) Electrical System Grounding.** Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.

Electrical safety is enhanced if all metallic piping systems, including CSST, are bonded equipotentially to the grounded electrical system so that voltage differences are minimized between these systems. If the piping is inadequately bonded or not bonded at all, gas piping of any type or material is more vulnerable to damage from indirect lightning strikes. Where installed in or attached to a building or structure, metal piping systems (including gas piping) that are likely to become energized are required to be bonded to the supply side of the electrical system in accordance with Article 250 of the *NEC*. Article 250 covers the bonding of different types of electrically conductive metallic systems, including metal water pipe, other metal pipe, including gas piping systems, and structural steel. Section 250.104(B), Other Metal Piping, provides the *NEC* requirements for bonding of gas piping systems.

Traditionally, the bonding conductor is sized in accordance with *NEC* Table 250.122 using the rating of the branch circuit that can energize the piping. Although the typical bonding conductor is of sufficient size to address ground fault conditions, this same conductor has not proven to be of adequate capacity to accommodate the frequency and voltage surge levels associated with lightning energy. The new requirement for bonding of CSST specifies that the bonding conductor be at least a 6 AWG copper conductor or equivalent. A 6 AWG copper conductor is often used as a bonding jumper for other metallic systems.

Direct bonding of metallic structures, such as piping systems, to the grounding electrode system on the power supply side provides a low-resistance path back to earth. This connection is intended to keep each metallic system at or near earth potential (ideally near 0 volts). This type of bonding for gas piping exceeds the requirements of the *NEC*. While the *NEC* requirements intend to maximize life safety protection, the additional bonding is intended to also minimize the impact of indirect lightning strikes on the CSST. This added protection will reduce the likelihood of arc-induced damage of the CSST by significantly reducing the difference in electrical potential between the gas piping, other metallic systems, and the electrical grounding system.

All of the existing CSST manufacturers have revised their installation instructions regarding the bonding of the CSST system to the electrical grounding system. Direct bonding of the CSST gas piping system is required for all new installations regardless of the type of connected gas appliance. The gas piping system is required to be bonded to the electrical earth grounding system of the structure through the use of a bonding clamp and wire. To keep it simple yet cost-effective, the size of the bonding conductor should be at least a 6 AWG copper wire (or equivalent) for most residential applications. However, commercial buildings may require larger size bonding conductors and additional points of attachment. Refer to the *NEC* for specific requirements. In residential applications, the bonding connection must be made to one of the following locations: the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor (if of sufficient size), or one of the grounding electrodes.

The bonding clamp must be a listed electrical fitting, and it must be attached to the gas piping system on a segment of rigid pipe, as shown on Exhibit S2.2, or a pipe component, such as a coupling. The clamp must always be located on the building side of the gas meter, as shown in Exhibit S2.3, near the entrance to the structure. The bonding connection for propane systems without meters must

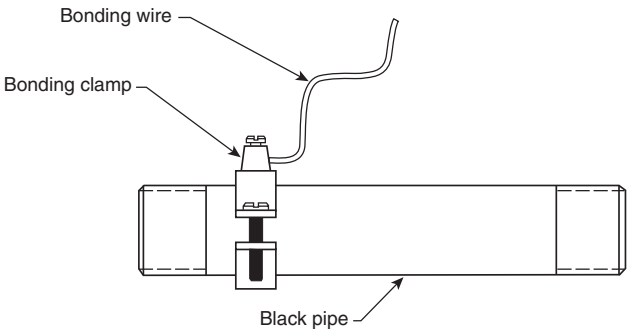

EXHIBIT S2.2 *Attachment of Clamp to Steel Pipe. (Courtesy of Cutting Edge Solutions, LLC)*

EXHIBIT S2.3 *Location of Bonding Clamp. (Courtesy of Cutting Edge Solutions, LLC)*

be made downstream of the second-stage pressure regulator at the entrance to the building. The clamp can be installed either indoors or outdoors and the bonding jumper must be protected in accordance with the *NEC*, based on its size. The clamp must make metal-to-metal contact with the pipe or component. The corrugated stainless steel tubing portion of the gas piping system must not be used as the point of attachment of the bonding clamp at any location along its length under any circumstances. The points of attachment of the bonding clamp and conductor must be accessible and must remain accessible after construction is completed. The length of the bonding conductor should be as short as practical, consistent within the physical layout and constraints of the installation.

Depending on site conditions specific to the location of the structure, including but not limited to whether the area is prone to frequent lightning strikes, the builder or owner of any structure has the option of installing a lightning protection system. The design of lightning protection systems are covered by NFPA 780, *Standard for the Installation of Lightning Protection Systems*. Bonding required by the lightning protection system standard must be connected to the gas piping system on the building side of the gas meter using one of the connection methods permitted for gas piping. The bonding of the lightning protection system is in addition to the bonding requirements for the CSST piping system.

REFERENCES

American National Standard, *Standard for Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)*, ANSI LC-1-2005/CSA 6.26-2005.

NFPA 70®, *National Electrical Code®*, 2008 edition, National Fire Protection Association, Quincy, MA.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2008 edition, National Fire Protection Association, Quincy, MA.

Additional Readings

National Electrical Code® Handbook, National Fire Protection Association, Quincy, MA, 2008.

Effectiveness of Direct Bonding of Gas Piping in Mitigating Damage from an Indirect Lightning Flash, Final Technical Report, Brian Kraft and Robert Torbin, August 2007.