Yellow Corrugated Stainless Steel Tubing (CSST) Questions and Considerations

1) **What is the concern with yellow CSST?** Corrugated Stainless Steel Tubing (CSST) is a flexible gas line material introduced in the late 1980's as a labor-saving alternative system to rigid steel gas pipe. Originally developed in Japan as a way to mitigate hazards associated with breakage of rigid lines during earthquakes, it performs very well in that regard, however, it has shown itself to be vulnerable to electrical insult due to arcing that can occur during a lightning event. The dielectric yellow jacket actually exacerbates the problem. CSST manufacturers developed electrical bonding requirements for yellow CSST that their testing shows will mitigate the problem to some extent, but they emphasize such protection is only for "indirect" lightning strikes (those that do not hit the home). We have experience with "direct" lightning strikes in Lubbock, and wish to protect our citizens to a greater degree by amendment to our code and provision of the following information.

2) **How do I determine whether I have yellow CSST in my home?** It is advised that a licensed plumber be contacted to make this determination; however, you can check for yourself by going in the attic and orienting yourself to the location of your gas appliances in the home, then look for the gas line that runs from the building exterior to either a main "trunk" line (typical for black steel gas pipe systems), or to a manifold/regulator station (typical for CSST systems) with multiple ports for individual gas connections. If you have CSST, the individual flexible "hose type" lines will run from the manifold across the attic to the individual appliance locations, and down the walls to each of them. Of course, the lines will be yellow in this case. You may also have black-colored CSST, which would be one of the second-generation, conductive-jacketed varieties.

Yellow CSST at Manifold with Regulator

3) **I have determined that I have yellow CSST in my home…**

   a) **Should I be concerned?** Yes. You need to explore further and possibly make some decisions. CSST has been determined to be vulnerable to very low levels of lightning energy due to the extremely thin stainless steel tube. Testing proves that the yellow jacket, which is dielectric (non-conductive), actually makes this problem worse. The average negative cloud-to-ground lightning flash carries 15.8 Coulombs of electrical energy. Yellow CSST has been shown to fail at levels of less than ¼ of a Coulomb.

   b) **Is my family in danger?** Not in immediate danger, no. As long as there is no lightning, there is no hazard. The question is one of balancing risk. Though lightning is perceived as a relatively rare event, it can and does happen. When it does, and if it strikes a home (*direct* strike), or close to a home (*indirect* strike), the potential for an arc-created hole and then a fire and/or explosion is there if yellow CSST is installed.

   c) **Is my property value affected?** That is something we are not really able to answer. Real estate inspectors in the State have begun to identify CSST as part of their standard inspection reports. Aware of the fire history of CSST, many potential buyers view it as undesirable at best, or defective at worst, and attempt to negotiate a lower sales price.

4) **Is yellow CSST defective?** Not really. It functions as intended. When it first appeared on the scene many years ago, no one anticipated the vulnerability to lightning. That did not become apparent until many years later when there were enough installations and enough claims to become statistically significant. The major manufacturers prescribed direct bonding as a mitigation measure, moved on to "improved" products, and eventually stopped manufacturing and distributing yellow CSST. There are still some minor manufacturers, however, and it is still available.

5) **Is yellow CSST illegal?** Through amendment to its Fuel Gas Code, the City of Lubbock has prohibited any new installation of yellow CSST, whether in whole or part.

6) **Am I required to do anything if I have yellow CSST in my home or business?** Yes, but perhaps not right away. Your yellow CSST will need to be bonded to the electrical service grounding electrode system if it has not already been. This will be enforced only when your gas system is altered for any reason that requires a plumbing permit and inspection, and prior to restoration of gas service if discontinued for any reason other than non-payment. Electrical bonding must be done by a licensed electrician. If unsure whether your system is bonded, contact a licensed electrician or plumber.

7) **What should I do if I find I have yellow CSST in my home?** Do not panic, as there is no hazard if there is no lightning; however, you should determine your own risk outlook, know what your mitigation choices are, and know what to do in the event of a lightning strike that you believe has damaged your gas installation, to wit:

   a) Have a licensed plumber look at your system to determine if it is directly bonded to the electrical system grounding electrode. If not, have a licensed electrician perform this work as soon as possible (see attached graphic) unless you intend to replace your CSST with a more robust system;

   b) Examine the choices in the table below regarding currently known mitigation measures;

c) Be familiar with what to do in the event of a lightning strike you believe has damaged your gas piping system. Note that an arc-produced hole will not always result in a fire, but will result in escaping gas, possibly in the attic, behind a wall, or in the home. Upon detection of smoke or the odor of gas, evacuate the home and call 9-1-1. Turn off the gas service in the alley, if able, or call the gas company, but do not go near the home.

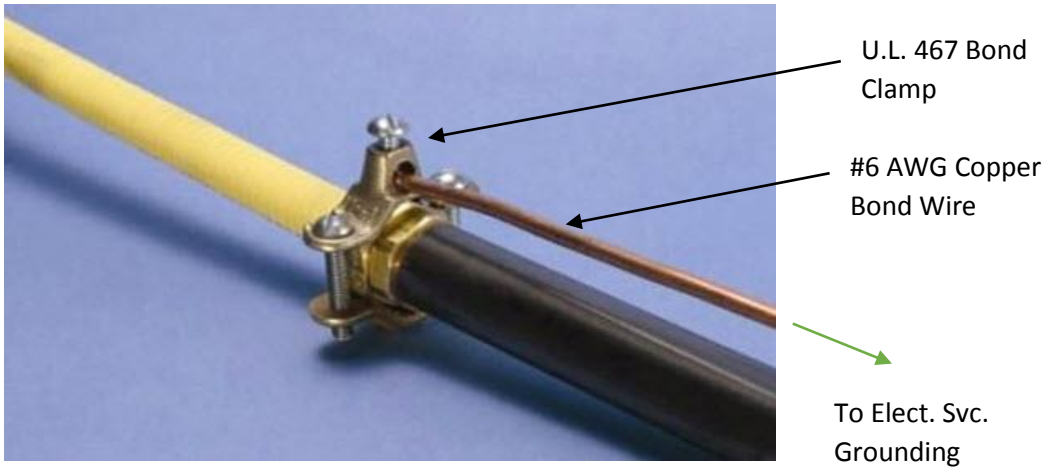
8) **What is required of me under the new code provisions?** Restrictions on yellow CSST systems have been put in place that affect new installations, replacements, repairs, and system upgrades, effective June 13, 2016.

a) **New installations:** No new installations of yellow CSST are allowed. This includes new construction as well as portions of systems in existing homes.

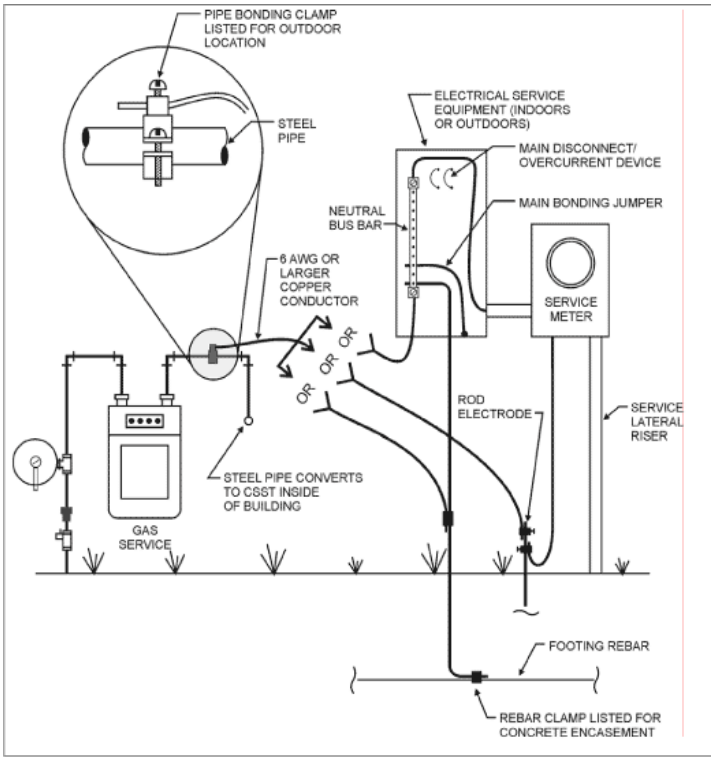
b) **Replacements:** If an owner desires to replace all or part of a yellow CSST system, the replacement piping material must of a variety approved by the code, as amended. This will mean ASTM A53 steel pipe ("black iron" pipe) or conductive-jacketed CSST (CJ-CSST) that is listed to the LC-1027 standard, or equivalent, and that has been tested to withstand 95 Coulombs of lightning energy. Replacement must be done by a licensed plumber pursuant to a permit.

c) **Repairs:** Leak repairs that do not require replacement of a section of yellow CSST may be done in accordance with manufacturer's installation instructions without a permit. A licensed plumber needs to do this work.

d) **System Upgrades:** Any work on a gas system containing yellow CSST that requires a permit and inspection from the City of Lubbock will require that the system be "directly bonded" to the electrical grounding electrode system if it hasn't already. Such work can include the replacement or addition of piping or any condition that requires a leak test witnessed by City of Lubbock inspectors. Should gas service be discontinued for any reason other than non-payment, a leak test must be conducted. At that time, the system will be checked for direct bonding. Bonding must be done by a licensed electrician. You may have to hire both a plumber and an electrician.



CSST "Direct Bond"



Source: Rob Austin, Suzanne Borek, Tom Pitcherello
Code Assistance Unit

CSST "Direct Bond"

DIRECT BONDING NOTES:

At point of gas service

Bond to electrical service grounding electrode system

Use #6 gauge (min) copper bond wire

Listed bonding clamp at rigid pipe or first hex nut in CSST system

75' max. bond wire length

Limits on bond wire bending radius

METHODS TO MINIMIZE THE HAZARDS ASSOCIATED WITH YELLOW CSST INSTALLATIONS				
	Method	**Relative Effectiveness***	**Expense**	**Notes**
A	Replace with ASTM A 53 Steel ("Black Iron") Pipe	High	Moderate to High	Expense varies based on home
B	Replace with Conductive-Jacketed CSST (CJ-CSST) per COL Requirements	Moderate to High	Moderate to High	Expense varies based on home
C	Install a direct CSST electrical bond	Low to Moderate	Low	Should always be done
D	Establish & maintain minimum clearances to other metallic systems	Moderate	Low to Moderate	
E	Install an equipotential bonding system	Moderate to High	Low to Moderate	
F	Install a lightning protection system	Moderate to High	Moderate to High	Will normally include (C) & (E) Expense varies based on home
G	Excess gas flow valves	None to Low	Low	
H	Convert to All-Electric	Highest	Highest	Probably Not Feasible

A) **Replace with ASTM A53 Steel ("Black Iron") Pipe:** Rigid steel, or "black iron pipe" (BIP), with its threaded joints and fittings, has been the predominate method of running gas installations for a century, and is still the most common method used today. The need for knowledgeable, skilled labor in order to install this piping method, as well as the time involved, was the primary reason for the rise in popularity of CSST. BIP, however, is much more robust in terms of its ability to withstand electrical insult from lightning (tested up to 288 Coulombs and more without failure, compared to failure of CSST at 0.12 Coulombs). Opponents tout leakage of joints due to melt-out of pipe thread compound in a lightning strike; however, it is likely that such leakage even in multiple tight, tapered thread joints would not be equivalent to the rate of leakage even in a minor hole created by a lightning arc in CSST. Additionally, opponents point out that the short flexible appliance connectors used to terminate gas runs in BIP systems are as vulnerable to lightning as CSST. While likely true, these appliance connectors are normally located in areas accessible to the building occupants, and their cumulative length (and therefore potential for exposure) is but a fraction of the total length of CSST piping in a typical installation.

   Though individual situations will vary, total replacement with BIP can be an expensive proposition in a pre-existing home, due to structural constraints and the lack of flexibility involved with rigid pipe runs.

B) **Replace with Conductive-Jacketed CSST (CJ-CSST) per City of Lubbock Requirements:** The City of Lubbock has approved the use of conductive-jacketed CSST products that are listed to ICC PMG LC-1027 or equivalent, and that are shown to have been tested to lightning energies of 95 Coulombs (cumulative) without failure. Additional requirements apply, including a requirement to direct bond (see "C" below), and to maintain the tubing a minimum of 24" from all metallic chimneys, flues, vents, and masts that extend through the roof. Using such a product, homeowners have the ability to replace their yellow CSST with a flexible product that is safer and will simplify issues associated with structural constraints.

   The LC1027-compliant CSST products are one version of the "second generation" CSST products shown to have a degree of resistance to electrical insult due to lightning. This is accomplished by providing an electrically conductive jacket construction that directs the current around the underlying stainless steel tube, allowing it to dissipate and/or run to the earth (ground).

C) **Install a direct CSST electrical bond:** Since 2007, CSST installations in Lubbock have been required to be directly connected to the electrical service grounding electrode system via a #6 AWG (American Wire Gauge) copper wire ("bonding jumper") and a listed bonding clamp attaching the wire to a rigid portion of the gas piping near the point of gas service entrance. The connection to the grounding electrode system may be made at the electrical service panel (grounding side), or at any accessible point between there and the grounding electrode (rod or concrete-encased electrode, usually the foundation steel). There are many installations prior to 2007 where this was not done. It is relatively inexpensive to have this work done by a licensed electrician.

   The effectiveness of direct bonding, correct bonding methods, and its ability to mitigate damage to CSST due to lightning has been a controversial topic for quite some time. There are definitely situations where CSST has been damaged by lightning when the home has been struck by lightning

directly (a "direct" strike), such as at a chimney cap, even though the CSST was directly bonded in accordance with all requirements. In recommending bonding requirements, the CSST industry does not purport to imply that homes will be protected from "direct" lightning strikes. On the contrary, the industry states that homes will only benefit from direct bonding in "indirect" strike scenarios (those that do not hit the home), where voltages can enter the home through magnetic coupling, inductance, via underground lines, etc.

Given the relative ease with which direct bonding can be accomplished, and the fact that some percentage of lightning events will be mitigated, it goes without saying that it should always be done. It is *not*, however, a "cure-all". See diagrams for direct bonding.

D) **Establish & maintain minimum clearances to other metallic systems:** When lightning strikes a home, all of the metallic systems therein are at once energized by immense amounts of electrical current which will seek *all* paths to ground, and can potentially jump, or "arc" from one pathway to another, where it "sees" a potentially better path to ground. In arcing, heat is created, which will melt items such as gas lines and electrical wiring. If CSST is nearby or in direct contact with other metallic systems, such as metallic chimney flues, vents, pipes, ducts, wires, and so forth, experience shows that some separation should be created and maintained between them. Experts have never agreed on what separation distance is sufficient, coming up with everything from the "thickness of the CSST jacket" (no separation, really) to 2 inches to "reasonable". Some CSST manufacturers had no minimum separation distance specified in their instructions, while others specified a "reasonable distance". The City of Lubbock has established 24 inches for new CJ-CSST installations out of an abundance of caution, but that is only advisory in the case of existing installations, and may not be possible to establish on existing homes. *Any* clearance between CSST and other metallic systems is better than nothing at all. Moving these items should only be done by an appropriately licensed contractor.

E) **Install an equipotential bonding system:** As stated in "D" above, lightning will energize all metallic systems in a building as the current seeks a path to ground. When all of the electrical components are electrically bonded together and connected to the earth ("grounded"), they are at an equal ground "potential", allowing the voltage between them to rise and fall together, minimizing the likelihood of an arc forming between them, which would occur if one ground path had a better potential to ground than an adjacent one, and they were relatively close together. Equipotential bonding is accomplished by having an electrician connect all metallic piping, flues, vents, masts, fireplaces, etc. together with a #6 AWG (American wire gauge) copper bond wire ("jumper") using appropriate connectors, then connecting them to the electrical service grounding electrode system, similar to the "direct bond" discussed in "C" above. Metallic fireplace flues should not be neglected, as their chimney caps are generally the highest point on the home, and the most likely projection to experience a lightning strike.

F) **Install a lightning protection system:** A whole-house lightning protection system, installed in accordance with NFPA standard 780, involves the placement of air terminals (lightning rods) at strategic points around the top of the home, a system of down conductors, ground rods and various bonding connections throughout the home. They will typically incorporate the items mentioned in "C" and "E" above. Such systems must be designed and installed by specialty contractors knowledgeable in the science of lightning protection of structures. *CSST industry experts have*

stated that lightning protection cannot truly be achieved without such a system, also incorporated with equipotential bonding and direct bonding.

G) **Excess gas flow valves:** Excess gas flow valves, or EFV's, are specialized valves designed to be installed in the gas line system, usually either on the main line at the point of service (meter), at the individual appliance connections directly ahead of the appliance, or both. They are designed to allow a predesignated gas flow sufficient to serve the attached appliance(s) and equipment, but will shut down if that flow is exceeded by a marginally higher amount. They are an excellent and affordable safety feature to prevent massive gas leaks associated with major line breakages, but would likely not be very helpful in the typical CSST leak caused by electrical arcing, or even a nail puncture. Given that the appliance EFV's are installed at the individual appliances downstream of the gas line, they would not "sense" any leak upstream, where the CSST hole would occur. Only the EFV at the main service would then come into play, and it must be sized to allow for the total home gas demand. It would, therefore, not shut down until that total demand was exceeded by the specified amount, which could amount to several hundred thousand BTUH's, far more than even a very serious CSST leak.

H) Of course, the obvious option is to eliminate all fuel gas service by converting all gas appliances to electricity. While this would eliminate the potential for any gas-fed fire or gas explosion in a lightning event, it would undoubtedly be the most expensive, as all appliances would require replacement, new circuits would have to be run, and the main electrical service would require upgrading to handle the additional electrical load. Clearly this is overkill and is likely not feasible. Lightning strikes destroy electrical circuits perhaps more easily than they do CSST piping; however, electrical circuits do not carry an unlimited supply of pressurized flammable gas.

Relative effectiveness: The "low to high" ratings given are an educated guess as to the relative effectiveness of the various mitigation methods as compared to unprotected, first generation (yellow) CSST, and are based on our exposure to various engineering viewpoints, case studies, and experience. One must remember that in any discussion of CSST protection methods, no matter who is doing the talking, there are always two paradigms- the direct lightning strike and the indirect lightning strike. You have to know which one is being discussed, or it can be misleading. In all likelihood, *no* mitigation method is sufficient for the relatively rare direct strike involving the also rare positively-charged lightning flash of several hundred Coulombs of energy. For the less rare negatively charged flashes that *do not* directly strike a home, it is felt the ratings should be appropriate. However, one does not want to assume that these much more common events, 50% of which can generate energy of more than of 15.8 Coulombs, are only going to hit the back yard or the neighbor (an indirect strike) either, particularly when the yellow CSST can fail at 0.12 Coulombs. For this reason, either total replacement with a more robust system should be considered, or a combination of the other methods. Direct strikes can and do happen, have happened in our area, and we believe our flat, treeless topography and tendency to place utility infrastructure underground increases the likelihood of direct strikes on structures.

If you have yellow CSST in your home, you are urged to study the above, become informed, and discuss options with a Texas-licensed plumber and electrician.