RICHMOND ICC
INTERNATIONAL CODE COUNCIL 2018

Welcome to the

2018 Annual Conference Educational Sessions

Session: Why, When, What and Where Lightning Protection is Required

Sponsored by ORACLE

OmegaFlex®

Why, When, What and Where Lightning Protection is Required

Model Codes, Standards, Listings and Instructions

October 2018

TracPipe® CounterStrike®
Flexible Gas Piping by OmegaFlex®

Why, When, What and Where

Who is Bob Torbin?

Professional Engineer
BS and MS Mechanical Engineering
Over 40 years industrial experience
Director of Codes and Standards
NFPA 54-TC and Chair-ANSI LC-1

Why, When, What and Where

“Lightning is a stochastic, if not capricious, natural process. It behavior is not yet completely understood.”

NFPA Standards Council

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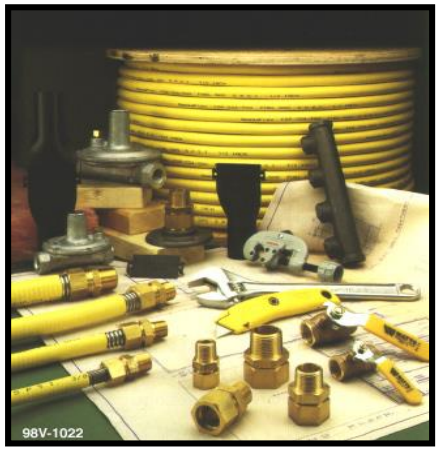
Why, When, What and Where

What is CSST?



- National Standard ANSI LC-1
- System performance-based standard
- Listed system installed in accordance with manufacturer's instructions and local code
- Standard recognized in all fuel gas codes
- Commercially introduced in 1990
- More than 1.2 billion feet installed

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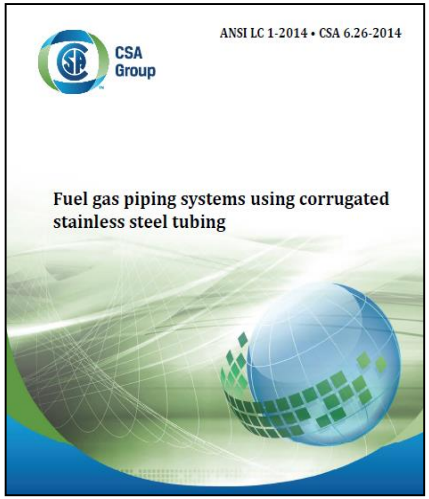
Why, When, What and Where

Applicable Certifications and Listings

- Tested and listed by CSA (NRTL) to ANSI LC-1
- Tested and listed by IAPMO R&T
- Tested and listed by ICC ES
- Tested and listed by UL for E-84



ICC ES PMG

IAPMO ES™

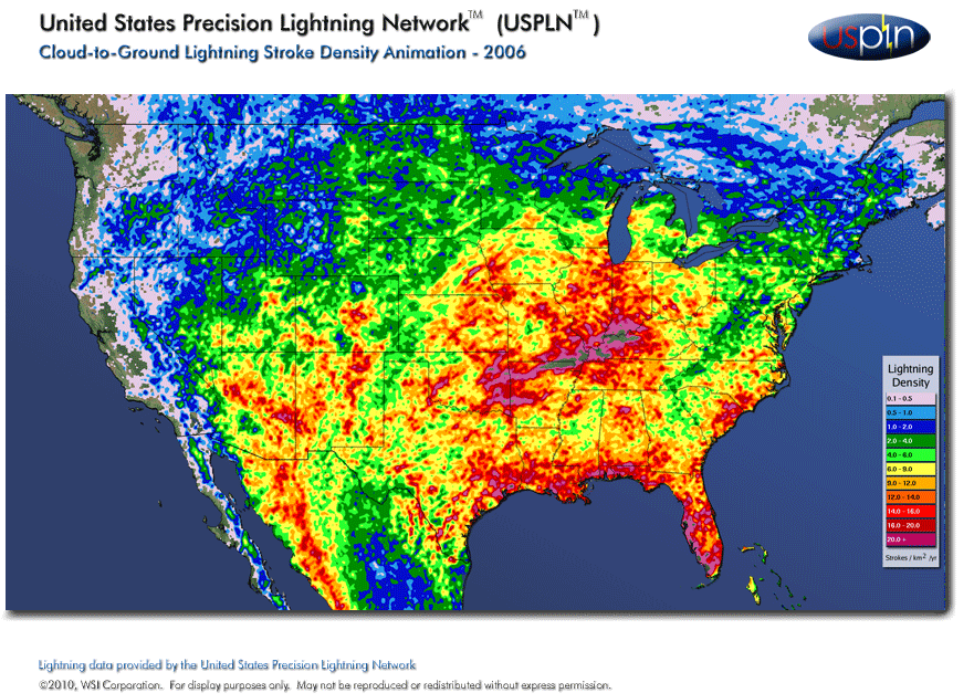
CSA Group

Why, When, What and Where

Advantages of CSST

- Long continuous runs
- Few joints
- Smaller installation crew
- Faster installation time
- Only simple hand tools required
- No threading machines/mess
- Safer interaction with structure

Why Lightning is a Problem



Total lightning strokes in US per year: 20-40,000,000*

Regional issue

No house, equipment or material safe from direct lightning strike

[*USPLN: 2005-2009]

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Why, When, What and Where

Lightning Pathways

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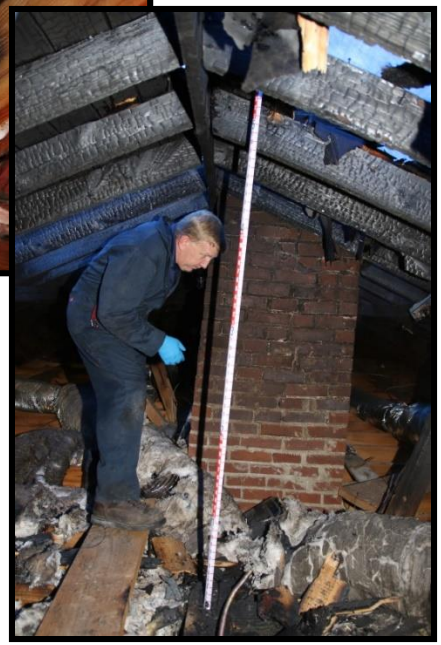
Why, When, What and Where



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Why, When, What and Where

Residential House Fire Statistics

Average annual number of U.S. home fires by cause*:

- 1 & 2 family house fires: 358,000
- Fires caused by electric distribution: 31,960
- Fires caused by fuel gas: 9,040 (2440 leaks & breaks)
- Fires caused by lightning: 4,300
  - Fires caused by lightning/wires: 380
  - Fires caused by lightning/fuel gas: 210

Lightning damage to gas piping is an uncommon event compared to other causes of fires.

[* 2010-2014 NFPA Statistical Data]

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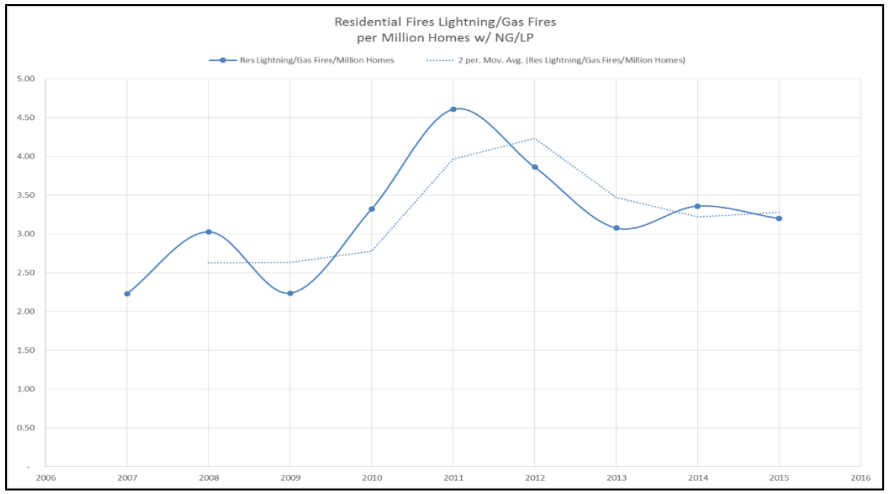
Why, When, What and Where

Reality Check: Lightning Damage

- Less than 100 lightning CSST fires per year and declining
- CSST lightning fires are less than 0.05% of total house fires
- CSST lightning fires are less than 1% of all gas fires
- 75% of lightning damage: yellow CSST not bonded
- Over 200,000 insurance claims per year for lightning damage



CSST does not represent a clear and present danger to consumers.

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Why, When, What and Where

Lightning does not discriminate. It seeks all pathways to ground.

Arcing damage impacts all metallic systems including wiring and all gas piping materials.

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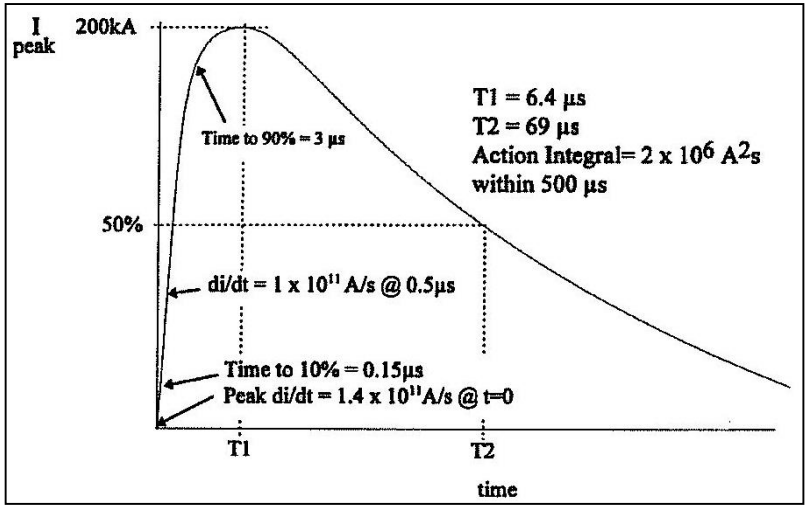
Why, When, What and Where

Why Bonding Works

Damage not due to lightning induced voltage levels, but due to large differential in voltage potential.



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When Did Things Change

Changes in Construction

No residential sprinklers
Lightweight engineered wood products
Large homes wood frame construction
Southeastern/western demographics
Former farm fields

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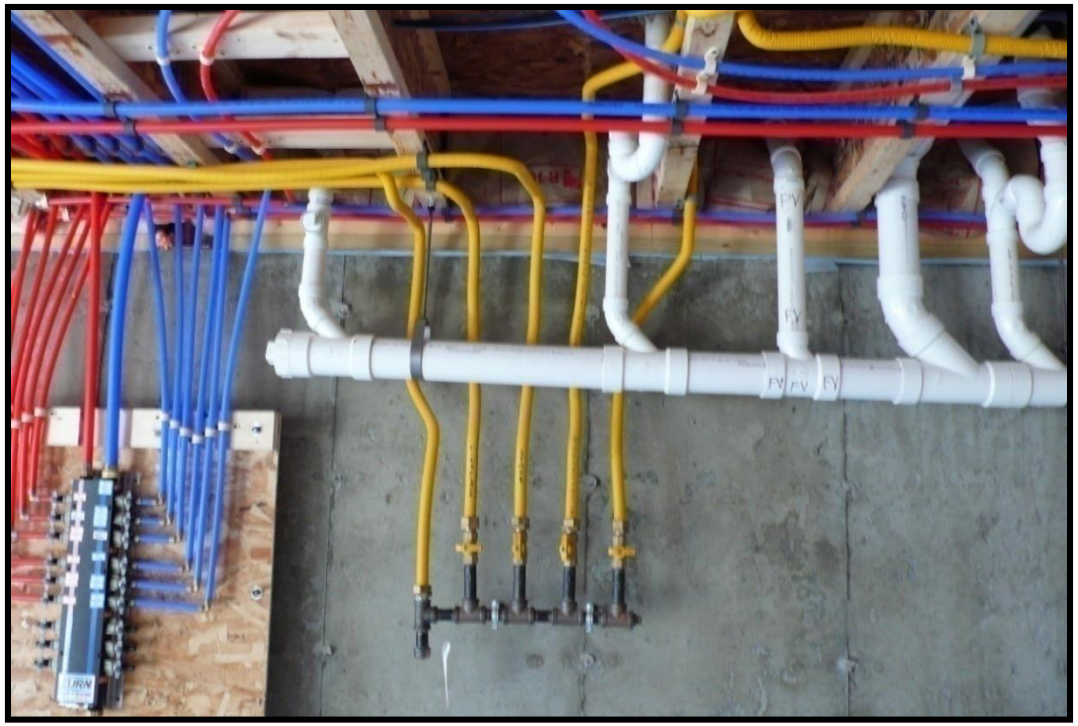
Why, When, What and Where

Changes in Plumbing/Fuel Gas



Loss of metal piping

- Vents/drains
- Water
- Fuel gas

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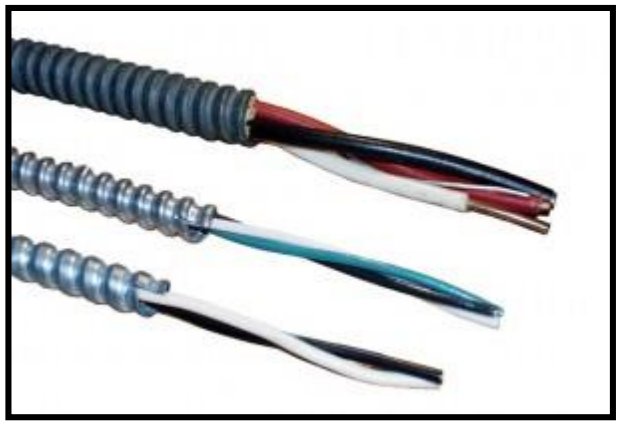
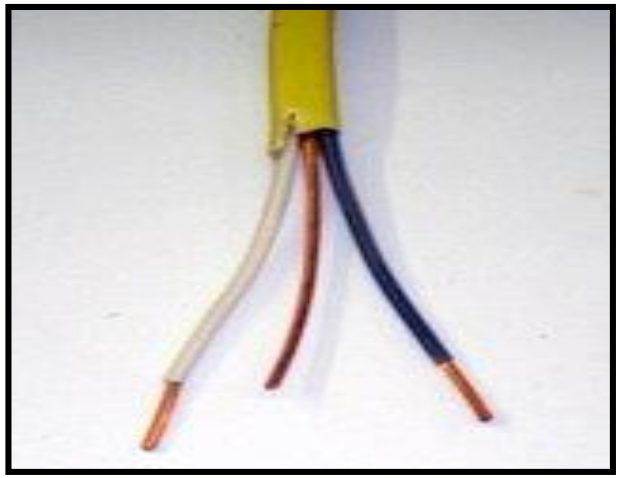
Why, When, What and Where





Changes in Electrical

- Replacement of metallic conduit for electric power cable (such as MC or EMT) with NMS (romex) wiring.
- Dielectric strength of wire insulation can breakdown under lightning stress and cause arcing.
- Alternative communications

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Why, When, What and Where

Changes in Mechanical

Metallic appliance flue (in stead of brick/clay chimneys) which rise above the roofline. Metal vent acts like lightning rod not directly connected to the electrical grounding system.

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What are the Code Requirements

Codes and Standards

- National Electrical Code (NFPA 70)
- National Fuel Gas Code (NFPA 54)
- International Fuel Gas Code
- Lightning Protection Std. (NFPA 780)
- ANSI Standards

- 50 State Fuel Gas Codes

No requirements for lightning protection

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Why, When, What and Where

Product Standards

- National consensus standards
- No requirements for lightning resistance or certification
- No prescribed national test method for lightning resistance
- For both mechanical and electrical equipment

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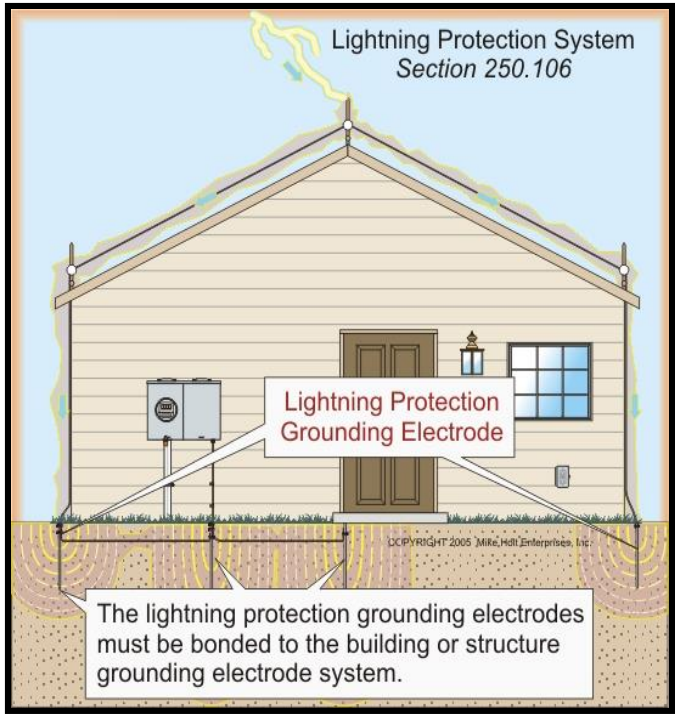
Why, When, What and Where

NFPA 780: Lightning Protection System



- Lightning protection not mandated
- Designed to protect the structure but not a 100% guarantee
- Active and passive protection
- LPS require equi-potential bonding of all metallic systems
- Bond all gas piping (6 AWG)

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Why, When, What and Where

National Electrical Code (NFPA 70-2014)

Bonding of Piping Systems

(B) Other Metal Piping. If installed in or attached to a building or structure, metal piping system(s), including gas piping, that is likely to become energized shall be bonded to any of the following: equipment grounding conductor for the circuit that is likely to energize the piping system; service equipment enclosure; grounded conductor at the service; grounding electrode conductor if of sufficient size; or one or more grounding electrodes used. The bonding conductor(s) or jumper(s) shall be sized in accordance with 250.122 using the rating of the circuit that is likely to energize the piping system(s). The points of attachment of the bonding jumper(s) shall be accessible.

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Why, When, What and Where

NEC- Ground Fault Protection

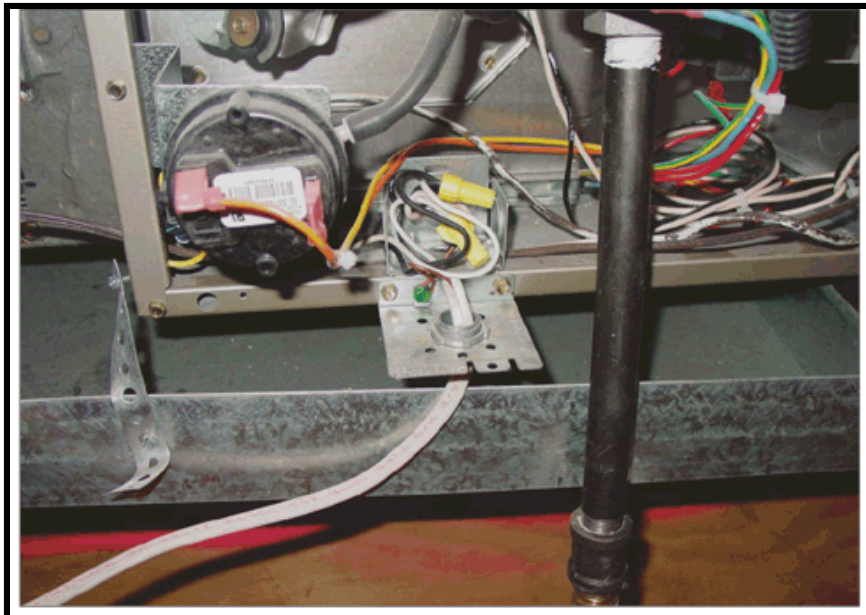

Photo 5. A gas furnace supplied by a branch circuit that has a metal gas piping system supplying it

EGC sized to protect against ground faults

Bonding wire sized based on size of branch circuit

12 AWG wire not designed to handle large DC voltage associated with lightning

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Why, When, What and Where

Manufacturer's Bonding Requirements (2006)

- Downstream of point of delivery
- Single point of attachment required
- Bonding clamp on pipe/fitting
- Conductor at least 6 AWG copper
- Conductor as short as practical
- Connect to grounding electrode system

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Why, When, What and Where

2009/2012 IFGC/IRC: Electrical Bonding*

CSST. CSST gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream CSST fitting. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of CSST shall be bonded in accordance with this section.

*** Informational Note in 2011 NEC**

Why, When, What and Where

Bonding Effectiveness Research

gti®

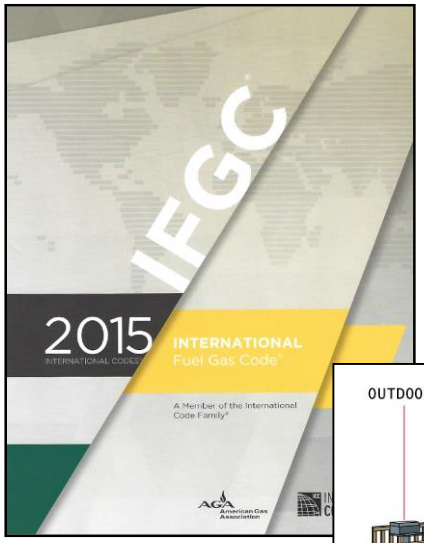
Phase I: State-of-the-Art Review: SEFTIM

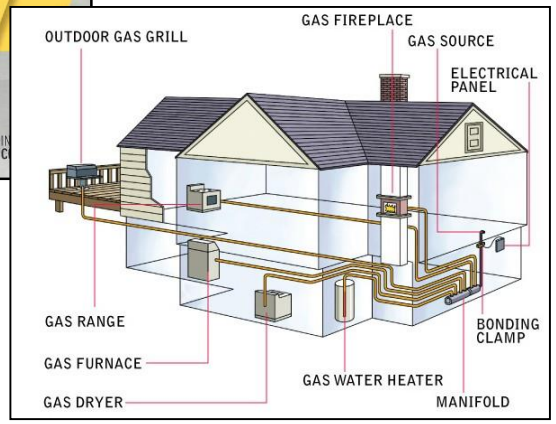
Phase II: Testing Program
- Parametric testing of CSST
- Computer simulations
- System testing/verification
- Final predictive simulations

Phase III: Publish Results

Why, When, What and Where

2015 IFGC Requirements





- Bonding is required for all CSST
- Clamp located anywhere
- Single point of attachment
- Conductor of 75-ft or less
- Required for new and retrofit
- Bond all grounding electrodes

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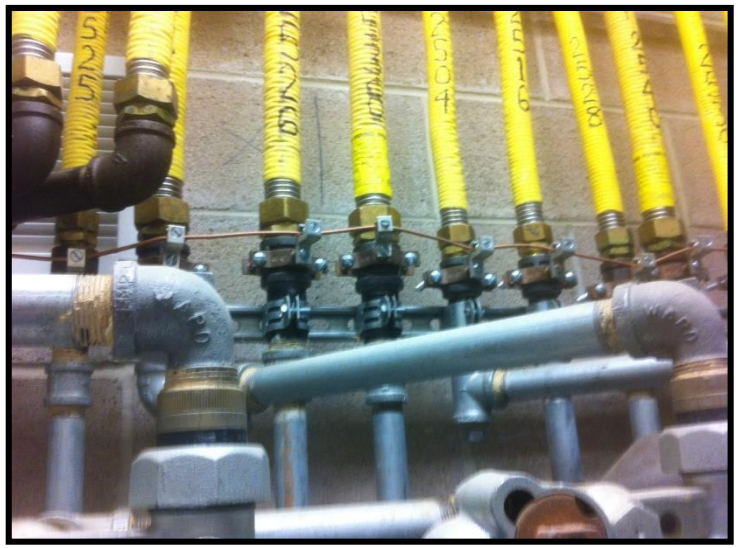
Where is Bonding Performed

Bonding Gas Systems After “Point of Delivery”



* Bonding Clamps listed to UL 467

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Why, When, What and Where

Bonding Gas Systems After “Point of Delivery”

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Why, When, What and Where

Bonding Clamp* Attachment

* Clamps listed for CSST fittings

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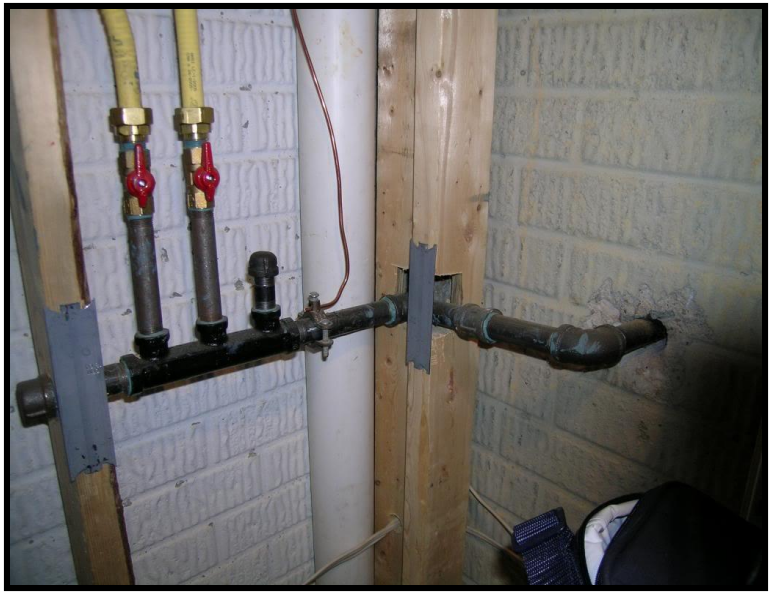
Why, When, What and Where

Bonding Clamp Attachment



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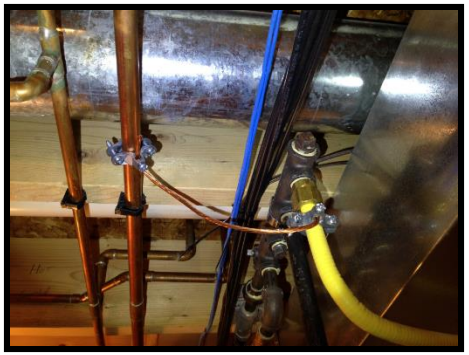
Why, When, What and Where

Bonding Clamp Attachment

Never place bonding clamp directly on CSST tubing or jacket



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Why, When, What and Where

Bonding Requirements

Gas piping systems that contain one or more segments of CSST shall be bonded.

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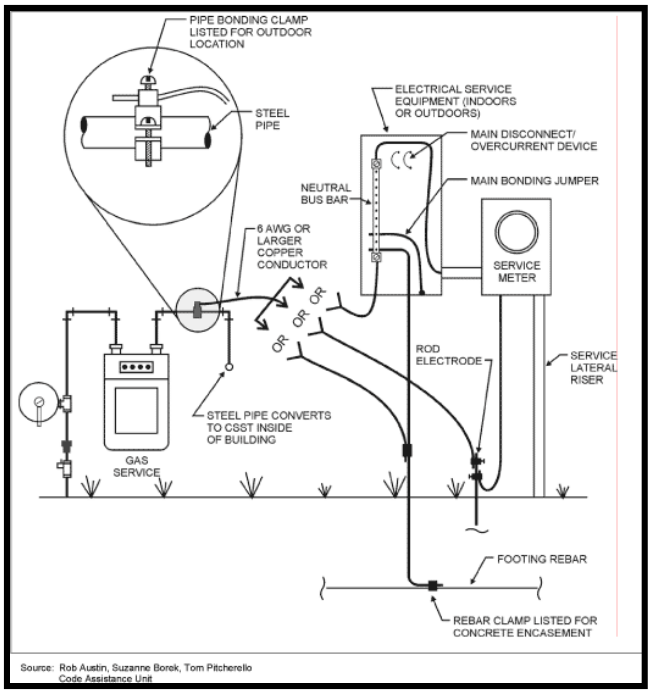
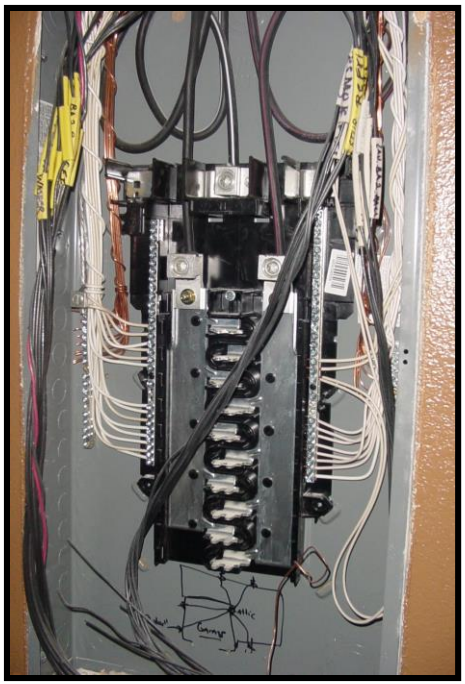
Why, When, What and Where

Bonding Connections





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Why, When, What and Where

Bond Connection to Grounding System

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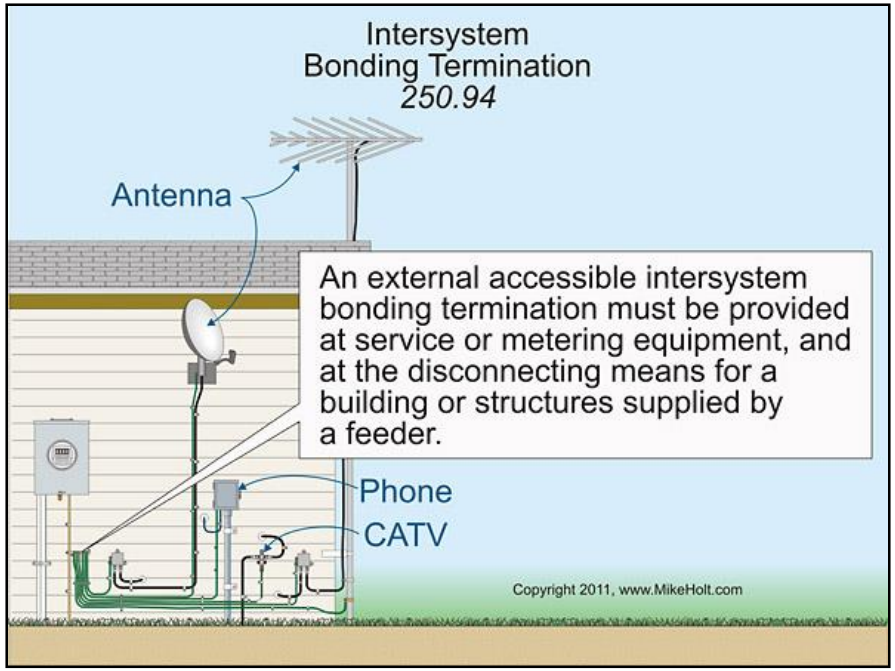
Why, When, What and Where

Bond to Intersystem Bonding Terminal?



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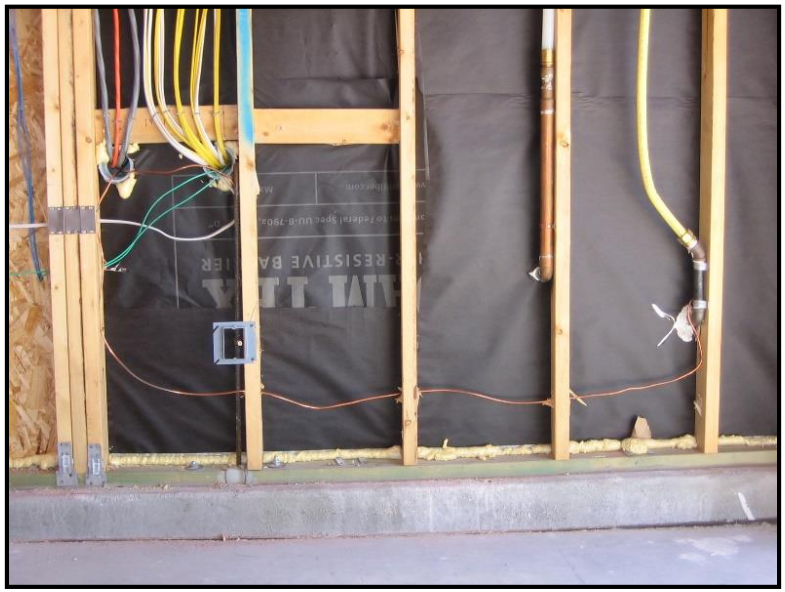
Why, When, What and Where

Bonding Requirements



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Why, When, What and Where

Bonding Conductor Sizing

- Conductor at least 6 AWG copper or 4 AWG aluminum
- Conductor single or multi-strand
- Conductor length less than 75-ft
- Shorter is better

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Why, When, What and Where

Bonding Effectiveness Factors

- Lightning entry point
- Equi-potential bonding
- Bonding location
- Length of conductor
- Proximity of other pathways
- Grounding electrode system

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Why, When, What and Where

Technical Innovation - Arc-resistant CSST

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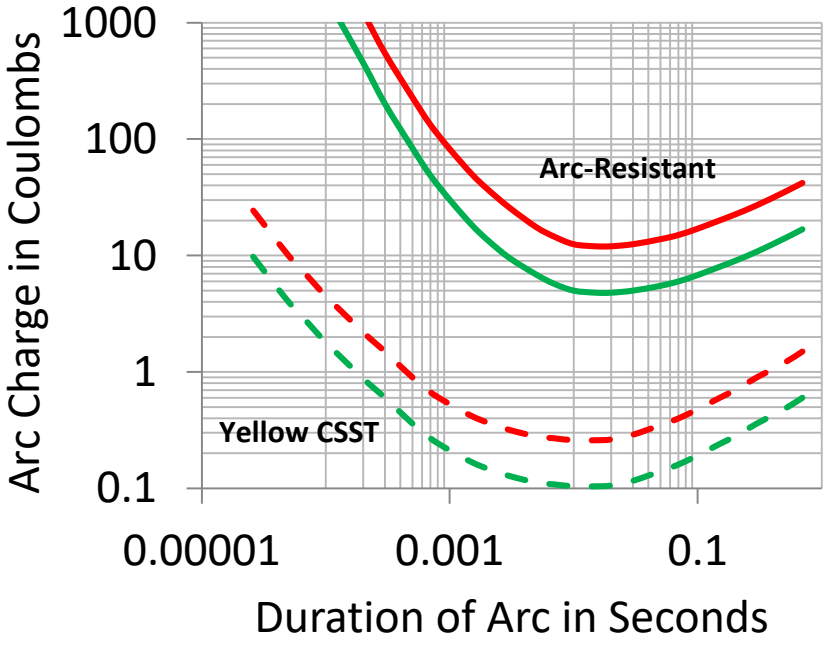
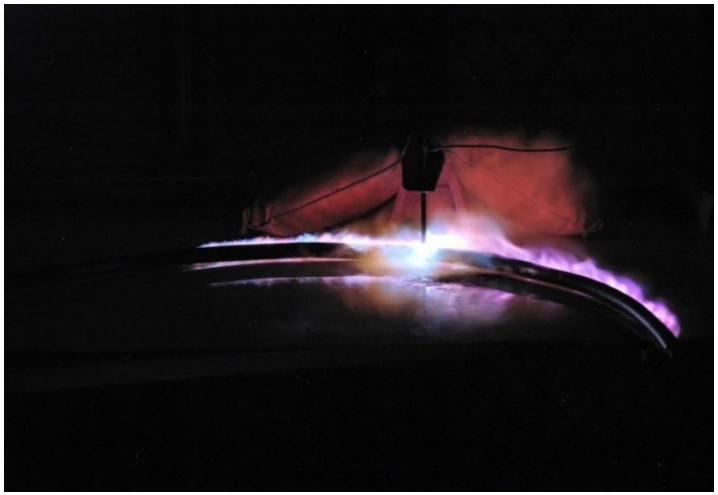
Why, When, What and Where

Arc-resistant Protective Jacket*





[* No product is immune from lightning damage.]

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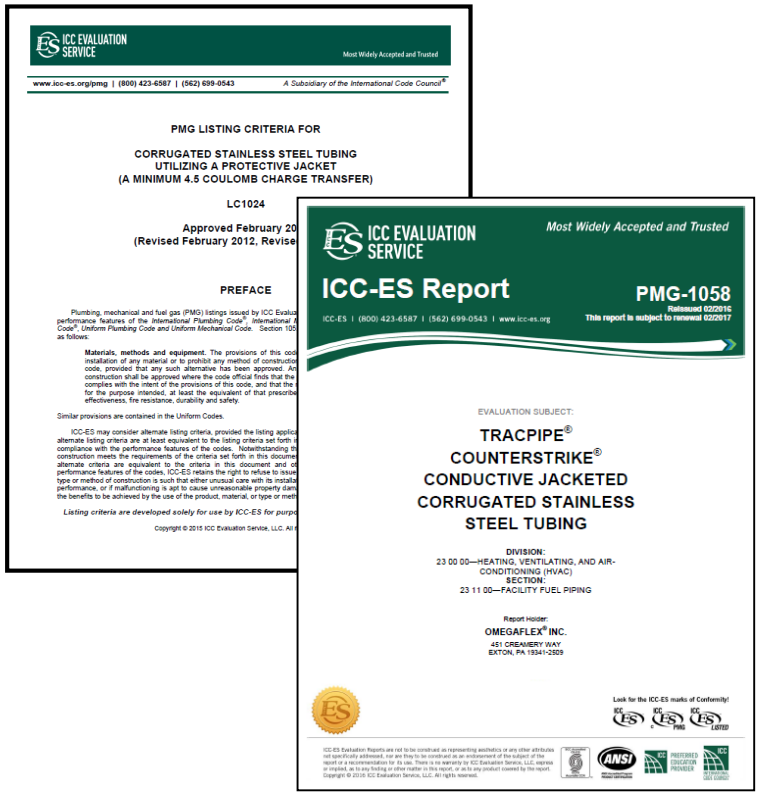
Why, When, What and Where

CSST Listing Criteria (2010/2011)



- Establish minimum arc-resistance
- 4 arc-resistant CSST available
  - CounterStrike/OmegaFlex
  - Wardflex Max/Ward
  - FlashShield/Gastite
  - Flak Jacket/ProFlex
- Show bonding equivalency

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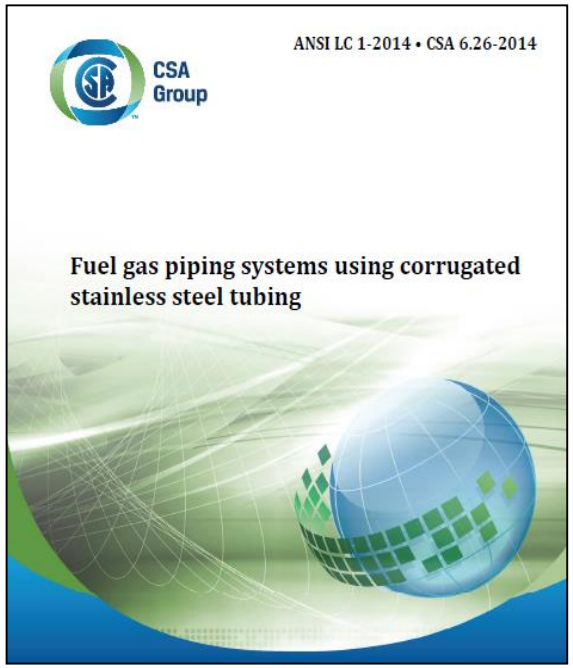
Why, When, What and Where

ANSI LC-1-2014 CSST Standard



- Both yellow and black CSST
- Electrical arcing testing: 4.5 C
- Jacket wear/ripping testing
- Cold temperature tolerance
- Corrosion evaluation on metallic parts
- All current black CSST certified

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Why, When, What and Where

2018 IFGC/IRC Code

Yellow CSST

- Bonding required
- Conductor of 75-ft or less

Black CSST

- Bonding not required
- CSST listed per ANSI LC-1-2014

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Why, When, What and Where

2018 IFGC: Electrical Bonding

310.2 CSST. CSST gas piping systems and piping systems containing one or more segments of CSST (not listed with an arc resistant jacket or coating system in accordance with ANSI LC-1) shall be electrically continuous and bonded to the electrical service grounding electrode system or, where provided, the lightning protection grounding electrode system. (and shall comply with Sections 310.2.1 through 310.2.5.

310.2.1 Point of connection
310.2.2 Size and material of jumper
310.2.3 Bonding jumper length
310.2.4 Bonding connections
310.2.5 Connection devices

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Why, When, What and Where

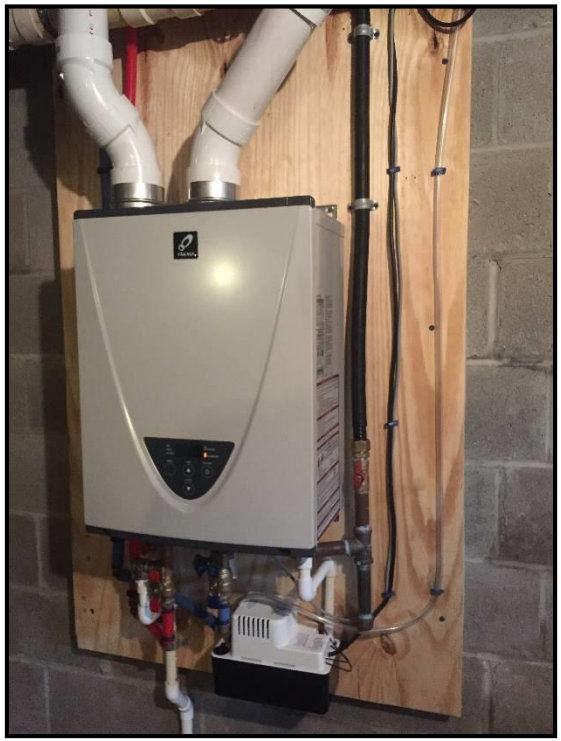
2018 IFGC: Electrical Bonding

310.3 Arc-resistant CSST. Corrugated Stainless steel tubing that is listed with an arc resistant jacket or coating system in accordance with ANSI LC-1 shall comply with this section. The CSST shall be electrically continuous and bonded to an effective ground-fault current path. Arc-resistant-jacketed CSST shall be considered to be bonded where it is connected to an appliance that is connected to the appliance grounding conductor of the circuit that supplies that appliance.

Where any CSST component of a piping system that does not have an arc resistant jacket or coating system, the bonding requirements of Section 310.2 shall apply.

Why, When, What and Where

Installing Arc-Resistant CSST



Why, When, What and Where

Different Listing Criteria

ICC ES LC-1024

ICC ES LC-1027

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How Not To Bond

No Separate Gas Grounding Electrode

Gas piping shall not be used as a grounding conductor or electrode.

Bonding clamp always on customer side of the meter.

Only one grounding system for the house.

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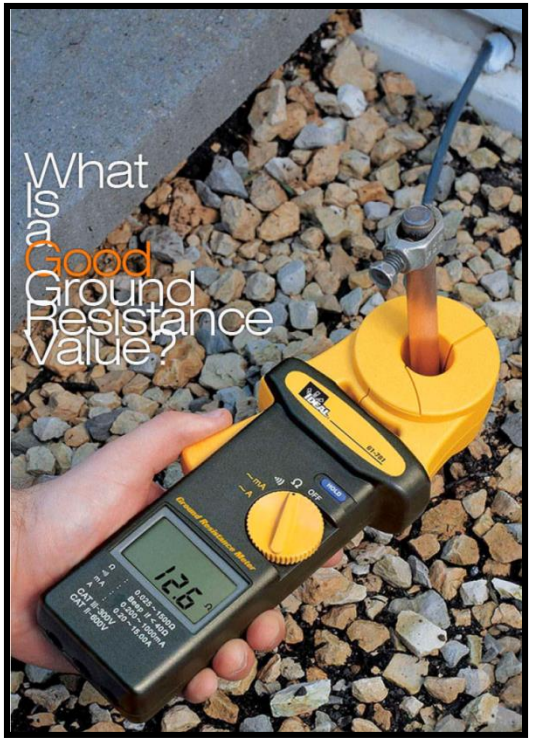
Why, When, What and Where

Ground Connection of Grounding Electrode(s)



Earth resistance reading at ground rod must be less than 25 Ohms or a second driven rod must be installed.

Earth resistance can vary based on soil type, season and type of electrode.

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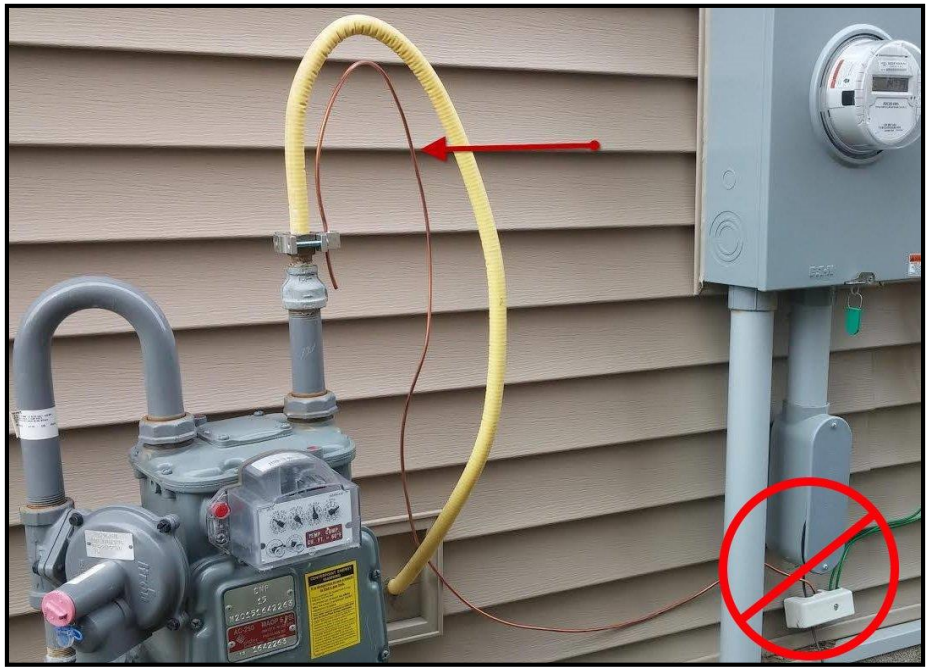
Why, When, What and Where

Protect CSST & Conductor From Physical Damage



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Why, When, What and Where

Good News and Bad News

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Why, When, What and Where

Avoid Direct Contact with Metallic Systems

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Where Do We Go From Here

Inspector Training/Education/Code Change

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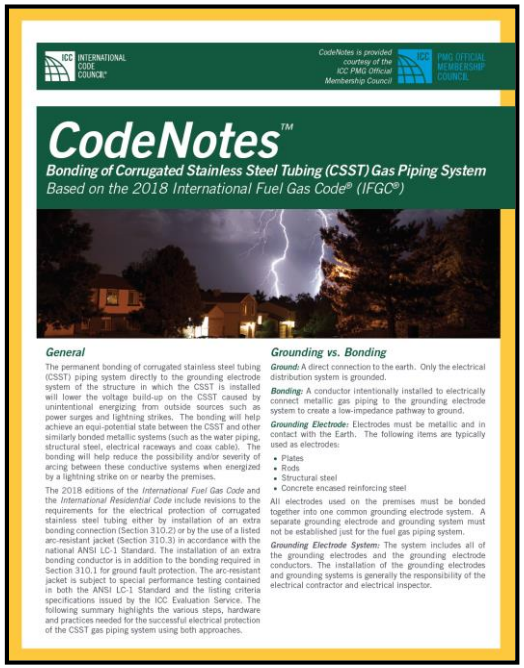
Why, When, What and Where

ICC CodeNotes (2015 and 2018)



CodeNotes is provided courtesy of the ICC PMG Official Membership Council

CodeNotes™

Bonding of Corrugated Stainless Steel Tubing (CSST) Gas Piping System

Based on the 2018 International Fuel Gas Code® (IFGC®)

General

The permanent bonding of corrugated stainless steel tubing (CSST) piping system directly to the grounding electrode system of the structure in which the CSST is installed will lower the voltage build-up on the CSST caused by unintentional energizing from outside sources such as power surges and lightning strikes. The bonding will help achieve an equi-potential state between the CSST and other similarly bonded metallic systems (such as the water piping, structural steel, electrical raceways and coax cable). The bonding will help reduce the possibility and/or severity of arcing between these conductive systems when energized by a lightning strike on or nearby the premises.

The 2018 editions of the *International Fuel Gas Code* and the *International Residential Code* include revisions to the requirements for the electrical protection of corrugated stainless steel tubing either by installation of an extra bonding connection (Section 310.2) or by the use of a listed arc-resistant jacket (Section 310.3) in accordance with the national ANSI LC-1 Standard. The installation of an extra bonding conductor is in addition to the bonding required in Section 310.1 for ground fault protection. The arc-resistant jacket is subject to special performance testing contained in both the ANSI LC-1 Standard and the listing criteria specifications issued by the ICC Evaluation Service. The following summary highlights the various steps, hardware and practices needed for the successful electrical protection of the CSST gas piping system using both approaches.

Grounding vs. Bonding

Ground: A direct connection to the earth. Only the electrical distribution system is grounded.

Bonding: A conductor intentionally installed to electrically connect metallic gas piping to the grounding electrode system to create a low-impedance pathway to ground.

Grounding Electrode: Electrodes must be metallic and in contact with the Earth. The following items are typically used as electrodes:

- Plates
- Rods
- Structural steel
- Concrete encased reinforcing steel

All electrodes used on the premises must be bonded together into one common grounding electrode system. A separate grounding electrode and grounding system must not be established just for the fuel gas piping system.

Grounding Electrode System: The system includes all of the grounding electrodes and the grounding electrode conductors. The installation of the grounding electrodes and grounding systems is generally the responsibility of the electrical contractor and electrical inspector.

CodeNotes is provided courtesy of the ICC PMG Official Membership Council

CodeNotes™

Conexión Equipotencial de Tubos Corrugados de Acero Inoxidable (CSST) para Sistemas de Tuberías de Gas

basado en el Código Internacional de Gas Combustible 2015 [2015 International Fuel Gas Code® (IFGC®)]

El CSST debe permanecer conectado eléctricamente de forma directa al sistema de electrodos del servicio eléctrico de la casa en la que el CSST está instalado. La conexión equipotencial de sistemas de tuberías de gas combustible es considerada como trabajo de electricistas y debe realizarse por un contratista calificado reconocido por la autoridad competente como capaz de hacer este tipo de trabajo. El siguiente documento destaca una lista de revisión de elementos, herramientas y prácticas necesarias para vincular eléctricamente e inspeccionar el sistema de tuberías de gas combustible CSST.

Generalidades:

La conexión equipotencial de tubos corrugados de acero inoxidable (CSST) del sistema de tuberías al sistema de electrodos de puesta a tierra en el cual el CSST está instalado, reducirá la acumulación de voltaje en el CSST que es provocado por las cargas de energía no intencional de fuentes externas tales como incrementos de voltaje repentinos y tormentas eléctricas. La conexión equipotencial ayudará a lograr un estado equipotencial entre el CSST y otros sistemas metálicos similarmente vinculados eléctricamente (tuberías de suministro de agua, acero estructural, conductos eléctricos y cable coaxial). La conexión equipotencial ayudará a reducir las posibilidades y la severidad de los puenteos entre estos sistemas conductivos cuando estén cargados eléctricamente a causa de la caída de un rayo en una tormenta eléctrica en el sitio o en las cercanías.

La edición 2015 de los Códigos de Instalaciones de Gas Combustible *(International Fuel Gas Code)* y de Vivienda *(International Residential Code®)* incluye revisiones a los requerimientos para la protección eléctrica de tubos corrugados de acero inoxidable mediante una conexión extra para la conexión equipotencial (Sección 310.1.1). Esto es además de la conexión equipotencial requerida en la Sección 310.1 para la protección por puesta a tierra.

Puesta a Tierra vs Conexión Equipotencial:

Puesta a tierra: Es una conexión directa al suelo. Sólo el sistema de distribución eléctrica es puesto a tierra.

Conexión Equipotencial: Es un conductor intencionalmente instalado a una tubería metálica de gas combustible conectada al sistema de electrodos puestos a tierra para crear una trayectoria de baja impedancia a tierra.

Electrodo de puesta a tierra: Los electrodos deben ser metálicos y estar en contacto con el suelo. Los siguientes elementos son usados típicamente como electrodos:

- Placas
- Varillas
- Acero estructural
- Acero reforzado encofrado en concreto

Todos los elementos del conjunto de electrodos deben estar conectados eléctricamente a un solo sistema común de electrodos puestos a tierra. Un electrodo puesto a tierra separado del sistema de puesta a tierra no se puede establecer únicamente para el sistema de tuberías de gas combustible.

Sistema de Electrodos de Puesta a Tierra: El sistema incluye los electrodos de puesta a tierra y los conductores de electrodos de puesta a tierra.

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Questions and Answers?

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