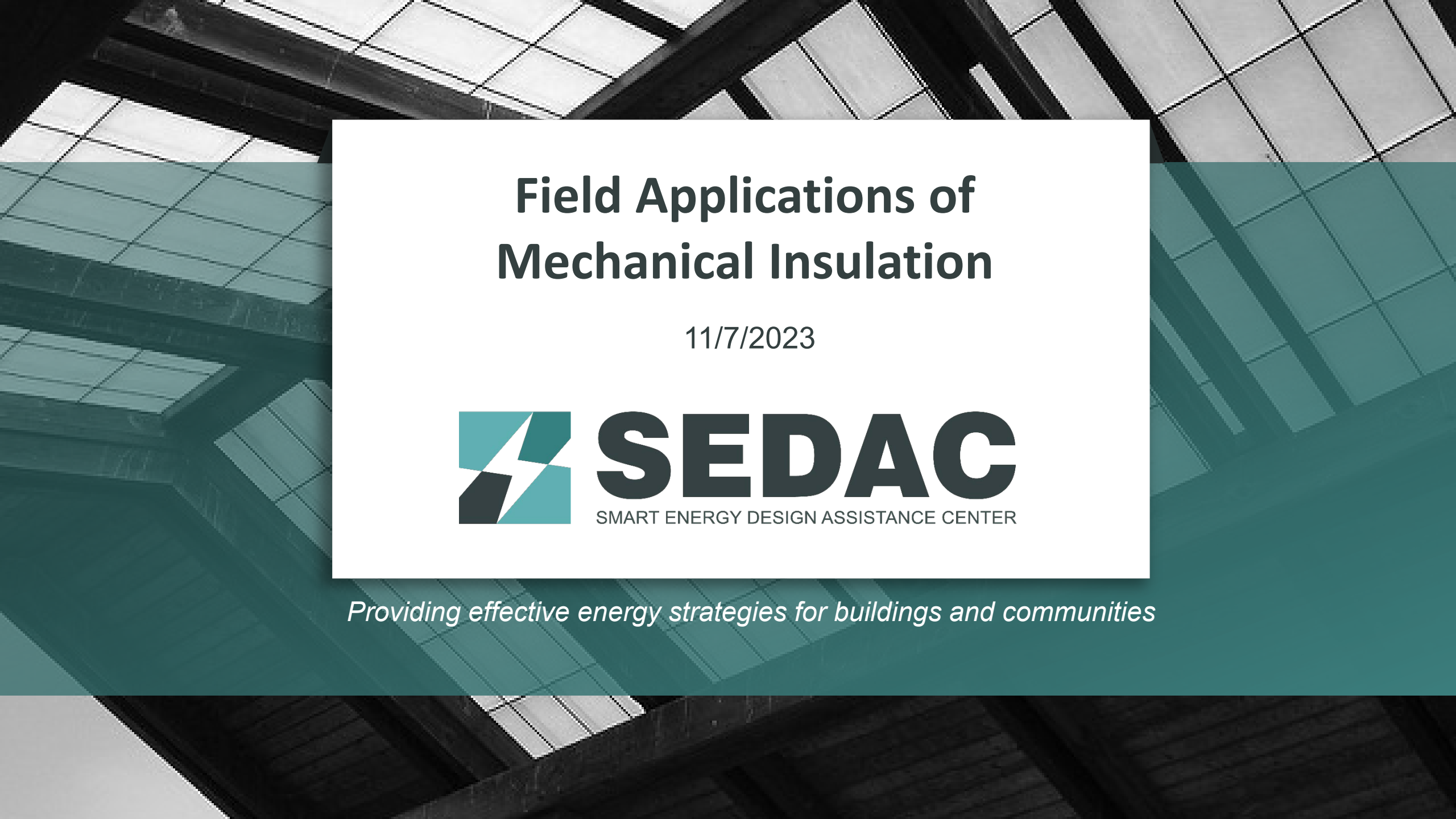

Field Applications of Mechanical Insulation

11/7/2023

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Providing effective energy strategies for buildings and communities

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Presenters:

Bob Flynn – Heat and Frost Insulators

Shawn Maurer - SEDAC

Learning Objectives

By the end of the presentation, participants will be able to:

1. Summarize the energy code requirements for mechanical system insulation.
2. Assess real world insulation examples for energy code compliance.
3. Identify design details that can help avoid common insulation installation issues.
4. Describe the energy and maintenance impacts of improper insulation installation.

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Who We Are

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Our mission: Reduce the energy footprint of Illinois and beyond

What We Do

We are an applied research program at the University of Illinois.

We assist buildings and communities in achieving energy efficiency, saving money, and becoming more sustainable.

We **help facilities** become more energy efficient.

We **educate.**

We **research.**

We **advocate** for a greener future.

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SEDAC is the Illinois Energy Conservation Code Training Provider

This training program is sponsored by **Illinois EPA Office of Energy**

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SEDAC is a Preferred Education Provider with the International Code Council (ICC). Credits earned on completion of this program will be reported to ICC for ICC members. Certificates of Completion will be issued to all participants.

ICC PREFERRED EDUCATION PROVIDER

This workshop is approved for 1 LU/HSW CES credits from the American Institute of Architects (AIA). Credits earned on completion will be reported for AIA members.

AIA Continuing Education Provider

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Energy Code Assistance

Technical support

- energycode@sedac.org
- 800.214.7954

Online resources at
smartenergy.illinois.edu/energy-code

- Workshops
- Webinars
- Online on-demand training modules

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SEDAC Energy Code Training Series

Energy Code Webinar Schedule

08.22.23 – ARCHIVED – Energy Code Basics
09.26.23 – ARCHIVED - Existing Residential Buildings
11.07.23 – Field Applications of Mechanical Insulation
11.14.23 – Residential Stretch Code
12.12.23 – Q&A Review – How We Answer Energy Code Questions
02.20.24 – Commercial Stretch Code
04.09.24 – Simplified Code Compliance
05.21.24 – Existing Commercial Buildings
06.11.24 – Q&A Review – How We Answer Energy Code Questions

Registration: https://smartenergy.illinois.edu/events

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SEDAC Energy Code In-person Workshops

10.17.23 - Energy Code Basics and Q&A review – Workshop 1
(Thanks for joining us in Springfield last month!)

03.19.24 – Workshop 2
Energy Code Basics, Simplifying Code Compliance & Q&A Review
– Location: TBD

Registration: https://smartenergy.illinois.edu/events

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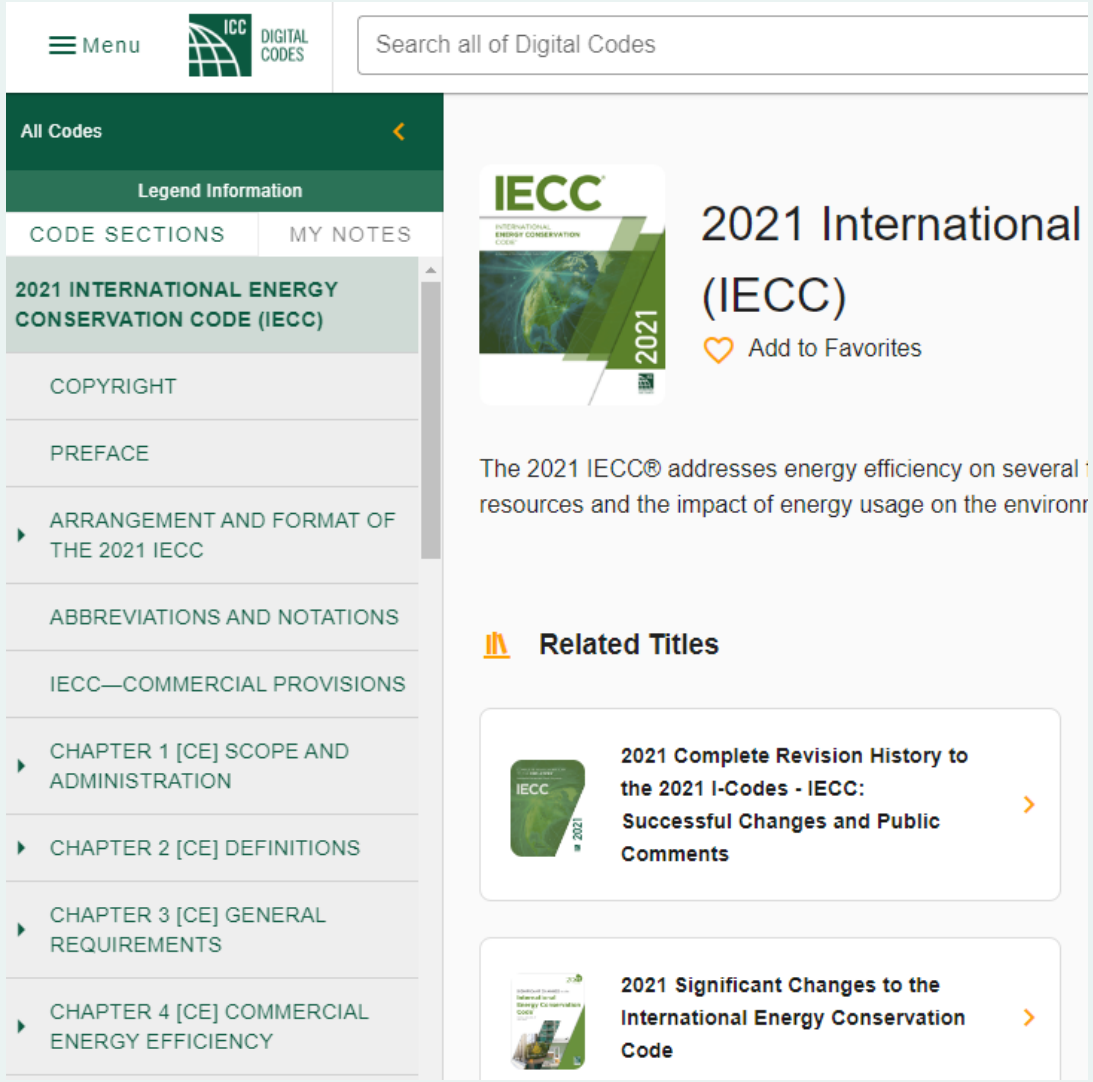
Illinois Energy Conservation Code

Updated Illinois Energy Conservation Code (2021 IECC with IL Amendments) is expected to be effective in the November of 2023.

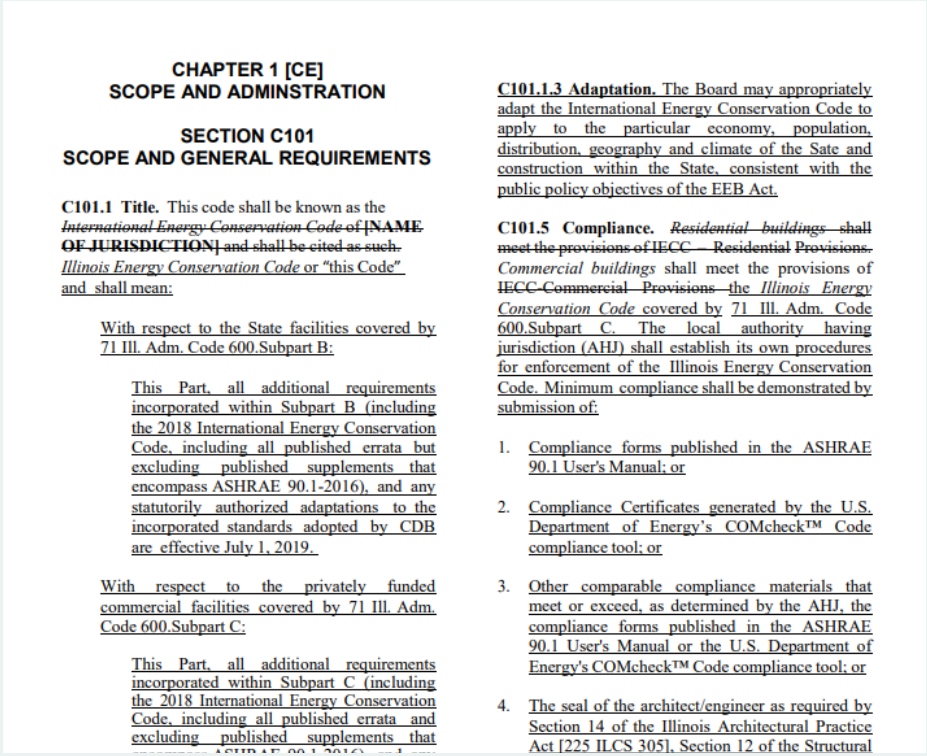
Amendments have completed public review, awaiting JCAR meeting for approval.

We will continue to update our site with the latest information.

Access to 2021 IECC & IL Amendments



IL Amendments DRAFT:
CDB May 2023 Board Book
pp 026-069



CHAPTER 1 [CE]
SCOPE AND ADMINSTRATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title. This code shall be known as the ~~*International Energy Conservation Code* of **[NAME OF JURISDICTION]** and shall be cited as such.~~ *Illinois Energy Conservation Code* or "this Code" and shall mean:

With respect to the State facilities covered by 71 Ill. Adm. Code 600.Subpart B:

This Part, all additional requirements incorporated within Subpart B (including the 2018 International Energy Conservation Code, including all published errata but excluding published supplements that encompass ASHRAE 90.1-2016), and any statutorily authorized adaptations to the incorporated standards adopted by CDB are effective July 1, 2019.

With respect to the privately funded commercial facilities covered by 71 Ill. Adm. Code 600.Subpart C:

This Part, all additional requirements incorporated within Subpart C (including the 2018 International Energy Conservation Code, including all published errata and excluding published supplements that

C101.1.3 Adaptation. The Board may appropriately adapt the International Energy Conservation Code to apply to the particular economy, population, distribution, geography and climate of the Sate and construction within the State, consistent with the public policy objectives of the EEB Act.

C101.5 Compliance. ~~*Residential buildings* shall meet the provisions of IECC—Residential Provisions.~~ *Commercial buildings* shall meet the provisions of ~~IECC-Commercial Provisions~~ the *Illinois Energy Conservation Code* covered by 71 Ill. Adm. Code 600.Subpart C. The local authority having jurisdiction (AHJ) shall establish its own procedures for enforcement of the Illinois Energy Conservation Code. Minimum compliance shall be demonstrated by submission of:

1. Compliance forms published in the ASHRAE 90.1 User's Manual; or
2. Compliance Certificates generated by the U.S. Department of Energy's COMcheck™ Code compliance tool; or
3. Other comparable compliance materials that meet or exceed, as determined by the AHJ, the compliance forms published in the ASHRAE 90.1 User's Manual or the U.S. Department of Energy's COMcheck™ Code compliance tool; or
4. The seal of the architect/engineer as required by Section 14 of the Illinois Architectural Practice Act [225 ILCS 305], Section 12 of the Structural

https://codes.iccsafe.org/content/IECC2021P2

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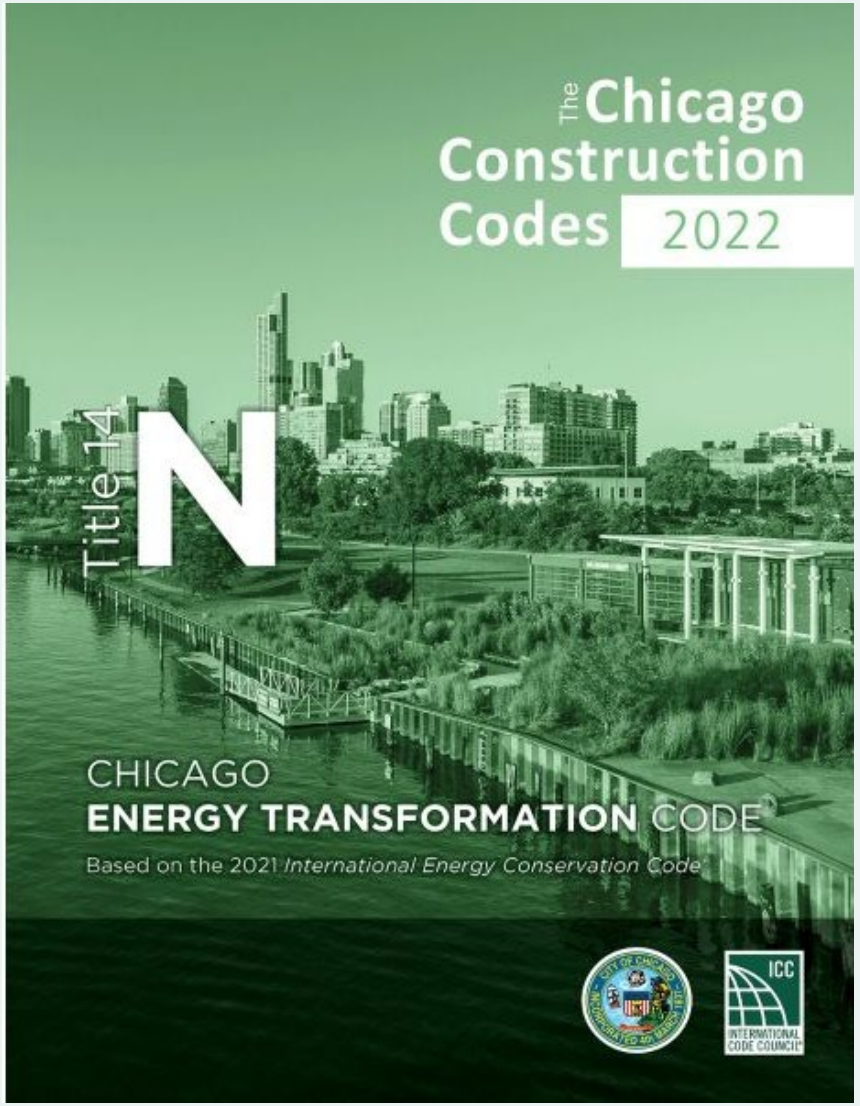
Access to Chicago Energy Transformation Code



ARTICLE XIII.
CHICAGO ENERGY CONSERVATION CODE

SECTION 1. The Municipal Code of Chicago is hereby amended by inserting a new Title 14N, as follows:

TITLE 14N ENERGY CONSERVATION CODE

PART I – COMMERCIAL PROVISIONS

CHAPTER 14N-C1 SCOPE AND PURPOSE

14N-C1-C001 Adoption of the commercial provisions of the International Energy Conservation Code by reference.

The commercial provisions of the *International Energy Conservation Code*, 2018 edition, second printing, and all erratum thereto identified by the publisher (hereinafter referred to as "IECC-CE"), except Appendix CA, are adopted by reference and shall be considered part of the requirements of this title except as modified by the specific provisions of this title.

If a conflict exists between a provision modified by this title and a provision adopted without modification, the modified provision shall control.

14N-C1-C002 Citations.

Provisions of IECC-CE which are incorporated into this title by reference may be cited as follows:

14N-C[IECC-CE chapter number]-[IECC-CE section number]

14N-C1-C003 Global modifications.

The following modifications shall apply to each provision of IECC-CE incorporated into this title:

1. Replace each occurrence of "*International Codes*" with "*Chicago Construction Codes.*"
2. Replace each occurrence of "*International Building Code*" with "*Chicago Building Code.*"
3. Replace each occurrence of "ASME A17.1" or "ASME A17.1/CSA B44" with "the *Chicago Conveyance Device Code.*"
4. Replace each occurrence of "NFPA 70" with "the *Chicago Electrical Code.*"

https://codes.iccsafe.org/codes/illinois/Chicago

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Goal of this Presentation

To further educate the group on some of the shortcomings the Heat and Frost Insulators Union sees in the field through:

- Value engineering
- Cutting corners
- Engineering issues
- Poor execution of projects through our area

Disclaimer: This presentation is in no way critical of any specific group. This presentation is a tool to further educate on the importance of proper mechanical insulation as a health safety and energy savings tool for the stakeholders of a building or facility.

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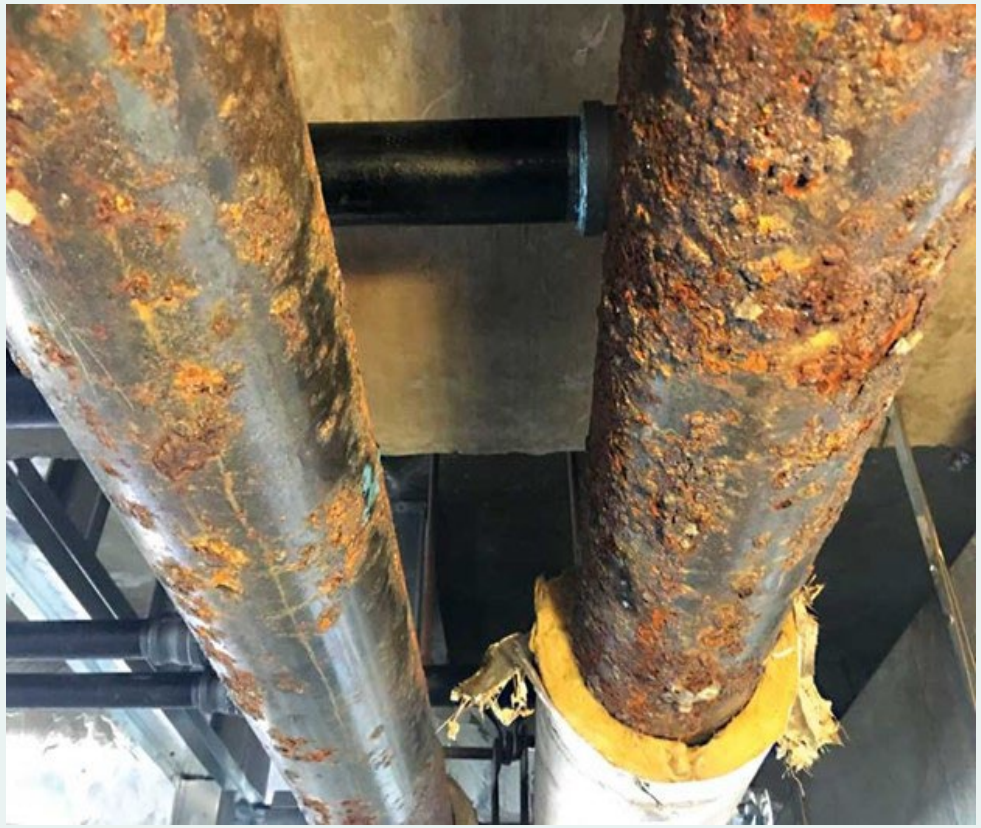
Corrosion Under Insulation



Result of many practices in this presentation:

- Corrosion Under Insulation (CUI) occurs when humid air penetrates insulation to cold pipe or duct
    - Wets insulation, degrades performance
    - Wet insulation can harbor mold
    - Moisture on metal pipes causes corrosion

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Code Provisions Addressing CUI

- Not directly addressed by code.
- C403.12.3.1 requires piping exposed to weather to be protected.
- C303 requires insulation be installed per manufacturer's instructions.
  - Instructions often require insulation protection for indoor pipe/ducts.
  - All-service jacket or PVC jackets common air/vapor barrier.

Properly insulated air- and vapor-tight system

Corrosion Under Insulation (CUI)

Preventing CUI

Correct practice:

- Follow installation instructions for insulation and jackets
- Seal insulation ends, don’t leave open to air.
- Provide protection/provisions where damage is likely.
    - Horizontal insulation often used to step up to high valves/fittings.
        - Use rigid jacketing or nearby ladder/steps for maintenance access.
    - Insulation around fittings often removed for maintenance.
        - Formed or bag insulation easy to remove and replace.

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Spot the problem?

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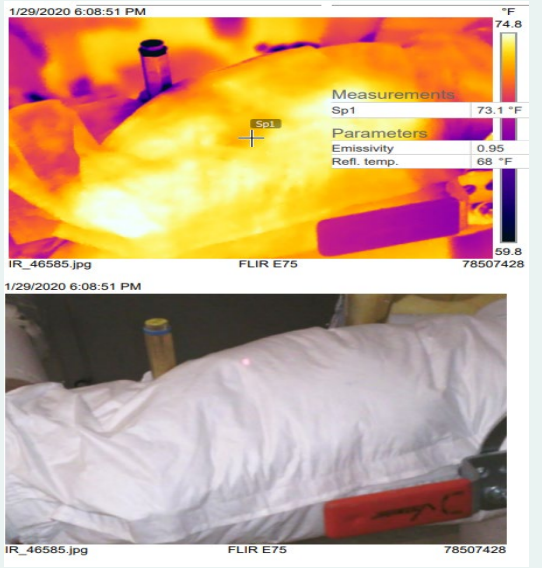
Use of Removable Bags

- Flexible insulation systems designed to prevent condensation when used with pipe insulation.
- Replaces permanent insulation for valves, strainers and other oddly-shaped fittings.
- When used and maintained properly can perform well, **but only if installed properly.**

Improper Installation

Use of Removable Bags

- **Energy code considerations:** If insulation is compressed, R-value reduced from requirements in C403.12.3.
- Flexible insulation is prone to mechanical damage that degrades performance over time.
  - C403.12.3.1 requires pipe insulation exposed to weather be protected from:
    - Solar radiation
    - Wind
    - Mechanical damage (stepping on it, maintenance work, etc…)
    - Moisture



Proper No-Sweat Bag Installation

- Insulation should not be compressed around fitting: i.e. doesn't need to be a "tight" fit.
- Bag ends tightly seal to neighboring insulation to prevent moist air infiltration.
  - **Outdoor bags need to be sealed along Velcro seam and to neighboring insulation with tape or sealant for water intrusion protection!**
- Bag sheathing is unmodified, providing continuous vapor protection around insulation.
  - Bags don't provide mechanical protection!
  - Building maintenance standards must note care around bad insulation.

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Tightly Engineered or Installed Piping

- **Common installation issue**: Mechanical systems often have limited space for pipe + insulation (see right image).
- Can lead to interrupted or compromised insulation.
- If insulation is compromised, can lead to unintended energy loss and corrosion of components.

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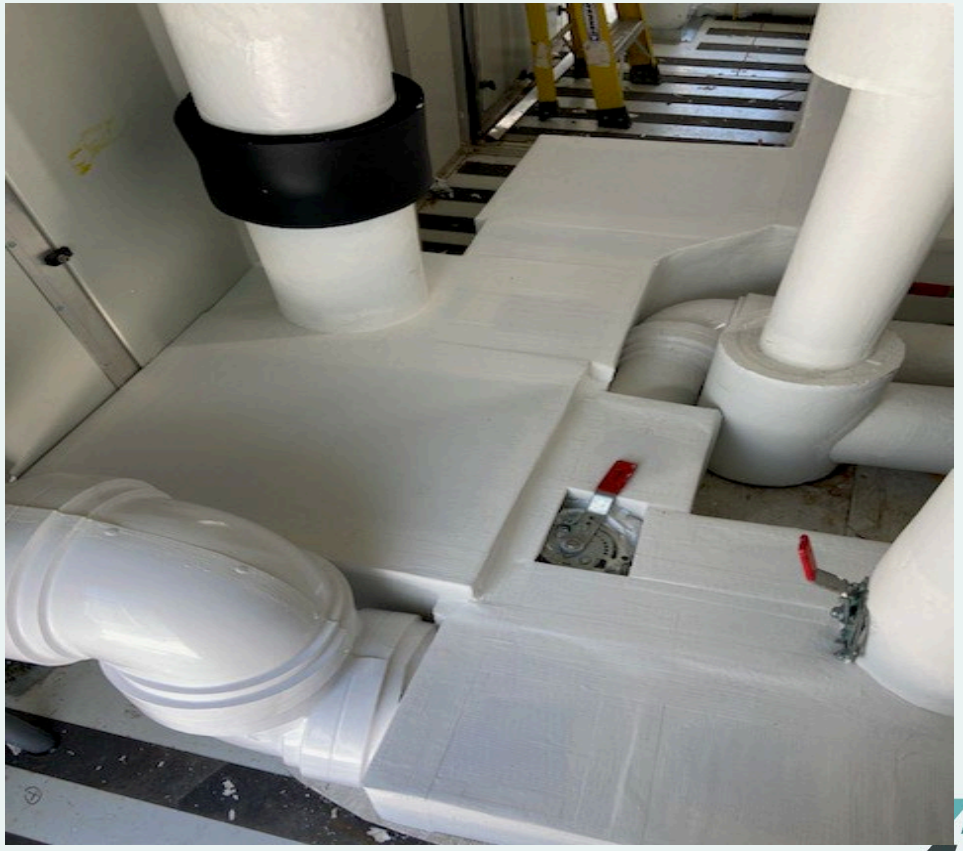
Tightly Engineered/Installed Piping: Code Consideration

C403.12.3: Piping insulation must meet thickness/performance requirement in Table C403.12.3

C404.4: Service hot water pipes must be insulated per Table C403.12.3 (see provision for further requirements)



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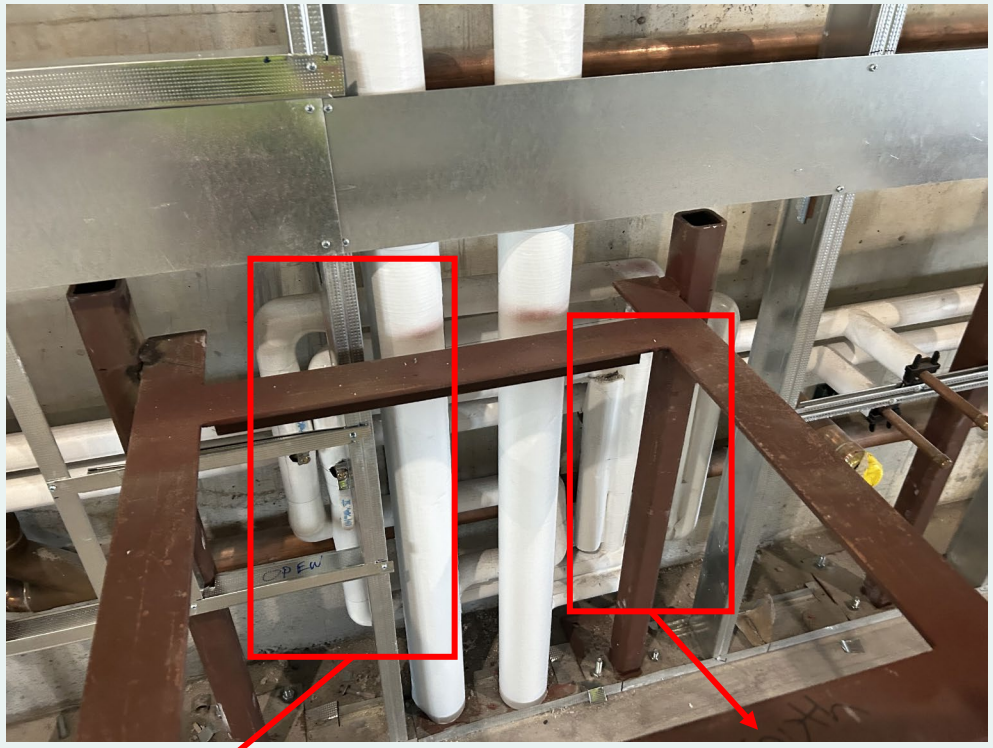
Tightly Engineered or Installed Piping

- Designers need to detail proper spacing on plan drawings.
- Often mechanical/plumbing contractors are not same as insulators.
  - Need to maintain spacing and tolerances for insulation to be added.
  - Use brackets, spacers, and mounts to maintain spacing.



Good spacing

Full thickness, but unable to wrap.

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Poorly Protected Outdoor Insulation

Adhesive claddings are a common material due to easy installation.

CARFULLY FOLLOW MANUFACTURER INSTRUCTIONS

- Installing below 40 °F impairs adhesion.
- Must be rolled for proper adhesion pressure.
- Clean/prepare surfaces for proper adhesion.

Insulated below optimal temperatures

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Code Requires Protection for Outdoor Insulation

Insulated at proper temperatures

Code consideration: Section 403.12.3.1 specifies insulation must be protected. Adhesive tapes **not permitted**.

- Removing adhesive damages insulation underneath.
- Adhesives can delaminate, removing protection.
- Moisture penetration can leak into building.

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Proper Outdoor Insulation Protection

Clamp on aluminum cladding

Code-Compliant Insulation:

- Integral cladding or non-adhered cladding (clamp on aluminum option shown at left).
- Adhesive-based sheathing acceptable if part of insulation system, not as stand-alone sheathing product.
  - REMEMBER: Adhesive tapes not permitted

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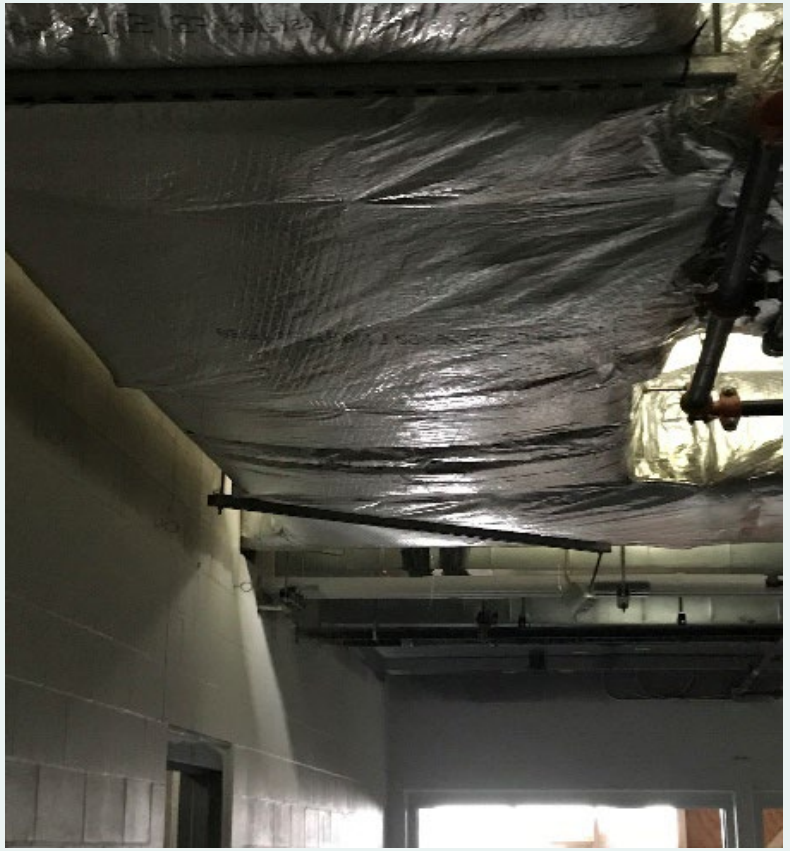
Baggy and Poorly Sealed Ductwork Wrap

Improper insulation practice: Installing baggy or poorly sealed ductwork wrap.

- Ductwork = piping when it comes to mechanical insulation.
- Poor duct insulation degrades overall system performance.
- Can also create health hazards



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Baggy and Poorly Sealed Ductwork Wrap

Properly sealed and supported duct insulation

Code consideration: 2021 IECC Section C403.12.1

- R-6 for ducts in unconditioned space
- R-8 to R-12 for ducts outdoors depending on climate zone
- No insulation required if within conditioned space
- Ducts in building cavities separated from unconditioned space by R-8
- Exempt within equipment or <15 F temp difference
- **2021 IMC 603.12:** Provisions shall be made to prevent condensation on any duct exterior

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Baggy and Poorly Sealed Ductwork Wrap

Proper installation:

- Uncompressed insulation fit snug to duct.
- Supported as needed by pins per manufacturer's instructions
- Fibrous insulation covered by air & vapor barrier
- Wrap tightly sealed at seams to prevent moisture penetration

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Hydronic System Valve Handles

- **Incorrect common practice:** Valve handles installed without considering thickness of insulation.
- Insulation often compromised to allow free travel of valve handle. Sometimes handle is bent, too.
- Breaks vapor seal for insulation wrap, allowing CUI.
- Damaged & wet insulation will not perform well.

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Valve Handle Code Compliance

Code consideration: Compressing or cutting away insulation around handles not compliant with C403.12.3 or C404.4.

Must maintain code thickness continuously around and along pipe & fittings.

Compressing or cutting away insulation around handles not compliant

TABLE C403.12.3 MINIMUM PIPE INSULATION THICKNESS (in inches)[a, c]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu × in./(h × ft^2 × °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1$^1/_2$	1$^1/_2$ to < 4	4 to < 8	> 8
> 350	0.32–0.34	250	4.5	5.0	5.0	5.0	5.0
251–350	0.29–0.32	200	3.0	4.0	4.5	4.5	4.5
201–250	0.27–0.30	150	2.5	2.5	2.5	3.0	3.0
141–200	0.25–0.29	125	1.5	1.5	2.0	2.0	2.0
105–140	0.21–0.28	100	1.0	1.0	1.5	1.5	1.5
40–60	0.21–0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20–0.26	50	0.5	1.0	1.0	1.0	1.5

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Valve Handle Extensions Are Solution

Correct practice:

- Use extensions to prevent interference with insulation.
- Valves designed for insulation (long-stem) also available.

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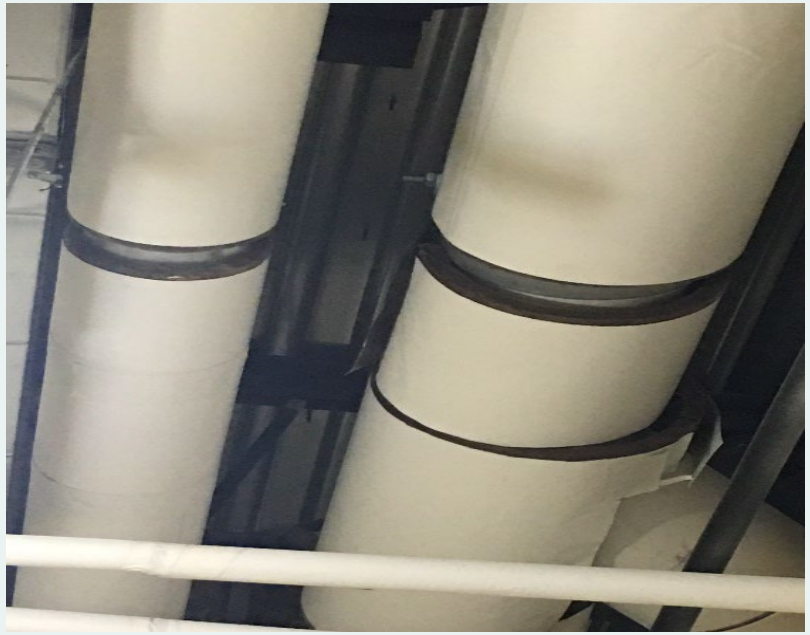
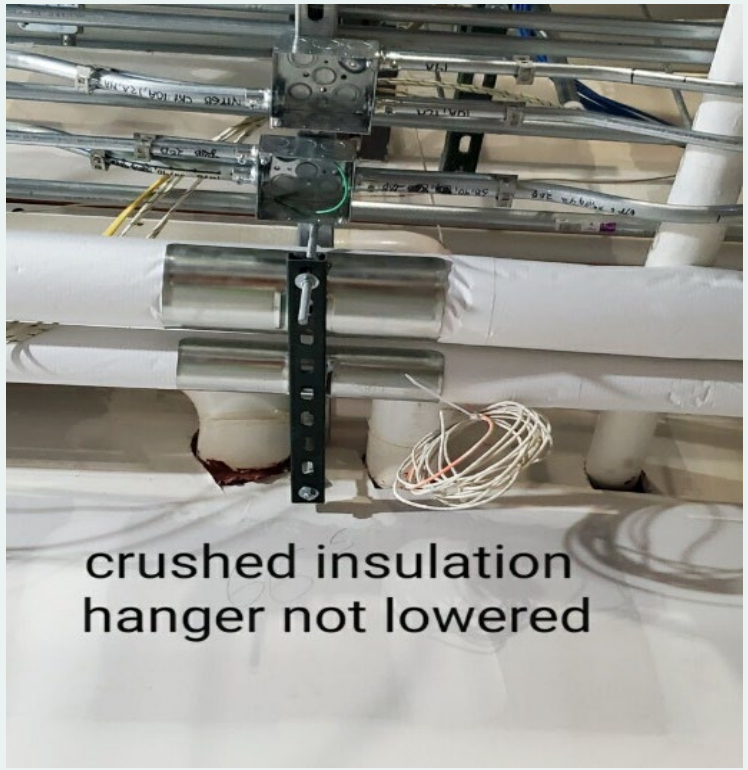
Improper Piping Support

Incorrect common practices:

- Installing wrong hanger sizes on piping systems.
- Installing supports without considering insulation thickness

Wrong size hangers break insulation continuity





Improper support height crushes insulation

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Code Considerations for Pipe Supports

Code consideration: Section C403.12.3 and C404.4 of IECC 2021 sets requirements for R-values around piping.

- That R-value must be maintained by proper installation practices.
- C303.2 requires installation per manufacturer's instructions and IBC/IRC requirements.

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Proper Piping Support

Correct installation practice:

- Hanger heights uniform with pipe level and include provision for insulation thickness.
- Hanger saddles used to spread forces & prevent crushing.
- Hanger widths sized to insulation diameter, not pipe.

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Insulating Duct/Pipe Wall Penetrations

Insulation butts up to partition, but not continuous through assembly

Incorrect common practice: Duct or pipe passes through partition, but insulation butts up to and stops at partition.

- Duct or pipe is not insulated through partition.
- If penetration is into chase, it is often missing insulation in chase.
  - Lack of insulation wastes energy.
  - Condensation and moisture damage to insulation possible.
    - Moisture damage to partition also possible.

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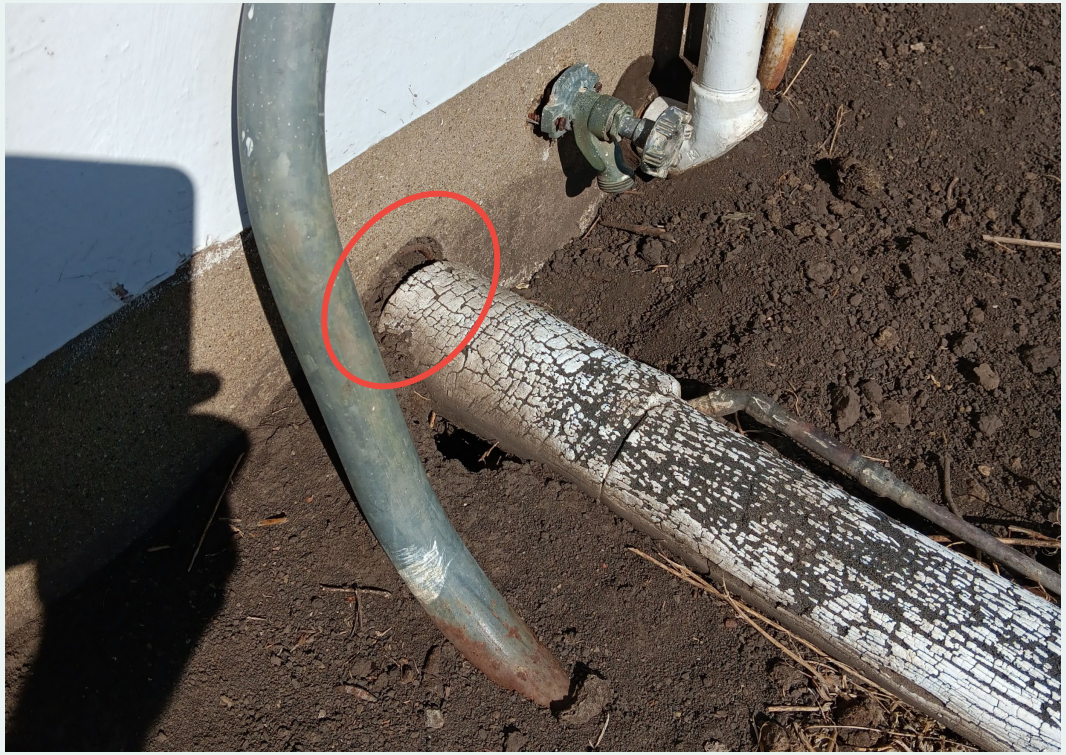
Code Requirement for Insulation

Code consideration:

- Section C403.12.3 states insulation for mechanical piping must be installed continuously to table values.
- Insulation must be consistent along pipe with Table C403.12.3 thicknesses.
- Must be continuous through assembly penetrations as well.

Sleeve too small, insulation interrupted



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Pipe/Duct Penetrating Partition

Correct practice:

- Partition opening made large enough for pipe and insulation thickness
  - No sleeve required
    - Rigid pipe material, such as iron
    - Partition not moisture sensitive, such as CMUs
  - Penetration needs sleeve when
    - Pipe is flexible material such as PEX
    - Partition is moisture sensitive, such as drywall

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Pipe-In-Wall Insulation Practice

Common practice: Use wall cavity insulation to insulate pipes as well.

- Pipe often placed inside of cavity insulation.
- Pipe itself uninsulated.

Potential Issues:

- Heat lost to inner wall face (detrimental while cooling).
- Condensation potential for cold piping against drywall (health hazard).

Uninsulated service water piping in wall cavities

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Pipe-In-Wall Insulation Code Considerations

Code consideration:

- For insulated cavities, C402.2 or R402.2 R-value or U-factor compliance requires properly installed insulation. R303 requires following manufacturer instructions
  - Uncompressed.
  - Fills cavity with no air gaps.
- For pipe insulation, C403.12.3 or R403.4 & R403.5.2 require insulation around entire pipe at proper thickness to meet R-value.
- Uninsulated pipe to the interior of cavity insulation is not compliant!

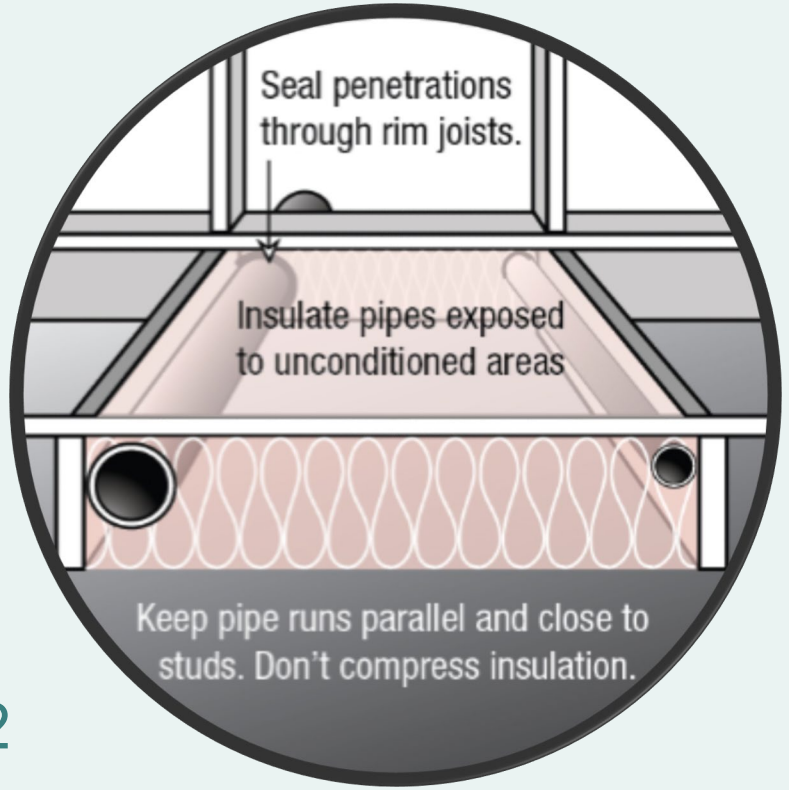

Image source: www.basc.pnnl.gov

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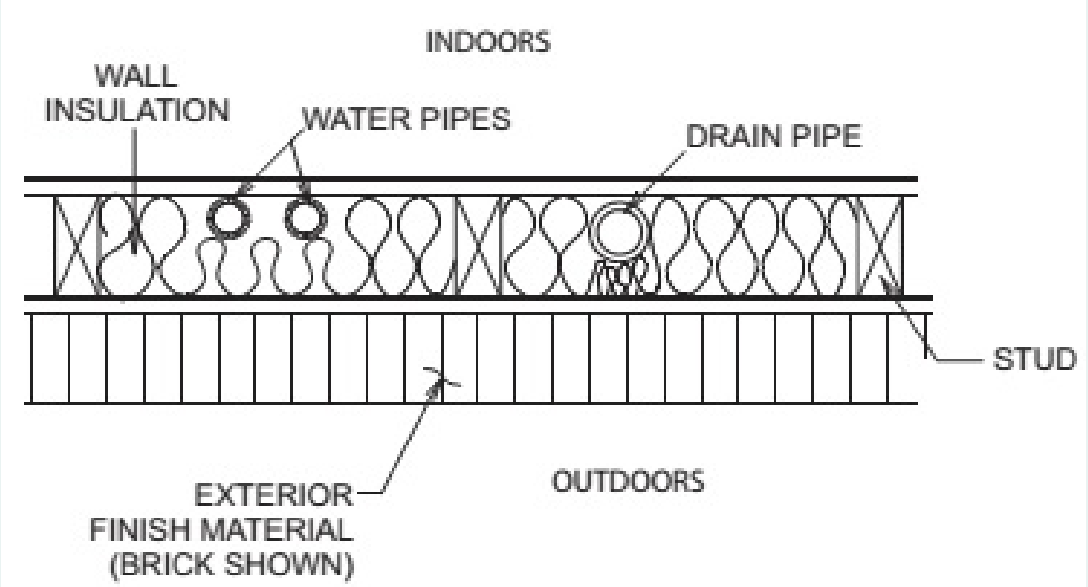
Proper Pipe-in-Wall Insulation

- Best Practice: Insulate pipe and wall cavity independently
- Acceptable Practice: Center pipe in wall so all sides surrounded by required insulation
  - Circulating service hot water in residential requires R-3 minimum
  - Other mechanical pipes required thickness/R-value varies per Table C403.12.3
  - Pipes not requiring insulation can be installed as shown



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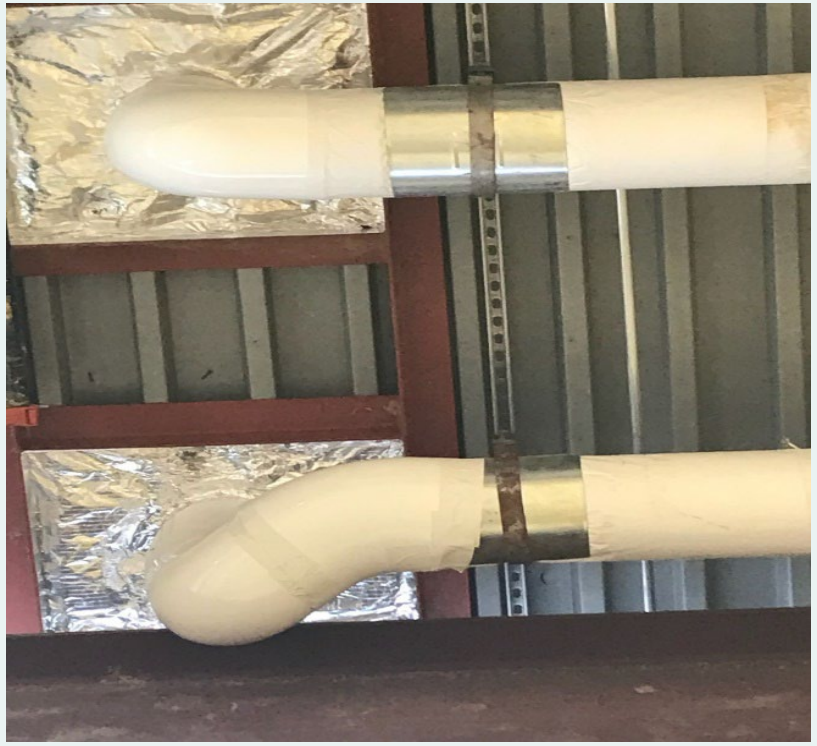
Blanket Insulation on Downspout Heads

Problematic common practice: Using duct wrap, fiberglass, or other air-permeable insulation instead of elastomeric insulation on downspout heads.

Poorly insulated downspouts



Results of condensation

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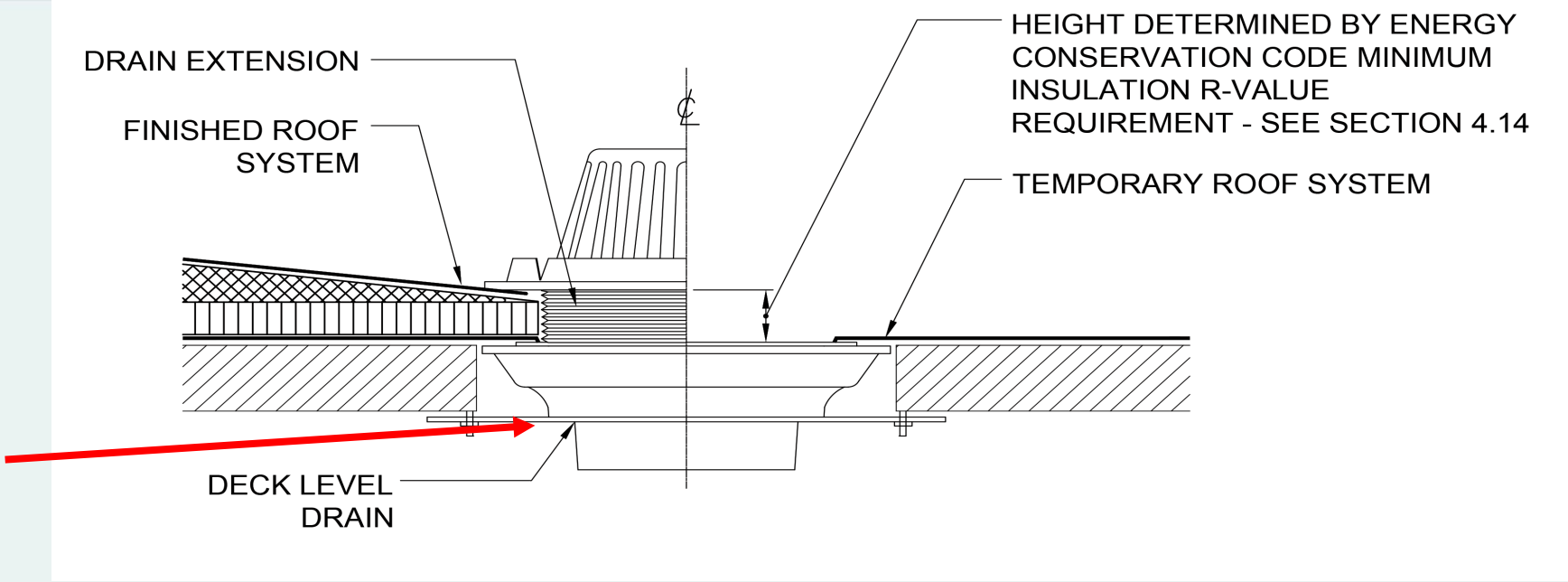
Downspout Head Code Considerations



Interior downspouts code consideration:

- Fluid is not conditioned by fossil fuels, so no energy code requirements
- 2021 IECC C402.2.1, roofs are required to have minimum 1” insulation at drains, scuppers, and gutters.
  - Can still condense around drain head
  - Closed-cell insulation here avoids condensation
- 2021 IPC, IBC, and IECC do not dictate insulation for roof drains

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Blanket Insulation on Downspout Heads

Proper method

Proper insulation of interior downspouts:

- Downspout drains or heads surrounded by above-deck insulation or other insulation system.
- Standard industry practice is to insulate the head with elastomeric insulation (rubber).
  - This insulation is closed-cell, thus air-tight

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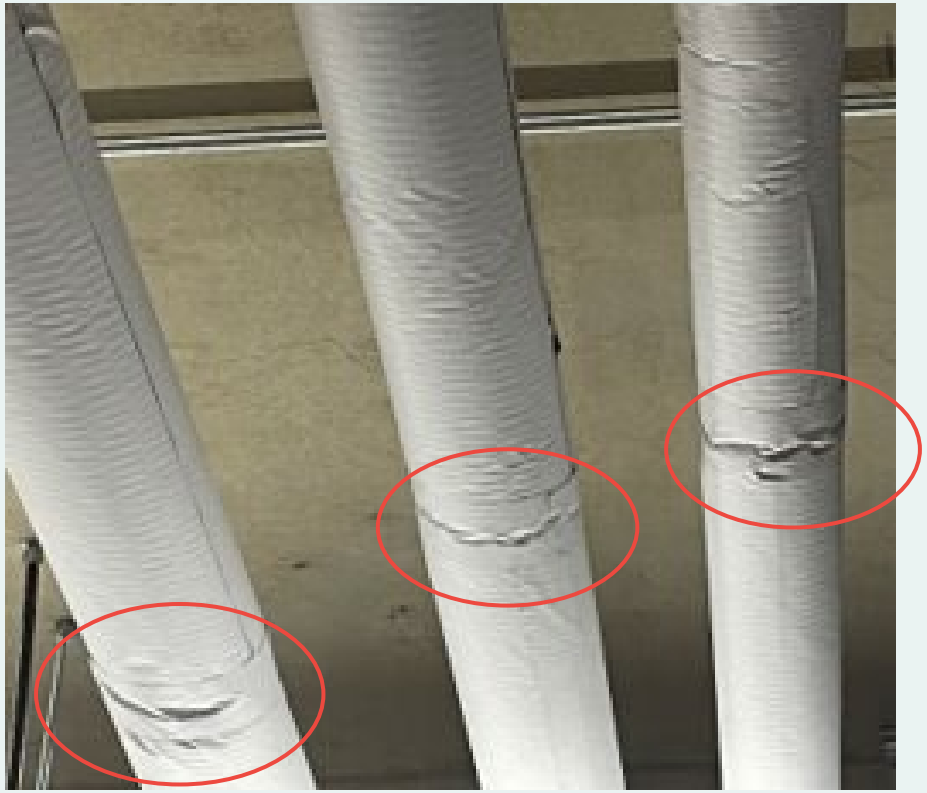
Airtight Butt Joints

Suboptimal common practice:

- Dirt, improper application pressure, or other issue prevents proper seal between butted insulation sections
- Resulting air gap allows moist air to contact pipe = CUI potential



- Butt joints aren't flush
- For CHW pipes, condensation likely
- Overall, sloppy appearance

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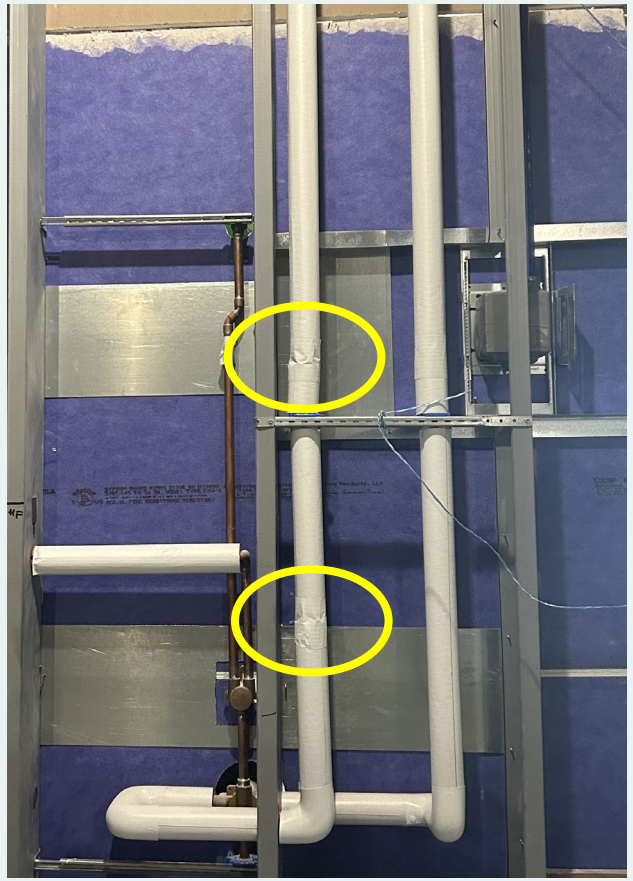
Energy Code Connection: Airtight Butt Joints

Code consideration:

- C303.2 requires insulation be installed per manufacturer's instructions
- Improper sealing allows moist air between pipe and insulation
  - Condensation in insulation degrades performance
  - Also causes corrosion under insulation
- Gaps between butted insulation are thermal breaks
  - Must be butted together for continuity!



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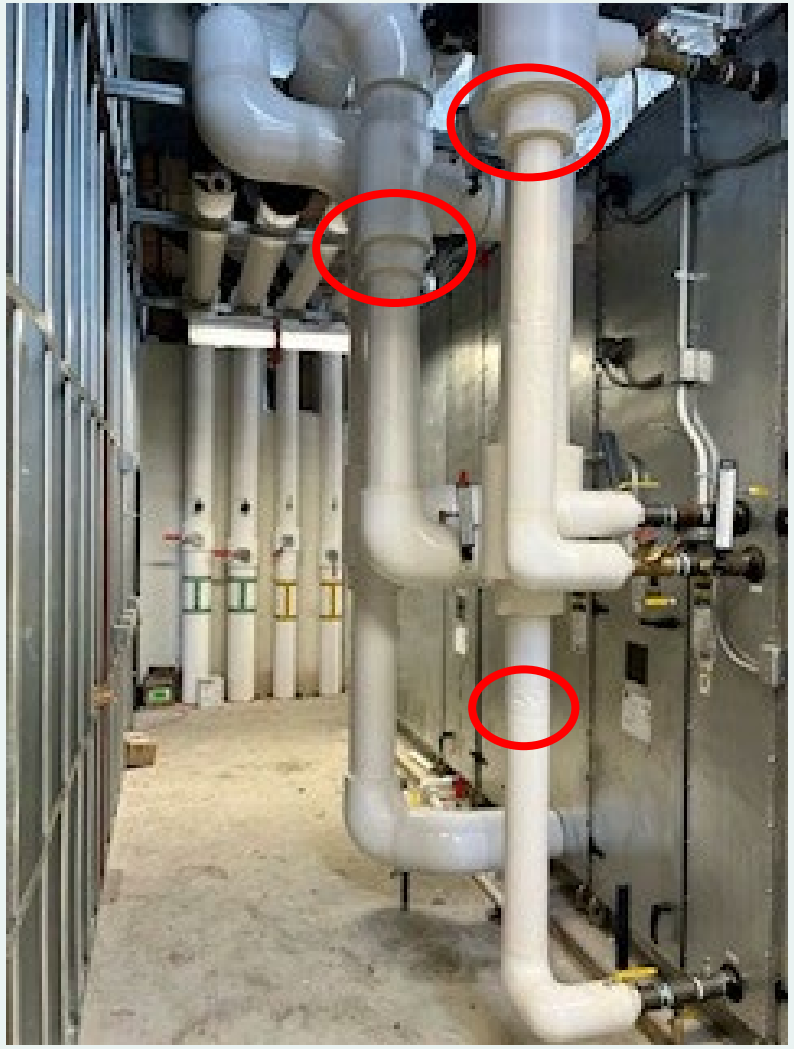
Airtight Butt Joints



This image depicts the proper sealing method.

- Clean work.
- All gaps are sealed
- All butt joints flush to installation

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Installing Elastomeric Pipe Insulation

Incorrect common practice:

- Insulation is slid around pipe without compensation for pipe bends
  - Bending around corners reduces insulation at throat and heel
    - Throat (inner radius) is compressed
    - Heel (outer radius) is stretched
  - Stress eventually tears insulation, or splits seam
- Butt joints often not sealed with appropriate adhesive

Code Implication for Elastomeric Pipe

Code considerations

- C303.2 requires installation per manufacturer's instruction
- C403.12.3 requires insulation to meet conductivity and thickness requirements in table
- C403.12.3.1 requires protection of weather-exposed insulation
- C404.4 requires insulation of service hot water piping per Table C403.12.3
- R403.4 requires R-3 pipe insulation for heated/cooled fluids

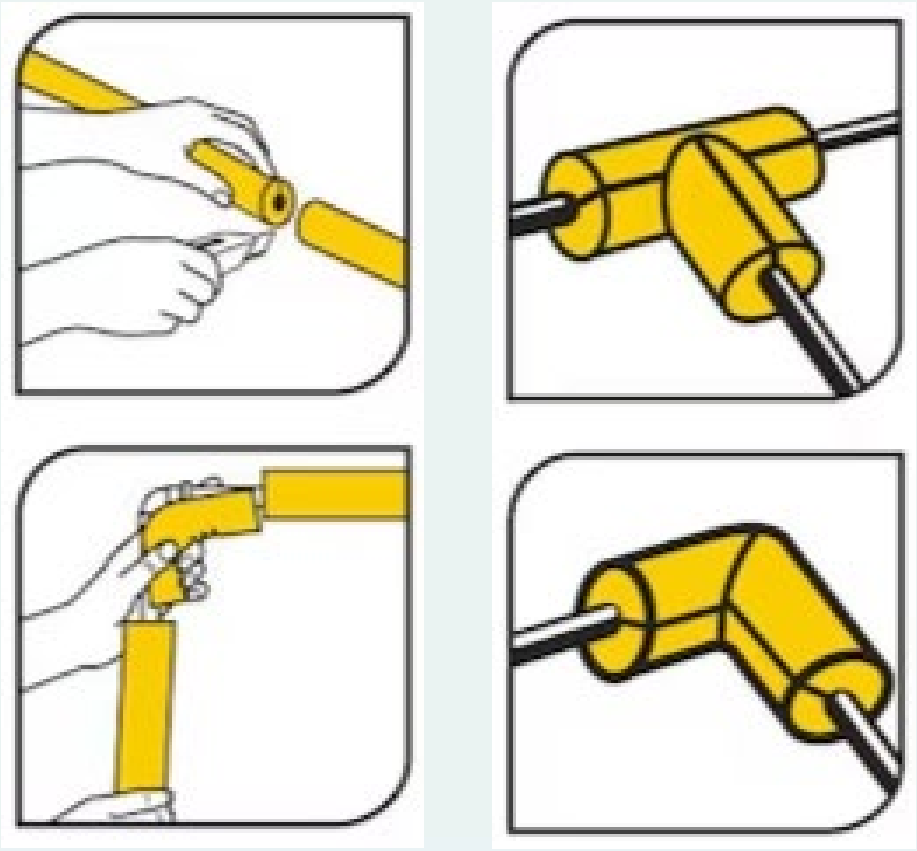

Image source: Frost King Installation Instructions

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Elastomeric Insulation Proper Practice

Correct practice:

- Miter elbows and joints to prevent stress
- Use elastomeric glue to seal seams and butt joints
- Duct tape or electrical tape should not be used
- Zip ties discouraged due to insulation compression
  - Can be used with proper saddle
- Outdoor elastomeric insulation needs UV protective coating

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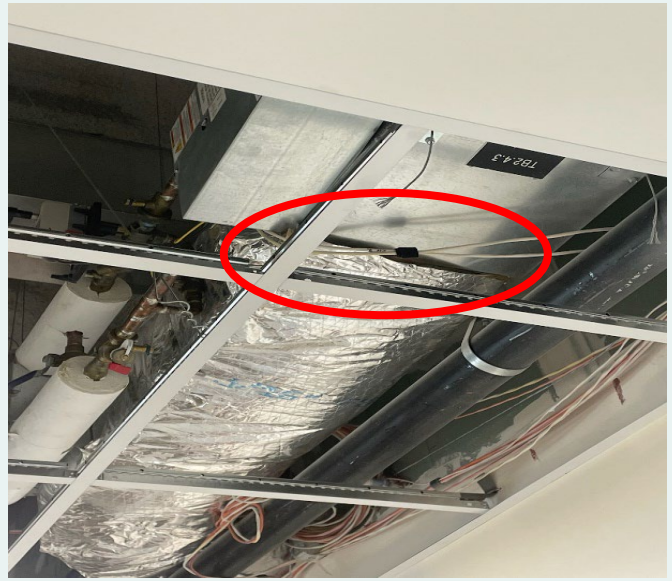
Improper VAV Box Insulation Connection

Incorrect common practice:

- Blanket insulation not taped to variable air volume (VAV) box. This is not a good practice.
- Air movement between insulation and duct negates insulation placement
- Ceiling plenums often connected to outdoors, making condensation on ducts a concern
- Heat from reheat coils lost to plenum without heating space

VAV box not taped



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Code Requirements for VAV Boxes

Code consideration: C403.12.1 states:

- Ducts, air handlers, and filter boxes shall be air sealed
- Ducts insulated when in unconditioned space or outdoors
  - R-6 in unconditioned spaces
  - R-8 for outdoor ducts in CZ 4
  - R-12 for outdoor ducts in CZ 5

R403.3 states residential ducts:

- In unconditioned space must have R-6 to R-8 depending on diameter
- Minium R-10 separating duct from exterior in building cavities

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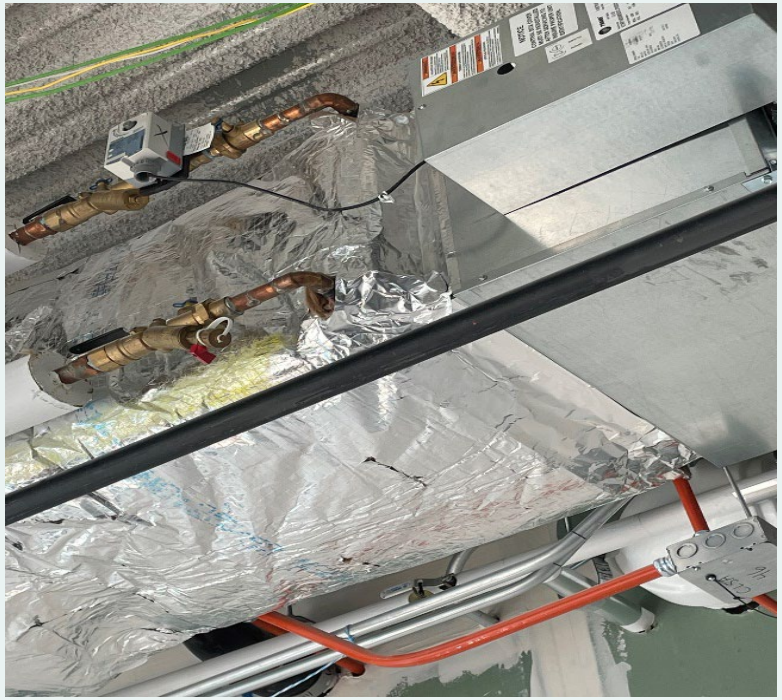
VAV Boxes: Insulation Not Taped to the VAV

Proper insulation method:

- Many project specifying insulation over VAV reheat coil
- Extending insulation over coil avoids losses to plenum
- The tape should be secured to VAV box after coil to enclose the heat in the system.



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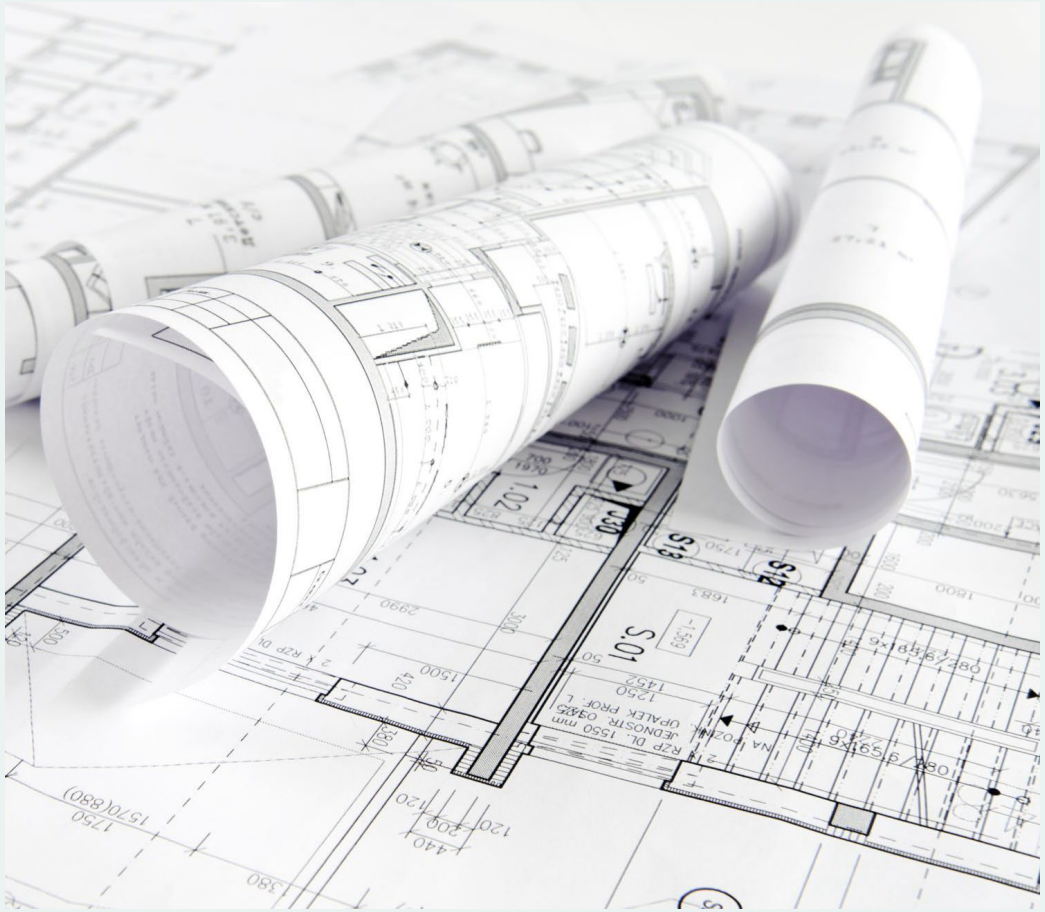
Conclusion



Most of the projects performed in the State of Illinois are done per plans and specifications.

- Sometimes issues arise that degrade quality installations
  - Value engineering
  - Rushed schedules
  - Confusion on responsibilities
- Shortcomings can have significant impact on system longevity and efficiency
- Can also have impact on health and safety in facility!

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Questions?

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Insulation Practice

Heat & Frost Insulators