CONSIDERATIONS FOR DISTRICT ENERGY INSULATION SYSTEMS

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NIA | National Insulation Association®

The Voice of the Insulation Industry™

AGENDA

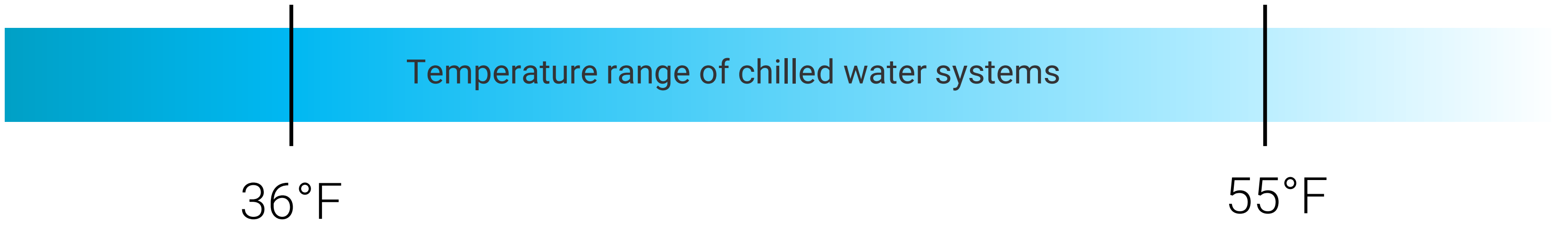
- Vapor Drive
- Chilled Water Systems
- Vaults & Tunnels
- Direct Burial

DISTRICT ENERGY SYSTEMS

- District energy systems are becoming more commonplace
  - Universities
  - Hospitals
  - Downtown urban areas
- Combination of chilled water and hot water/steam lines
- Typically underground, either direct buried or in vaults/tunnels

CHALLENGES WITH CHILLED WATER LINES

CHILLED WATER SYSTEMS



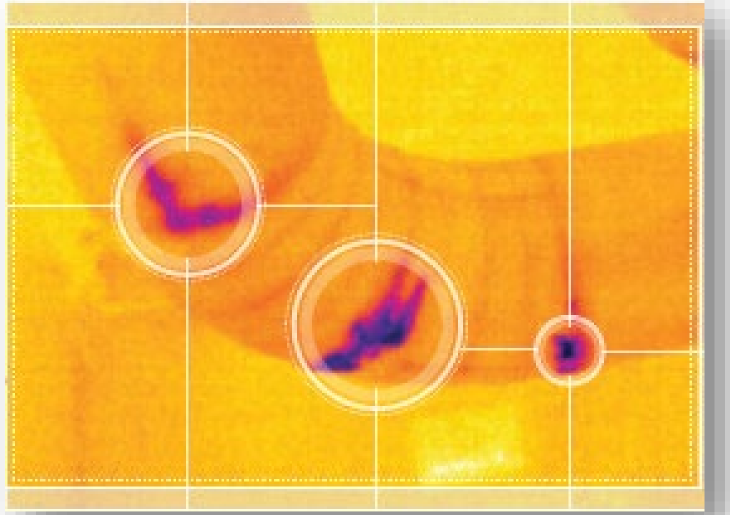
Challenges with chilled water insulation systems:

- Strong vapor drive towards cold pipe
- Reliant on integrity of vapor barrier
- Problems may remain hidden for months/years

LOSS OF INSULATION EFFICIENCY

Problems associated with saturated insulation:

- **Thermal bridging**
  - More heat gain into chilled water supply lines
- Energy losses ($)
  - More energy required to cool back to 40°F operating temp.
- Loss of process control
  - Warmer supply lines = diminished cooling effect
- Equipment strain
  - Added stress on chillers



CORROSION UNDER INSULATION

- Key ingredients for carbon steel corrosion:
  - Oxygen
  - ***Liquid moisture***
- Damage can remain hidden

KEY CONSIDERATIONS: CHILLED WATER LINES

KEY CONSIDERATIONS

HUMIDITY

Humidity is the concentration of water vapor present in the air

Relative humidity, as a percentage, compares the actual amount of moisture in air versus the amount that it could hold at that temperature

VAPOR PRESSURE

Vapor pressure is the pressure at which water, liquid and vapor exist in equilibrium

When the air temperature is lowered, this equilibrium is disturbed, and liquid water condenses as “dew” until equilibrium

DEW POINT

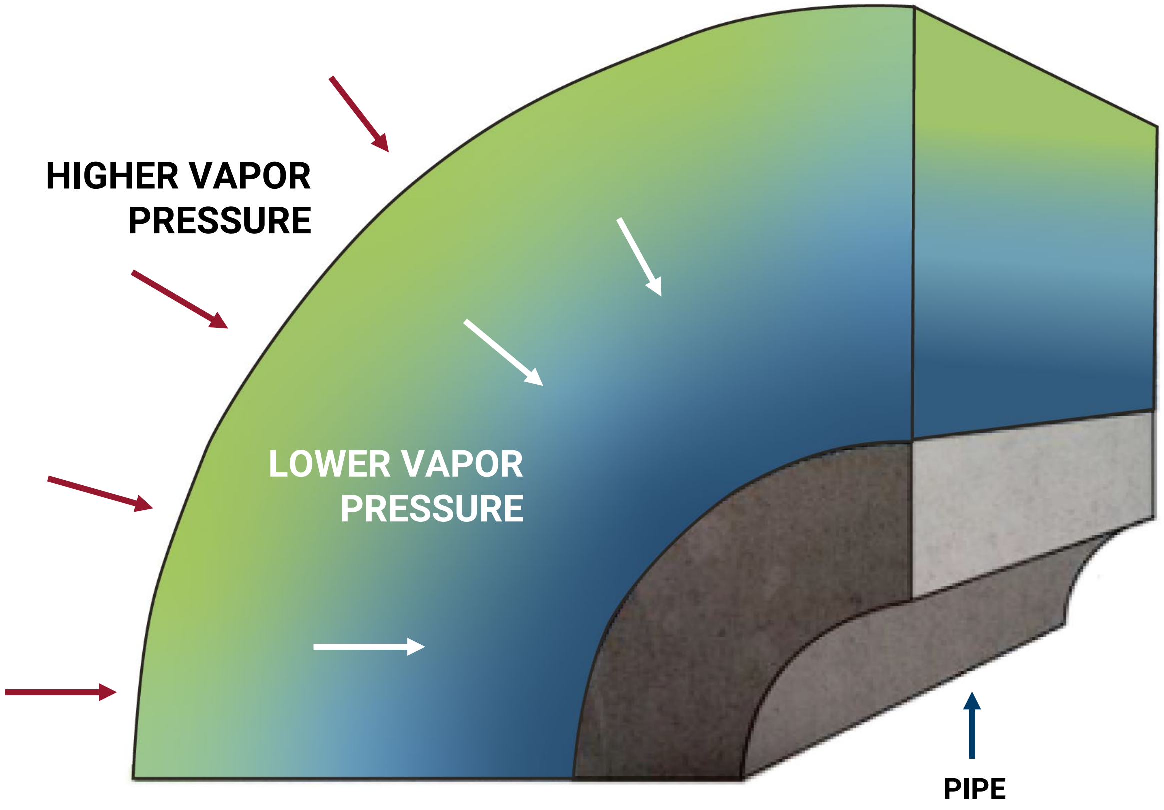
The dew point is the temperature at which this condensation begins

When air cools to its dew point through contact with a surface that is colder than the air, water will condense on the surface

VAPOR PRESSURE DRIVE

Vapor drives towards cold surfaces/pipes.

- A compromised insulation system can allow moisture to move towards the pipe where it can condense.
  - Poor installation
  - Physical damage

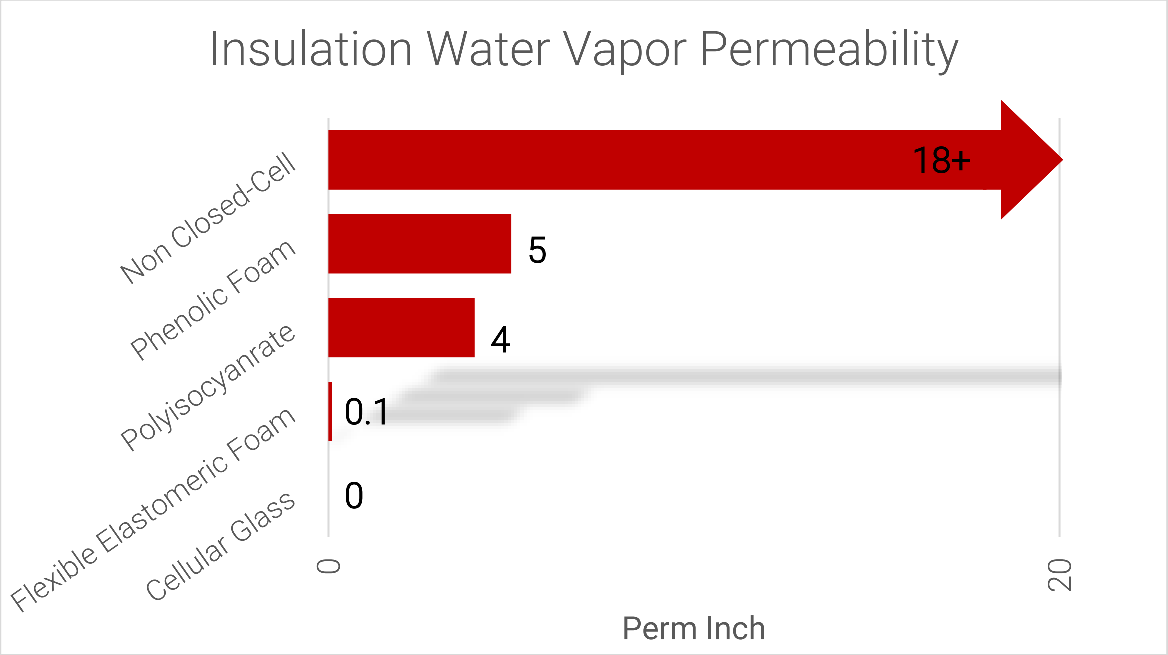


VAPOR PRESSURE DRIVE

Permeability: the tendency of a material to allow liquids or gases to pass through it

Permeable insulations:

- Rely solely on vapor barrier
- May allow water vapor to move towards cold pipe where it may condense.
- Can absorb and retain condensed water
  - Compromised k-value
  - Lower external surface temperature
  - Surface condensation occurs

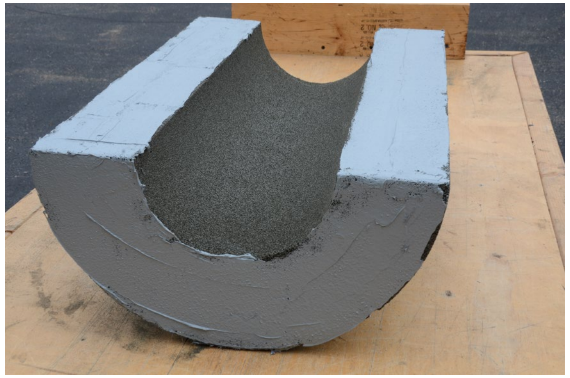


Source: ASTM Standards/ Manufacturer Data Sheets

FULLY SEALED SYSTEM

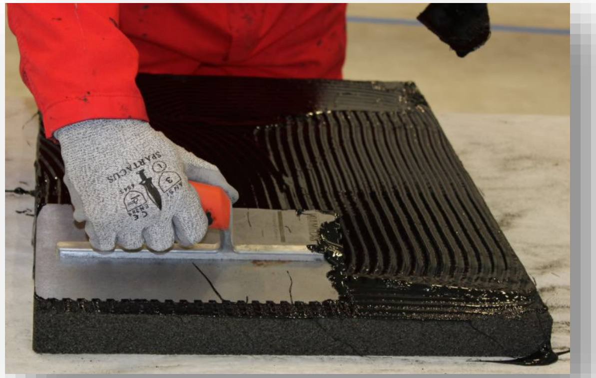
Use the right accessories to create a fully sealed and protected insulation system.

Joint Sealant



Vapor Retarder Jacketing

Vapor Retarder Mastic



Weather Barrier

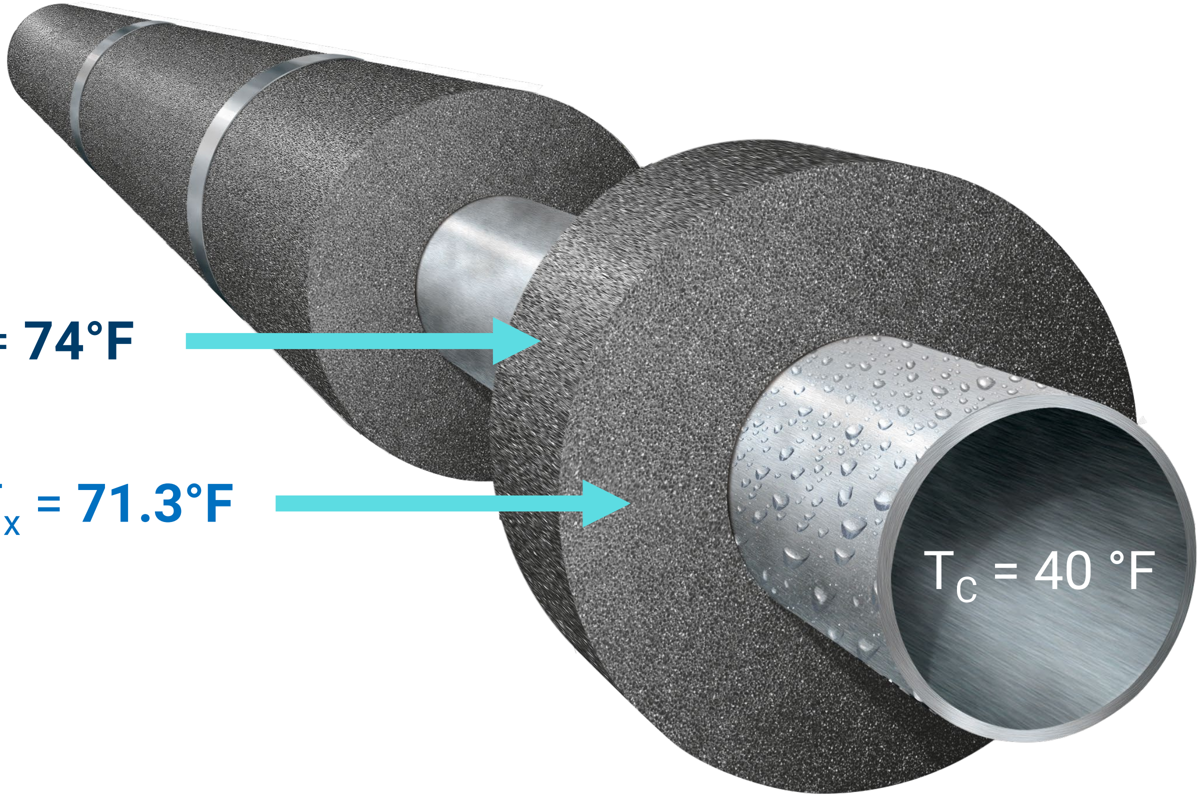
CONDENSATION CONTROL

- **Proper insulation thickness** is necessary to prevent surface condensation or "sweating."
- **Goal:** Ensure insulation surface temp. is greater than dew point.

T_{air} = 80°F
RH = 75%
Dew point = 71.3°F

$T_{surface}$ = **74°F**

T_x = **71.3°F**



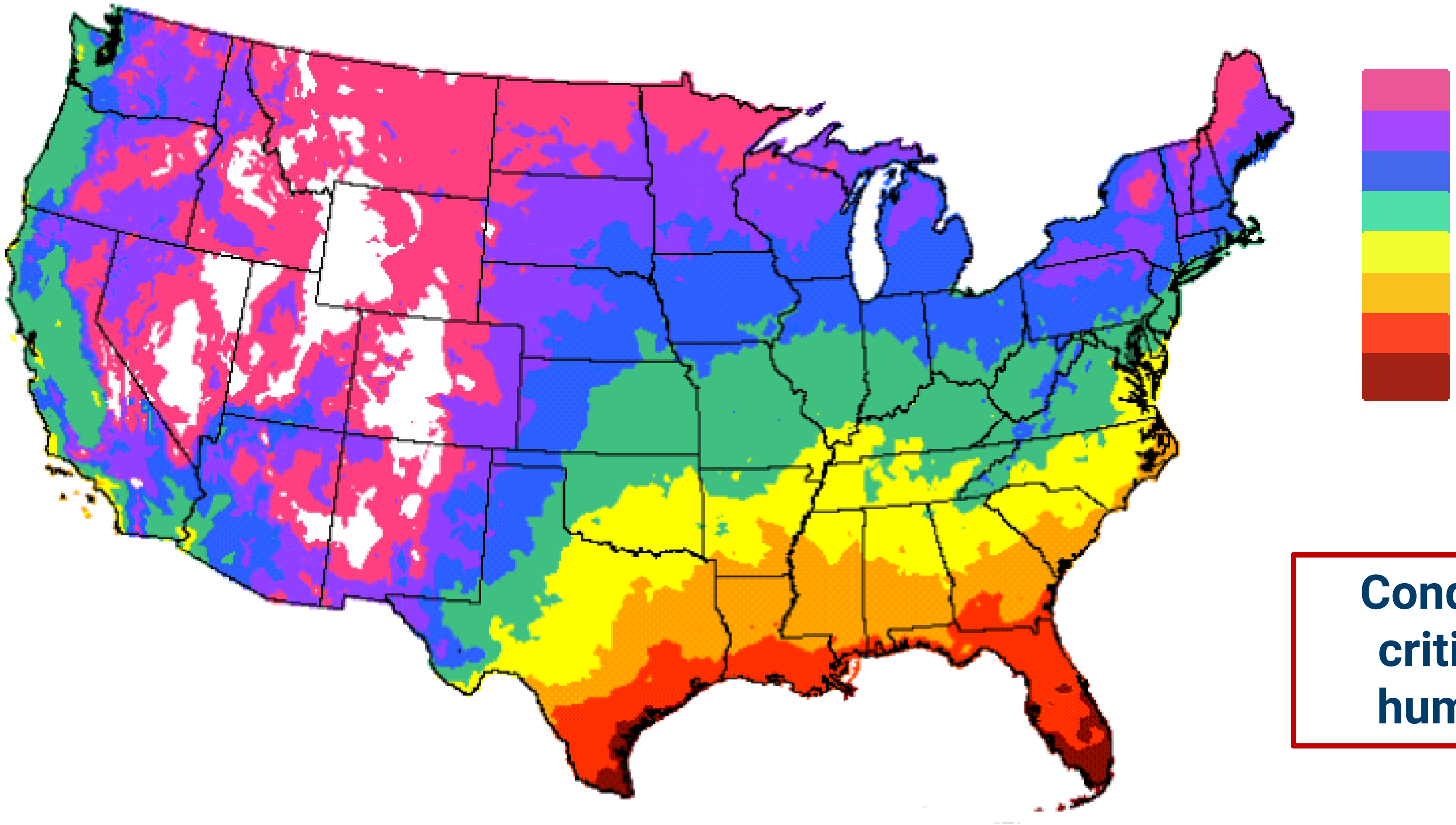
ASHRAE 90.1

ASHRAE 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings*

- Commonly referenced in determining thickness requirements for chilled water lines
- For energy conservation… not condensation control
- Necessary insulation thickness should be calculated for each set of parameters and ambient conditions

HUMIDITY IN THE U.S.

Annual Mean Maximum
Dew Point Temperature



Condensation becomes a critical concern in high-humidity environments.

Source: National Oceanic and Atmospheric Administration

JACKET EMISSIVITY

Emissivity: the relative effectiveness of a surface to emit and absorb heat by radiation

- Expressed as ratio between 0 and 1
- Applies to the outermost surface of insulation system
- Higher emissivity = more heat transfer via radiation

For chilled pipes in warm environments…

- Low emissivity jacketings (aluminum, steel) absorb less heat
  - ***Lower** surface temperature*
- High emissivity jacketings (PVC, ASJ) absorb more heat
  - ***Higher** surface temperature*

JACKET EMISSIVITY

Example

- 8” chilled water pipe (40 °F)
- 3 inches of “Type X” insulation
- No wind
- Ambient air of 90°F and 80% RH
  - Dew point = **83°F**

Aluminum Jacketing (ε = 0.04)

- Surface Temp. = **81.9°F**

PVC Jacketing (ε = 0.9)

- Surface Temp. = **86.7°F**

KEY CONSIDERATIONS: VAULTS AND TUNNELS

DURABILITY

- Insulation exposure to foot traffic/maintenance activities
- Tunnels can be homes to burrowing vermin

Emphasis on:

- Insulation compressive strength
- Resistance to burrowing vermin

FLOODING

- Tunnels are subject to flooding.
  - Sump systems can help, but are subject to clogging/failure
- Insulation systems can be submerged in water for periods of time
  - Permeable insulations can absorb and retain flood water.

Emphasis on:

- **Non-absorbing insulation material**
- **Appropriate insulation accessories**

FLOODING

- Steam lines may cycle from off to on
  - Retained water trapped within insulation can rapidly be heated into steam

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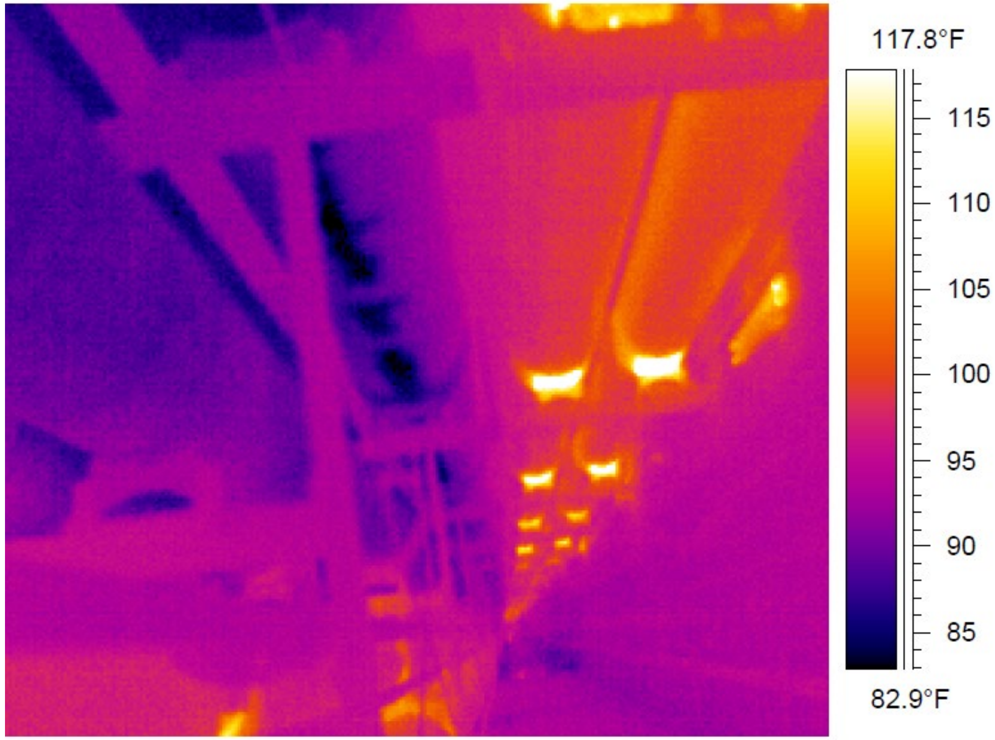
Potential for steam pressure to force the insulation off of the pipe

INSULATION EFFICIENCY

- Compromised insulation efficiency can lead to:
  - Increased energy costs
  - Loss in process control
  - Elevated ambient temperatures (heat from steam lines)

- Chilled water lines often share the same space as steam lines



AMBIENT CONDITIONS

- High vapor drive from warm air to chilled surfaces.

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Increased risk of vapor drive penetration into insulation

- **Emphasis on vapor barrier/ low permeability performance**

AMBIENT CONDITIONS

- Electrical wiring and internet cables may also be present

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Elevated temperatures could compromise plastic casing on electrical wiring.

KEY CONSIDERATIONS: DIRECT BURIAL SYSTEMS

SOIL LOADING

Direct buried pipes will experience a combined load from these sources

Soil Load: Weight exerted on pipe from above soil backfill

- Increases as:
  - Soil density increases
  - Burial depth increases

Live Load: Weight transferred to pipe from heavy moving objects on the ground surface above

- Increases as:
  - Weight of object increases
  - Movement of object increases
  - Pipe OD increases
  - Burial depth decreases

HYDROSTATIC PRESSURE

Hydrostatic Pressure: the pressure that is exerted by a fluid at equilibrium at a given point within the fluid, due to the force of gravity

- A factor in:
  - High water table locations
  - Seasonally high-precipitation locations
- Increases with soil depth.
- Can drive water into permeable insulations.
- Weak or poorly installed joints may be a source of water entry due to hydrostatic pressure

THERMAL EXPANSION

Metal will expand with temperature on high-temperature lines.

- Large stretches of piping will need space to accommodate
- Potential of damage to insulation joints if not accounted for

Example

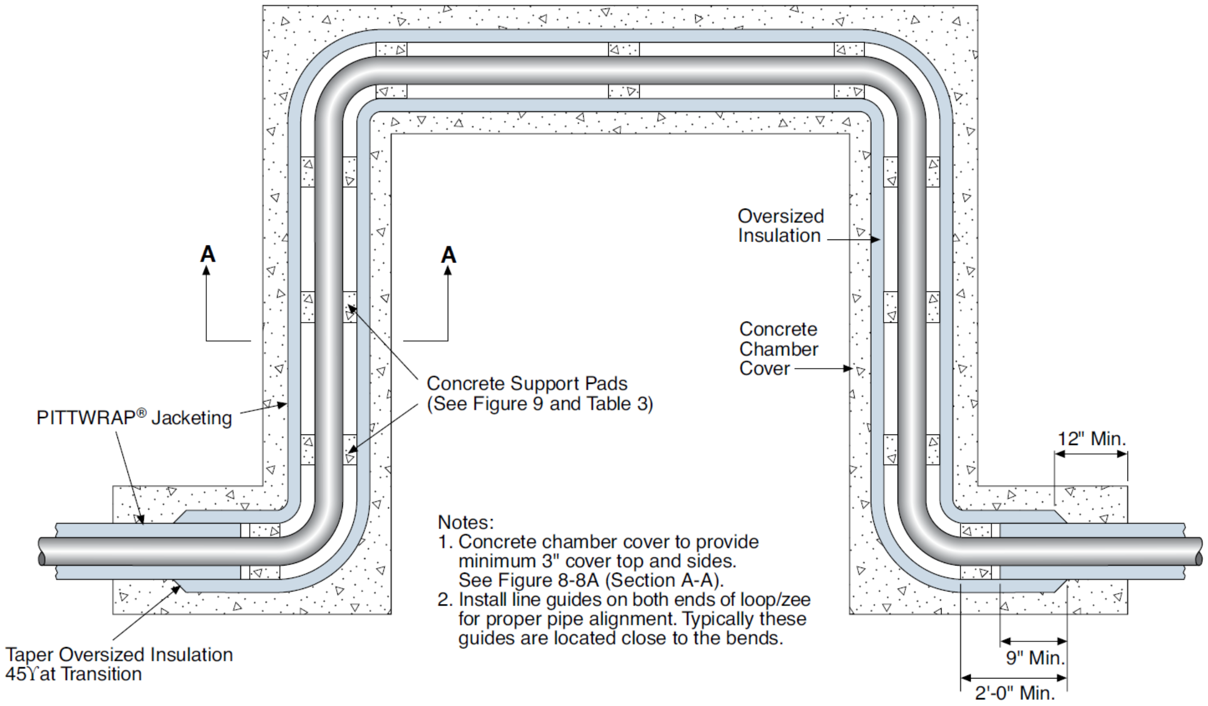
- 100 lineal ft. of carbon steel pipe
- Increases from 70°F to 400° F

= Expansion of +**2.6 inches**

Emphasis on:

- **Proper design of expansion loops/zees**
- **Compatibility of insulation to expand/contract with system**

EXPANSION LOOPS/ZEES



ESCAPING HEAT FROM STEAM LINES

Soil is not an efficient insulator.

For steam lines:

- If insulation fails, heat can escape to adjacent systems.

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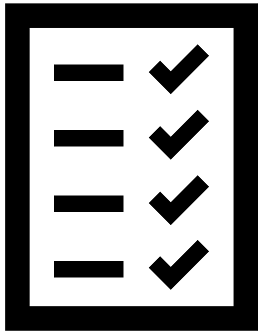
Potential to:

- **Heat nearby chilled water lines**
- **Damage/melt PVC pipes and electrical wire casing**

INSULATION SYSTEM CRITERIA

Design

- Determine worst-case conditions
- Chilled lines
  - Emphasize “zero-permeability”
  - Calculate thickness to prevent surface condensation
- Hot lines
  - Proper expansion loops/zees
  - Insulate to protect nearby electrical/PVC lines
- Ensure adequate spacing between pipes for insulation



Insulation Materials

- Choose the right material for the environment
  - Permeability
  - Water absorption
  - Compressive strength
  - Expansion/contraction
  - Long life cycle
- Quality installation

THANK YOU

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