Shipboard Pipe Insulation Tape

Project Summary Presentation

July 16, 2020

Project Team

National Shipbuilding Research Program

NAVSEA 05 SUPSHIP Bath

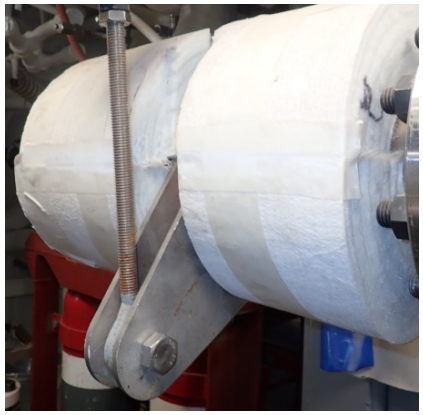
GENERAL DYNAMICS Bath Iron Works

Ingalls Shipbuilding A Division of Huntington Ingalls Industries

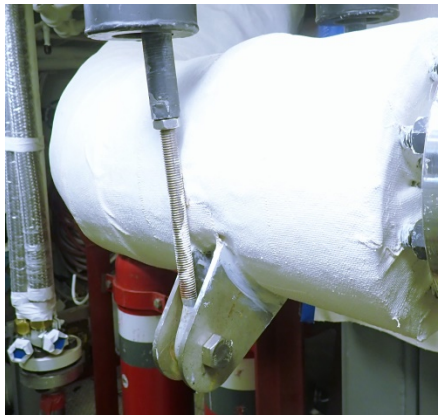
Project Lead

Background

- Pipe Insulation is Difficult and Time Consuming to Install
  - Primarily Applicable to Hot Pipe (>500 °F)
  - Piping Frequently Located in Tight Spaces
  - Installation Includes:
    - Custom Fit Pieces
    - Securing Mechanism – Currently Use Wire
    - Lagging
- This project is leveraging a high temperature tape installation pilot



Insulation Tape Before Lagging



Insulation Tape After Lagging

Goals and Objectives

- Find potential tape solutions that would have a high likelihood of being qualified for use to secure pipe insulation
- Propose design and qualification requirements for the alternative solution(s)
- Reduce labor and material costs associated with securing pipe insulation

Primary Tasks to Meet the Objectives

- Conduct a shipbuilder survey for potential applications
- Develop current state and future state process maps.
- Evaluate gaps between major sections of insulation. If gaps exist and they are not filled with some kind of insulating material, the surface temperature where the lagging covers the pipe insulation will increase.
- Evaluate potential vendor products relative to the requirements in order to select candidate solutions for further assessment.
- Conduct fire testing to assess potential impacts related to a shipboard fire.
- Conduct a cost/benefit analysis to evaluate the cost savings of the selected products relative to the cost of performing the project.

Target Audience

- Primary - The Navy and it's agencies
- Other Beneficiaries
  - NSRP Planning, Production Planning and Facilities Panel
    - Membership
    - Affiliates

Approaches and Methodologies

- Evaluate lagging, adhesive and paint as an integrated system to assess what is needed to secure the piping insulation from initial installation through in-service use.
  - Determine the current requirements
  - Identify potential securing alternatives
  - Evaluate the temperature characteristics of an insulation gap
  - Evaluate lagging and adhesive performance
  - Verify fire performance through testing
  - Validate that the recommended solution(s) meet the Shipbuilder's needs
  - Conduct a cost analysis to determine if the alternative solutions should continue to be pursued
  - Provide recommendations and path forward for implementing the proposed alternative solution(s)

Benefits

- Reduced Insulation Time
- Improved Installation Ergonomics
- Technology is Transferrable
  - Multiple Shipyards
  - Multiple Ship Programs
  - May be expandable to other insulation applications

Technical Assessment

- BIW mechanics have expressed frustration with the use of wire when securing pipe insulation and have recommended using fiberglass reinforced tape instead. It is their perspective that tape will be easier to use, have less ergonomic impact, is readily available and is relatively inexpensive. The focus of this project is to evaluate the potential alternatives to wire for securing pipe insulation during installation and determine their feasibility.

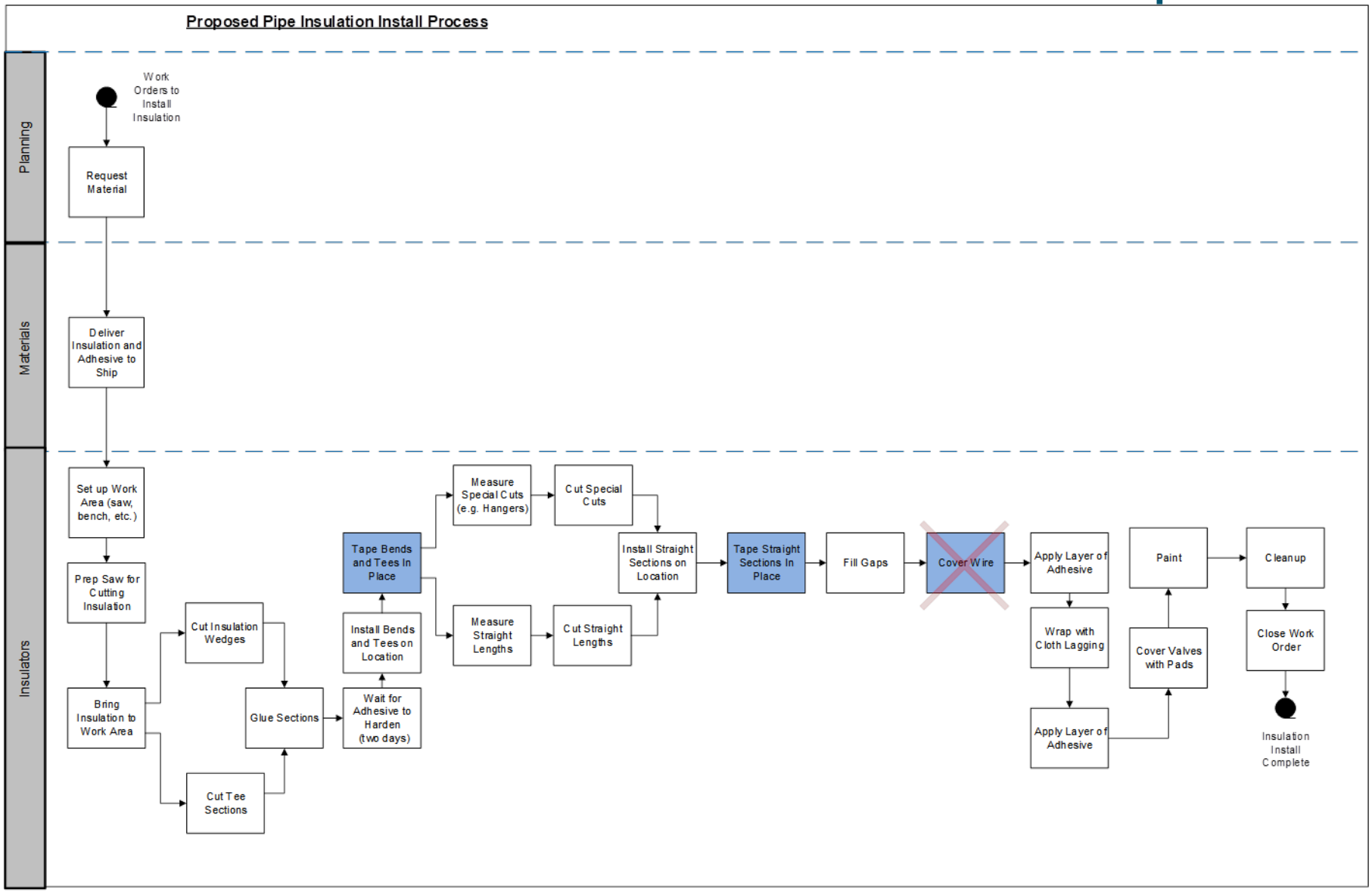
Shipbuilder Survey

- Evaluated Three Ship Programs
  - LHA
  - DDG 51
  - DDG 1000
- Results - Length of Pipe for Leveraging Opportunity
  - 2450 ft
    - Per Ship
    - Averaged across the three programs

Requirements Evaluation

- Specific Requirements Not Defined
- Derived Three Requirements
  - **Strength** - Equal or Better strength than Wire - Calculated to be at least 354 pounds per three foot section of insulation
  - **Temperature** - The securing mechanism shall have a design temperature limit of at least 133 °F consistent with the maximum insulation surface temperature allowed by MIL STD-769.
  - **Quality** - The surface of the pipe insulation when secured, shall have a rigid, smooth surface to allow the adhesive, lagging, and paint to be applied.

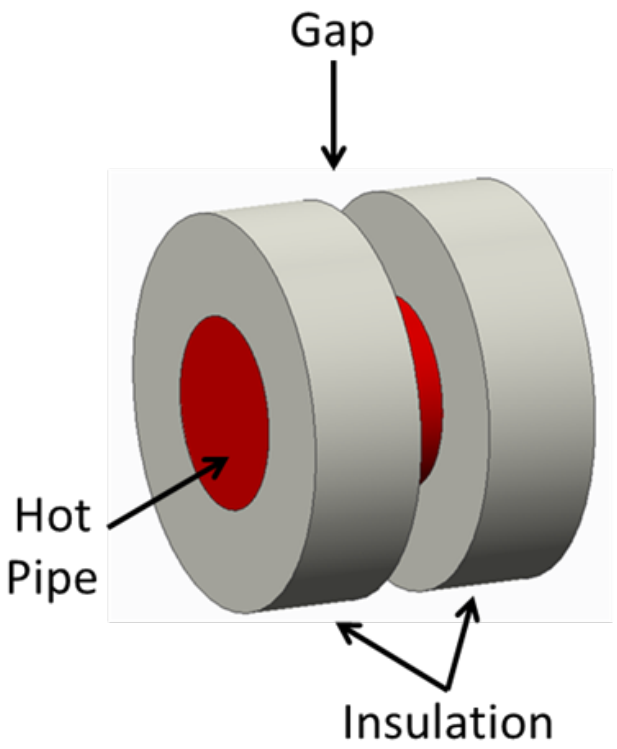
Current and Future State Process Map



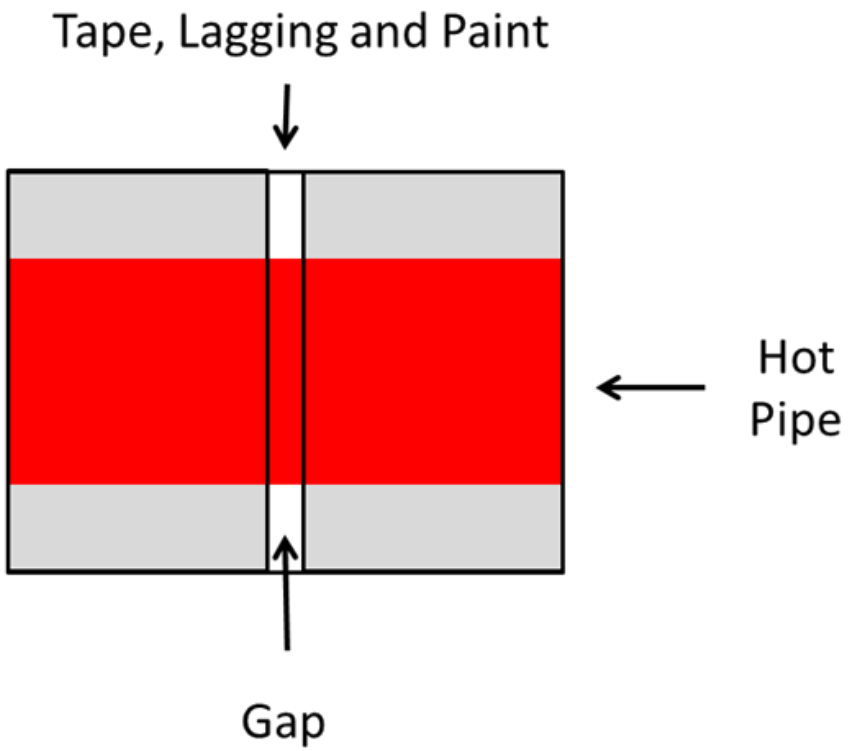
Insulation Gap Assessment – CFD Model

- Created a 3D Model
- Applied Thermal and Physical Properties
  - Thermal Conductivity
    - Insulation
    - Lagging
  - Radiation Emissivity
    - Rusted Pipe
    - Insulation (gap walls)
    - Lagging
  - Gap Width
- Applied Boundary Conditions
  - Hot Pipe Temp - 1200 °F
  - Ambient Temp – 85 °F
- Ran Model to Obtain Temperature Distribution
  - Multiple Gap Widths
  - Multiple Hot Pipe Temperatures

Insulation Gap Assessment – CFD Model



Isometric View

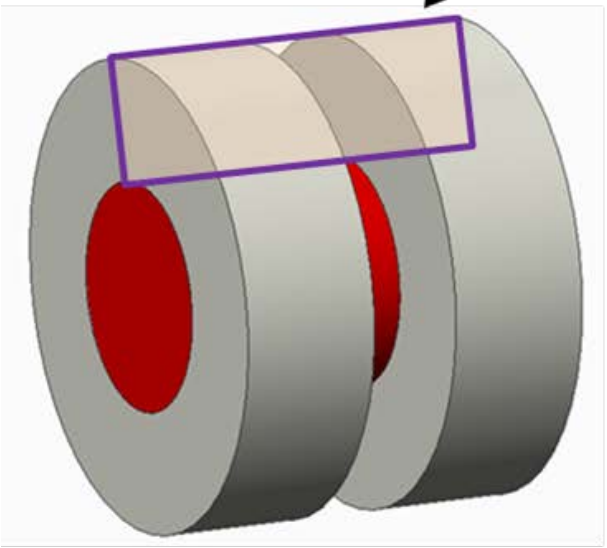


Section View

CFD Model – Temperature Distribution

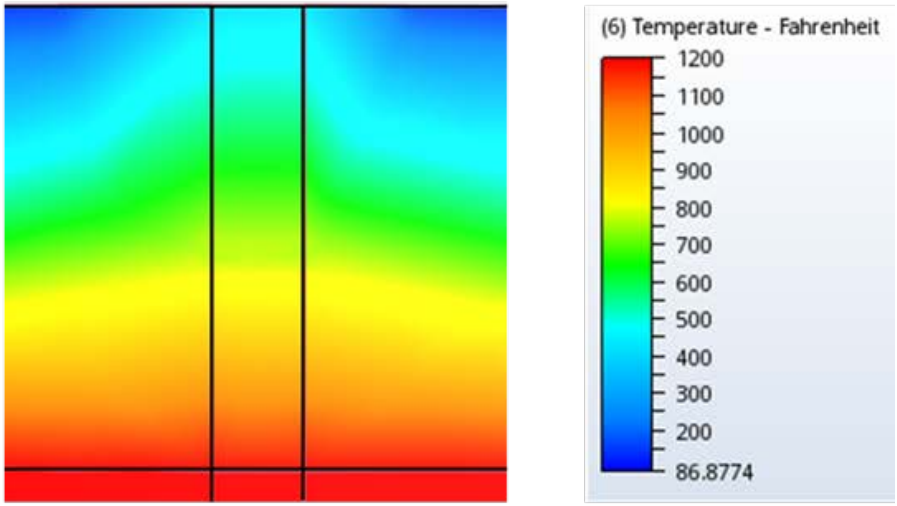
- Hot Pipe Temp - 1200 °F
- Gap Width – ½”

CFD Model Section

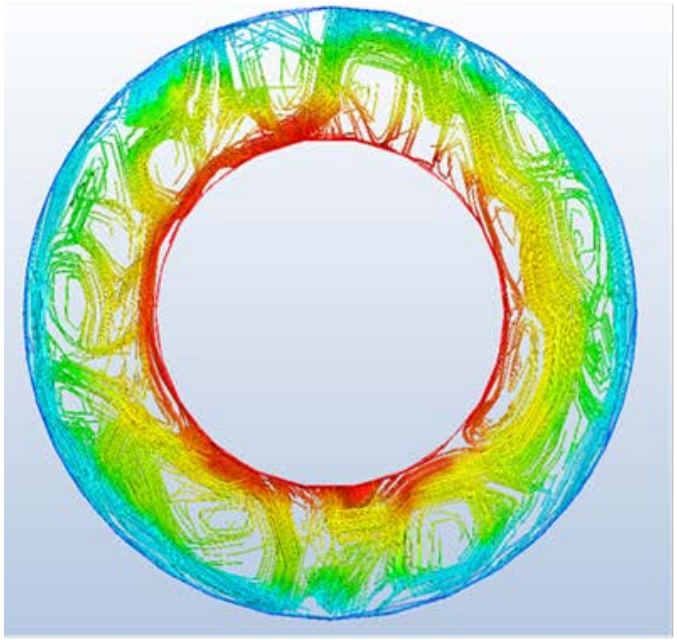


CFD Model

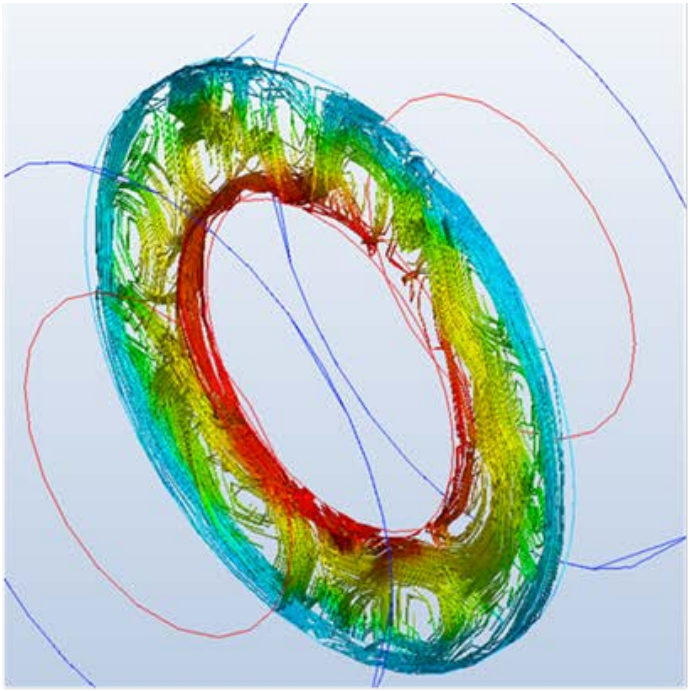
Surface Temp ~390 °F



CFD Model – Particle Trace



Cross Section View



Isometric View

Alternatives Assessment

- **Tape** - Multiple types of tape were evaluated as an alternative securing mechanism for pipe insulation. All of the tape alternatives have sufficient strength to hold the insulation in place; however, the masking tape and VentureClad tape are more likely to tear during the installation process.
- **Bands** – Abandoned for Safety Reasons
- **Adhesives and Lagging** – Part of current process - Layered approach to lagging and adhesive results in a very strong outer shell.
- **Adhesives** – Provides the greatest strength if an adhesive is used between the two halves of insulation.

Alternatives Assessment

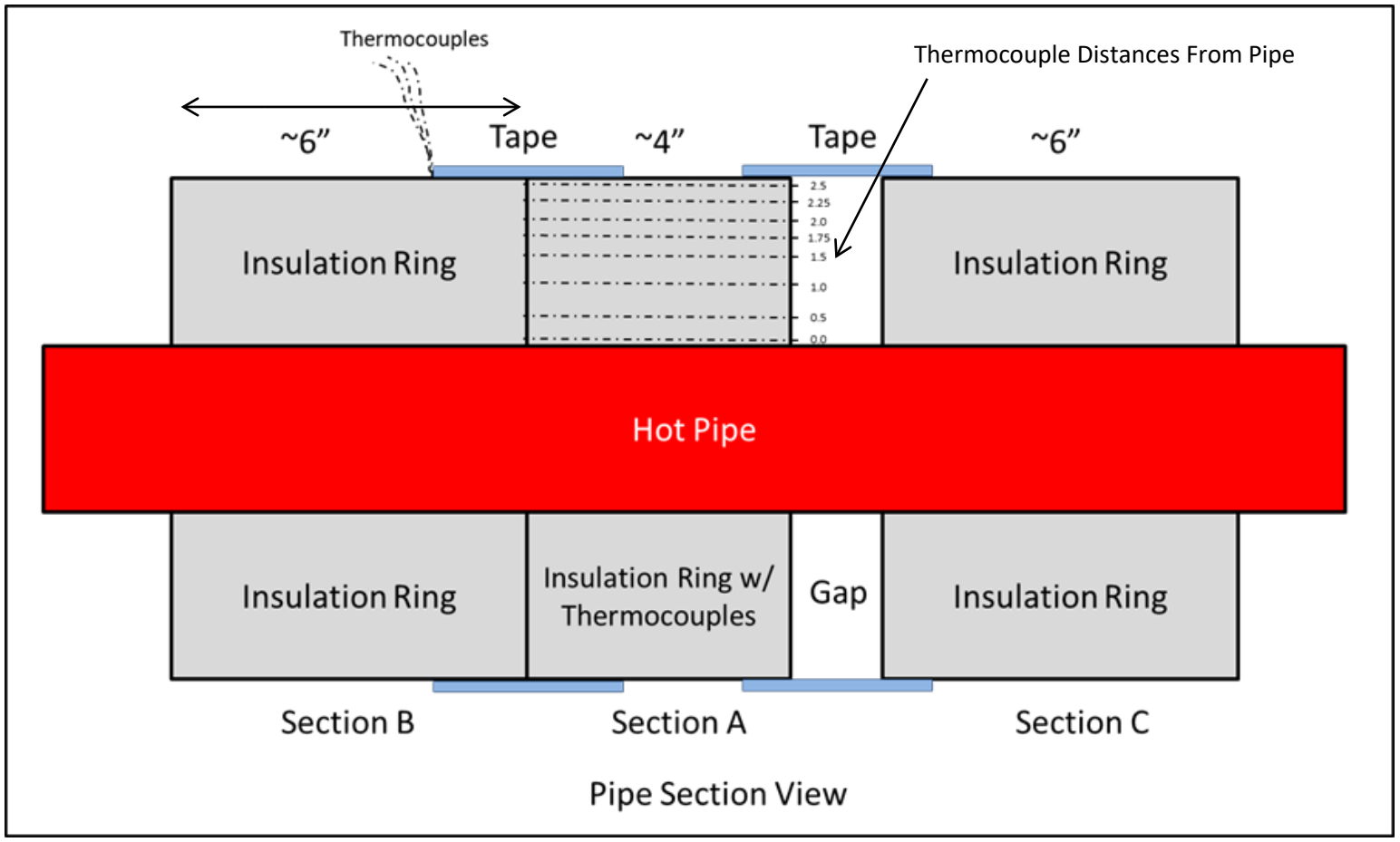
Securing Mechanism	Size	Tensile Strength (per 3 ft. Section)	Approximate Material Cost (per 100 ft Section)	Approximate Installation Time (per 3 ft. Section)	Temperature Rating	Notes
Steel Wire	18 gage	354 lb	$ 60	15 Minutes	> 2500 ºF	Difficult to Install. Potential sharp ends
PrimeTac® filament 220 (Fiberglass Reinforced Packing Tape)	1 inch	300 lb	$ 9	5 Minutes	<100 ºF	Recommended by BIW mechanics
3M 3615 (High Strength High Temp Fiberglass Tape)	1 inch	540 lb	$ 660	5 Minutes	450 ºF	Used on BIW Pilot
3M 301+ (Masking Tape)	2 inch	126 lb	$ 21	5 Minutes	180 ºF	Risk of Tearing
3M VentureClad Tape 1578CW-E	2 inch	414 lb	$ 70	5 Minutes	300 ºF	
Polyken #225FR-3 (Flame Retardant Duct Tape)	3"	234 lb	$ 109	5 Minutes	200 ºF	
Steel Bands	3/8 inch	2040 lb	$ 40	20 Minutes	> 2500 ºF	Safety risk. High profile buckle. Sharp band end.
VIMASCO 760 Adhesive (between halves)	N/A	7200 lb	$ 90	15 Minutes	800ºF	Tape must be used to hold in place while adhesive cures
Fosters 3036 Adhesive + Fiberglass Cloth	N/A	5822 lb	N/A (Part of current process)	N/A (Part of current process)	180ºF	Provides more strength than majority of other alternatives

Insulation Gap Temperature Testing

- BIW Boiler Room Testing
  - Hot Pipe Temperature – 316 °F
  - Ambient Temperature – 88 °F
- Multiple Insulation Gap Widths Tested
- Ran CFD Model with Same Boundary Conditions
- Good Correlation Between CFD Model and Test Data
  - Very close for small gaps up to ½"
  - Greater divergence above ½"
- Realistically, any visible gap will be filled with insulation

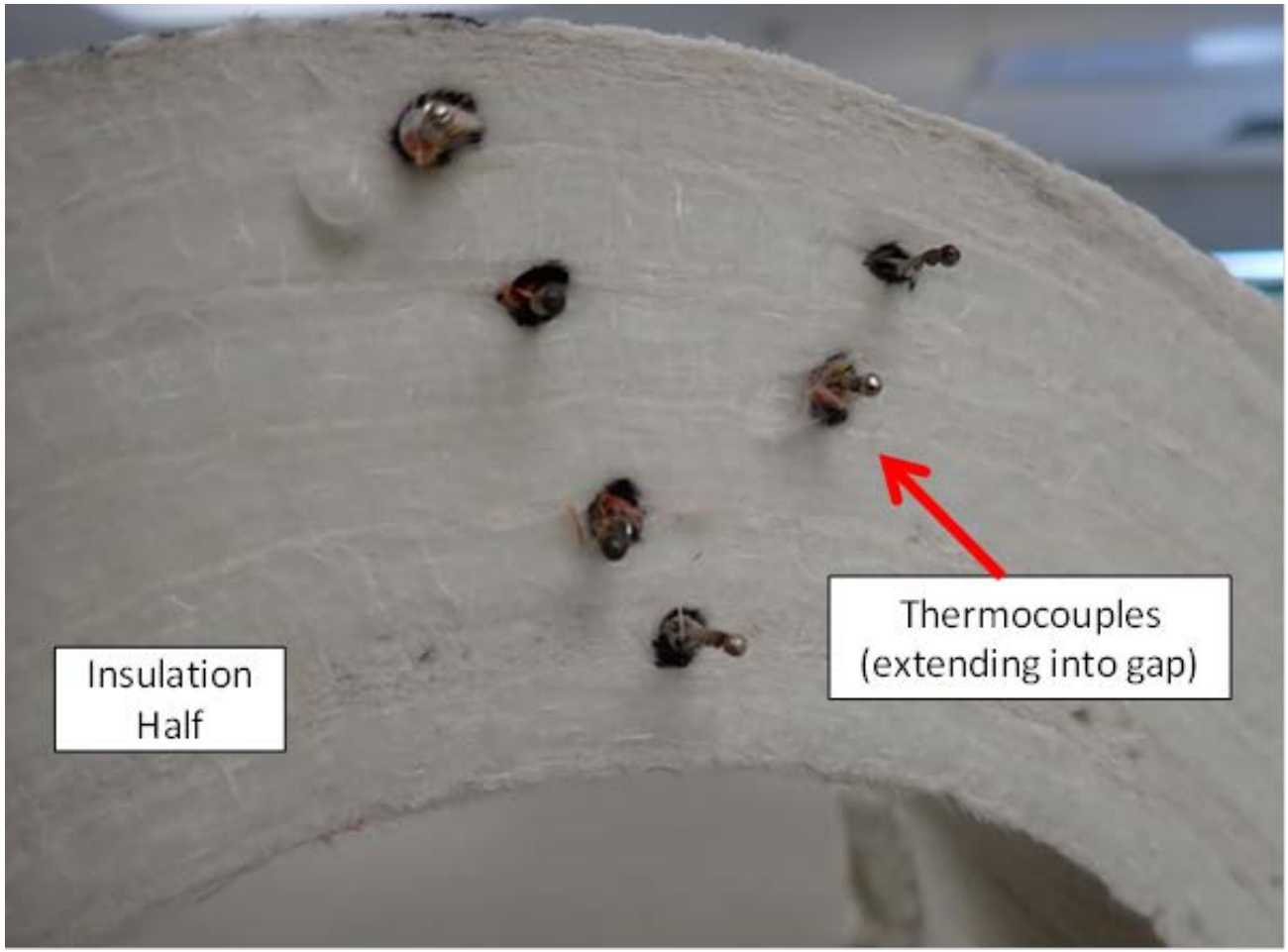
Insulation Gap Test Measurements

- Planned Test Setup



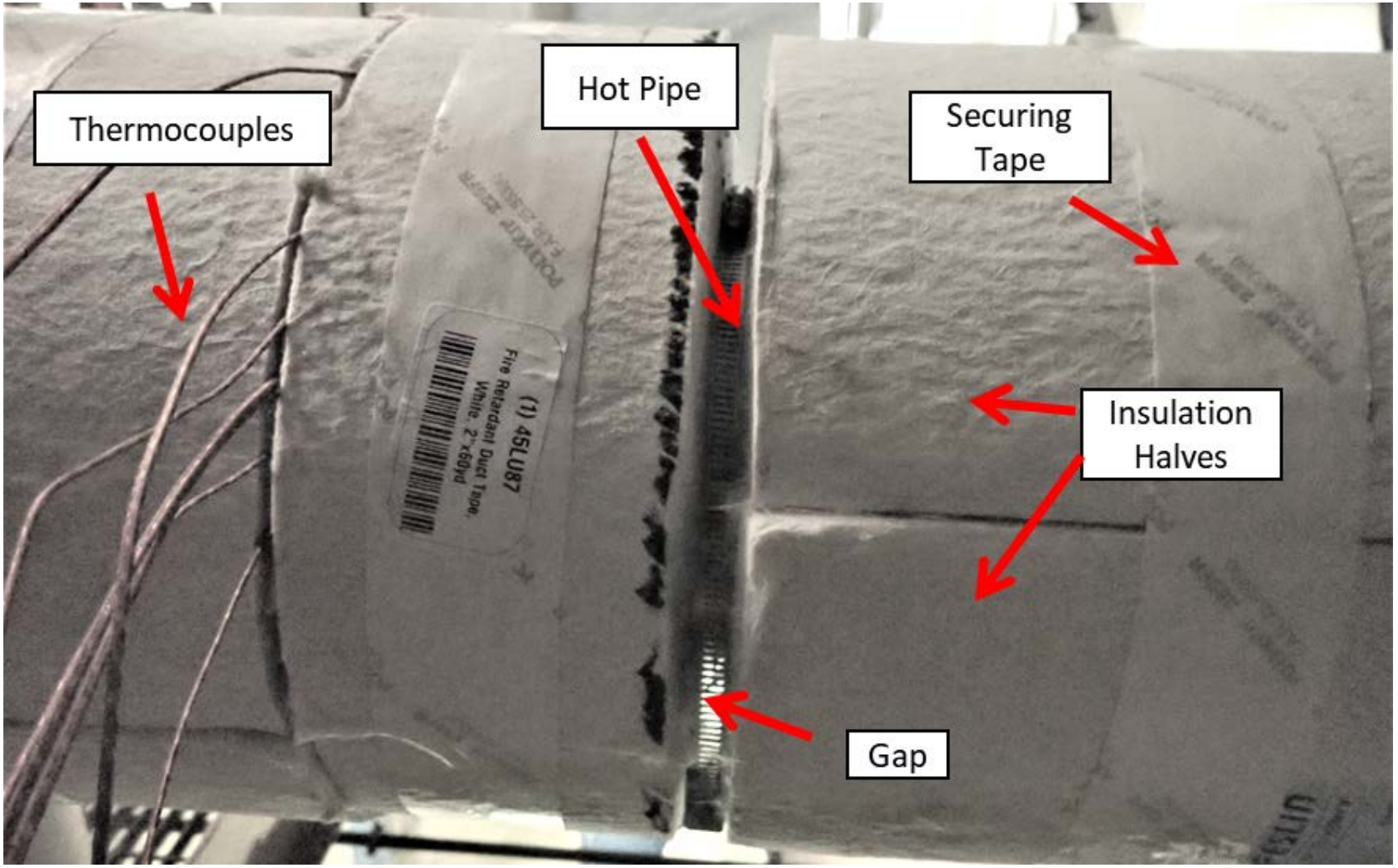
Insulation Gap Test Measurements

- Thermocouple Arrangement

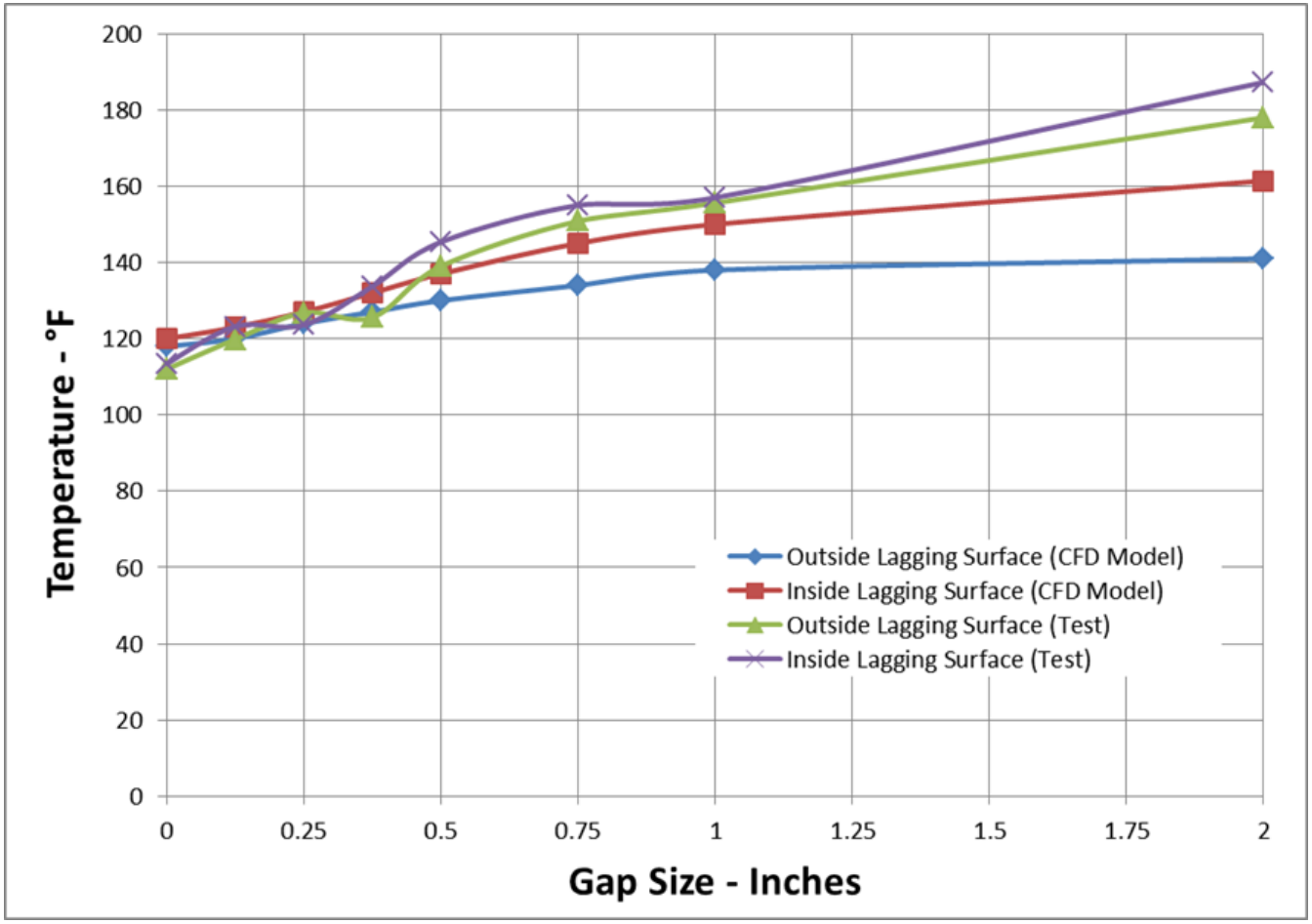


Insulation Gap Test Measurements

- Actual Test Setup



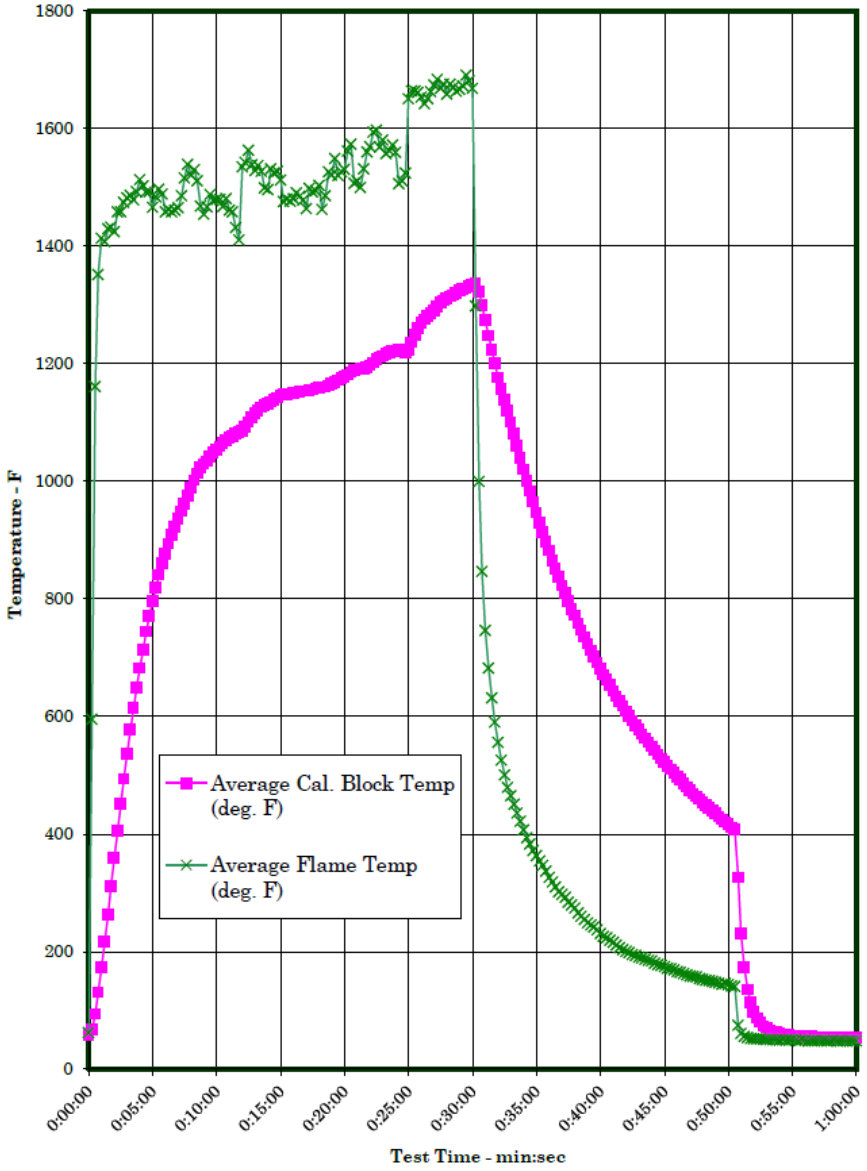
CFD Model / Gap Test Comparison



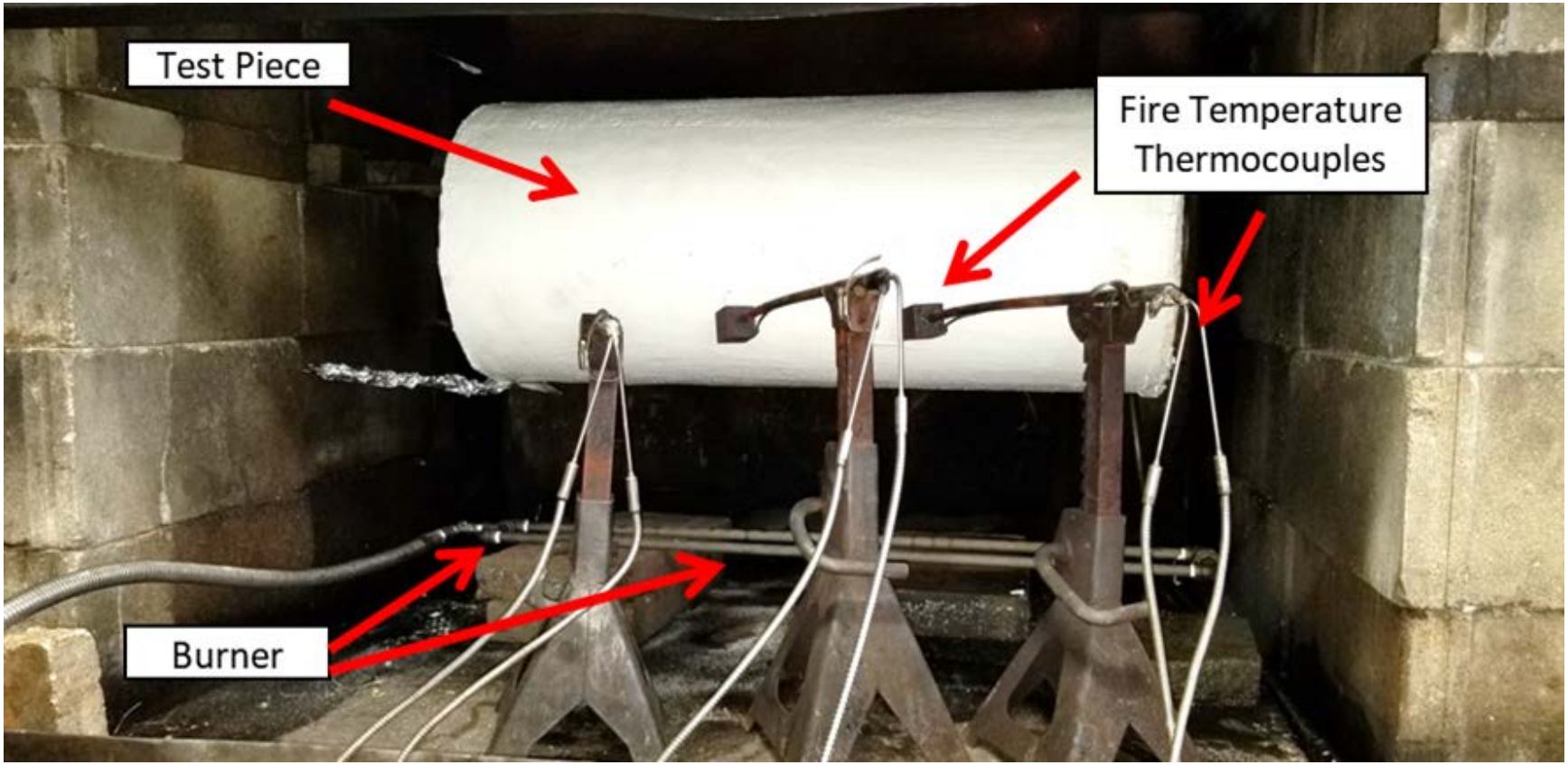
Fire Testing

- Potential Concern
  - If the insulation securing mechanism fails during a fire, the insulation could fall and create a tripping hazard for fire fighters
- Fire testing requirements are not specifically defined
- Derived fire temperature and duration requirements based on previous equipment testing
  - Flame Temperature – 1200 °F – 1800 °F
  - Flame Duration – 30 Minutes
- Cooldown
  - Air Cooling – 20 Minutes
  - Water Spray Cooling – As necessary to return to near ambient
- Post-Test Diagnostics
  - Lagging Removed to Assess Residual Tape

Example Temperature Data



Fire Testing – Fire Test Setup

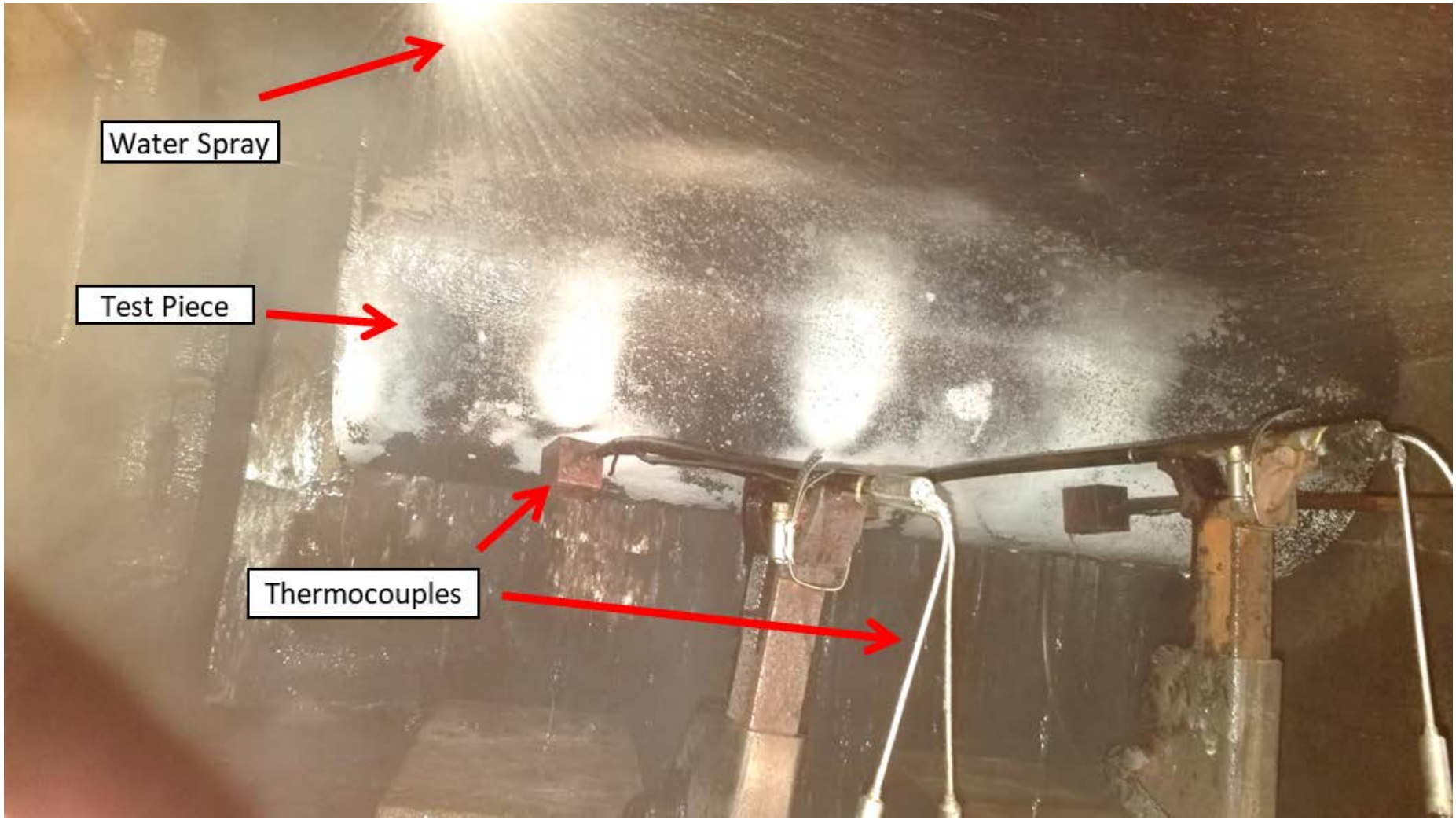


Fire Testing – Fire Testing

Video

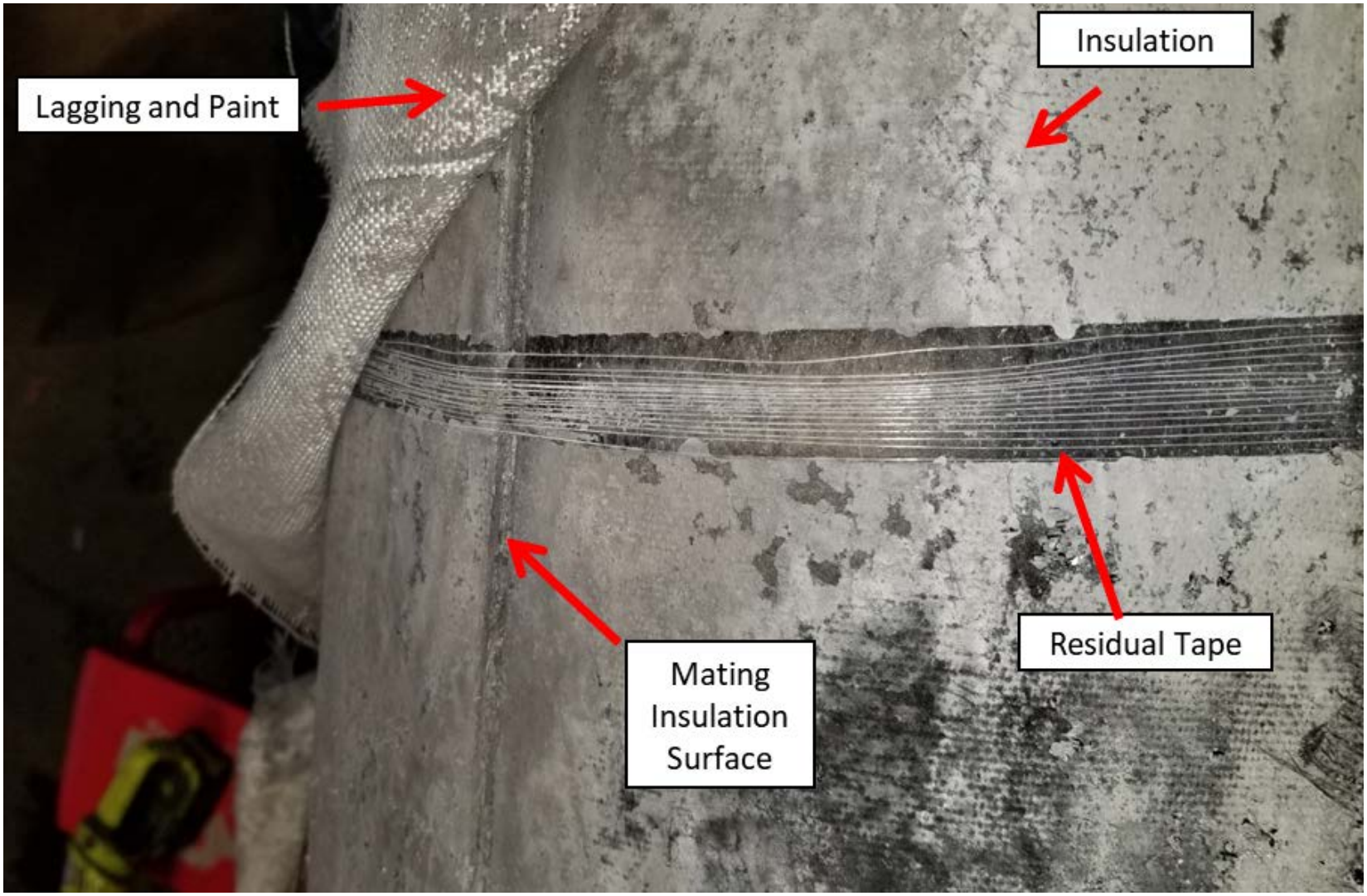
Fire Testing – Test Piece During Air Cooldown

Fire Testing – Test Piece During Water Cooldown



Fire Testing – Post Test Diagnostics

Video



Cost / Benefit Analysis

- Savings
  - Cost Savings per Ship - $19.7K
    - 2450 ft of pipe length
  - 42 Ships (next 5 years)
  - Total 5 Year Savings - $827K

- Costs
  - NSRP Project Cost - $147K
  - Implementation Cost - $20K
  - Total Cost - $167K

- ROI = ($827K - $167K) / $167K = 3.9 for 5 years (42 ships)

Conclusions

- Current use of fiberglass cloth lagging and adhesive over the pipe insulation provides primary securing mechanism
  - More than two orders of magnitude greater tensile strength than is required to hold up the insulation (wire only)
  - Temperature rating of 180 °F which exceeds the MIL-STD-769 required temperature of 133 °F.
  - Fire testing showed that the adhesive and lagging have sufficient residual strength during the fire, subsequent air cooldown period and water spray cooldown period to keep the insulation securely in place.
  - Any of the tape or banding options can be used as a temporary securing mechanism until the lagging and adhesive are applied.

Conclusions

- The BIW preferred option is to use fiberglass reinforced packing tape.
  - Lowest material cost tape alternative.
  - This tape was recommended by the BIW mechanics because it is readily available, cost effective, and easy to use.
  - The fiberglass reinforced packing tape allows the mechanic to pull on the tape to help force the two halves of insulation together prior to overlapping the tape and securing it in place.
  - Fiberglass reinforced tapes are less likely to tear.
- When covering a gap or special cutout filled with loose insulation, a higher temperature tape (VentureClad or similar) may want to be considered.
- The HII preferred option is to use VentureClad because of higher strength and temperature ratings and relatively low cost.

Recommendations

- Temporarily secure pipe insulation with fiberglass reinforced packing (or similar) tape until the adhesive and lagging have been applied.
- Allow the lagging and adhesive to be the primary securing mechanism.
- If tape is used to cover insulation gaps and special cuts (filled with loose insulation and/or cement), consider the use of a higher temperature tape (VentureClad or similar product).

Implementation Plan

- Shipbuilders
  - Submit a deviation that allows the use of alternative tape products be used for a small pilot area to ensure the method(s) used are acceptable for their application.
  - Develop a shipbuilder change request to implement their proposed solution for larger portions of the ship, the entire ship and/or follow ships.

Tech Warrant Holder Feedback

- The TWH generally agreed with the conclusions, recommendations and implementation plan for using an alternative to wire for securing pipe insulation.
- When submitting a change request, a general product (or equal) should be specified. This will allow for other options if a specific product is discontinued.

Recommendations for Future Work

- Additional shear strength testing of the Foster adhesive to determine the strength of the adhesive/lagging at elevated surface temperatures.
- Additional temperature testing of an insulation gap at higher temperature(s) would help validate the CFD modeling at shipboard representative conditions.
- Conduct additional assessments of other shipboard insulations. While conducting research for this project, the BIW project team found other pipe insulation opportunities that could have significant benefits if an alternative securing mechanism is used.


NATIONAL SHIPBUILDING
NSRP
RESEARCH PROGRAM