

INSULATIVE COATINGS FIT FOR PURPOSE


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Agenda

- Fit For Purpose – Process Heat Vs. Solar Heat
 - Conventional Insulation – Corrosion Under Insulation
 - BP Review – Insulation Optimization Tactics
 - Sample Applications – Thick Film Vs. Thin Film
 - Testing Methods – Process Heat Vs. Solar Heat
 - New Testing – Cathodic Shielding
 - New Applications – Below Grade Piping
 - LNG – Boil-off Reduction
- 

The Good News

- Insulative Coatings are now widely available through numerous manufacturers.
- Available in Epoxy, Acrylic, and Siloxane resins.
- Includes combinations of ceramics (low density), fibers, and glass hollow sphere beads.

Three Forms Of Heat Transfer

Convection

The transfer of heat by air.

Example: Warm air rises and transfers heat to ceiling.

Conduction

The transfer of heat through a solid material.

Example: Heat is transferred from warmer sections of the walls and ceilings to cooler sections

Radiation

The transfer of heat in the form of electromagnetic waves.

Example: Heat is transferred from roof to ceiling through “loading of heat”, then re-radiated from roof to ceiling.

Fit For Purpose – Process Heat (Thick Film)

1 Type of Coating

Hot Insulating Coating System for carbon steel and stainless steel service

2 General Data

2.1 Typical Use

Alternative to conventional bulk insulations for energy conservation in hot services. Used for personal protection on hot piping.

2.2 Service Condition Limitations

Maximum Service Temperature: 500°F (260°C)

Cost Of Corrosion



- Global estimated annual destruction responsible from corrosion equals \$2.5 trillion.
- 15% - 35% (\$375-875 Billion) could be saved by developing and implementing a multi step corrosion plan.
- \$10+ Billion is spent annually to remediate petrochemical and petroleum refinery equipment.

References:

G. Koch, et al., "International Measures of Prevention, Application, and Economics of Corrosion Technologies Study" (Houston, TX: NACE International, March 1, 2016).

G. Koch, et al., "Corrosion Costs and Preventive Strategies in the United States," National Technical Information Service, FHWARD-01-156, 2002.

Conventional Jacket Insulation



How it works:

Small pockets of air and fiber that slow conductive heat transfer.

Heat will be absorbed and transferred to the cooler side at an accelerated rate.

Corrosion Under Insulation



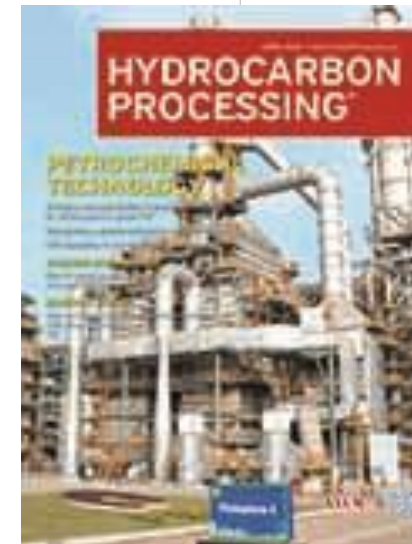
Rockwool, fiberglass, or other traditional types of insulation promote corrosion, and also act as a carrier and spread the corrosion to other areas of the pipeline

- Jacket insulation originally designed for safety, not insulation.
- Costly maintenance due to CUI.
- Corrosion occurs when insulation absorbs moisture, wets steel surface.
- Never designed to be air tight.
- Absorbs moisture, gains weight, sags or falls off pipe.
- Increases risk of leaks, fires, explosions.

BP – NACE BOTH Conference June 2018

Million\$ to be Saved Through Insulation Optimization

- **Muhannad Rabeh**, B.Sc., BP America – GoM DW
- **Shawn O’Hearn**, P. Eng., API 510/570, BP America – GoM DW
- **Jonathan Petersen**, CEng, IMechE, BP America – GoM DW



Hydrocarbon Processing, April 2018

BP – Insulation Optimization

What's the easiest ways to prevent CUI?

- *don't install insulation!!*
- *get rid of insulation!!*

BP – Insulation Optimization

Why is there so much insulation?

The ~~need~~ “perceived need” for ...

- Heat conservation
- Personnel burn protection
- Noise reduction

BP – Insulation Optimization

CUI Prevention Strategy

A. Perform insulation engineering review ...

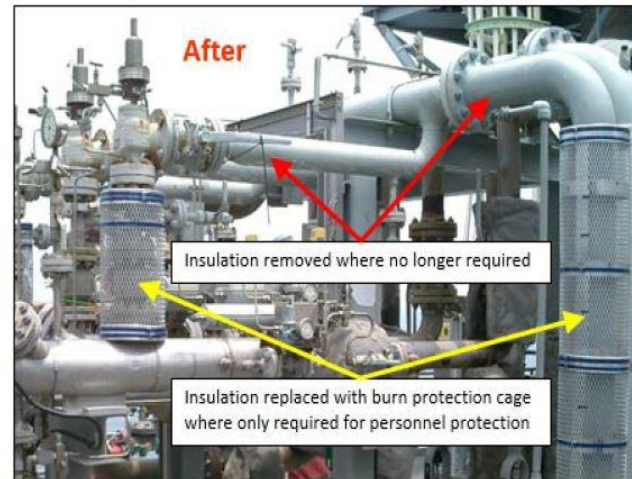
- Heat Conservation Evaluation
- Personnel Protection Evaluation

B. Aggressive inspection program ...

- where insulation is still required ...
- starting with highest consequence services ...

BP – Insulation Optimization

Implementation



BP – Insulation Optimization

Insulative Coatings



Active CUI



- After insulation removal
- Surface temp 340 F



- Thermal insulative coating system applied in place of conventional insulation
- Surface temp < 140 F

BP – Insulation Optimization

Conclusion

- Applied across GoM facilities
- A significant number of insulated lines can have insulation permanently removed
- A significant number of insulated lines can have insulation replaced with cage or coating
- *Where possible, remove insulation to prevent CUI*

Thick Film Insulative Coating Advantages



- replaces wrap & jacketing
- reduces CUI
- no shutdown required
- applied on hot or ambient surfaces
- internal temp/pressure increase
- reduce energy consumption
- protects personnel
- easy to inspect and repair

Before & After

BEFORE (bare pipe)	AFTER (30mm thickness)
463°C (865°F)	36°C (96°F)



Competitive Cost, Easy Application

Applied directly on valves and elbows, strainers, etc.



NACE TM 21423



- Personnel Protection
- Based on ASTM C1055
 - 5 second touch rule, up to 59°C (138°F) which is the start of a 1st degree burn.

NACE TM 21431-2020

ASTM C177: Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus.

- Test method based on ASTM C177
- Measuring Thermal Conductivity @ 73.4°F / 23°C
- 300 mils DFT, 12x12 AI sheet

Mean temperature °C	Thermal conductivity W/(m.K)
-10	0.059
0	0.060
10	0.061
20	0.062
30	0.063
50	0.066
100	0.071
200	0.083
300	0.094
400	0.106
500	0.117

Coating Integrity & Durability

- ASTM B117: Standard Practice for Operating Salt Spray (Fog) Apparatus used for new construction.
- ASTM D4541: Standard Test Method for Pull Off Strength
- B-117 can be used to test corrosion resistance of a insulative coating which has not yet been placed into service, while D4541 can be tested with thermal aging.


Case Study – Water Bath Heater

Water Bath Heater – 24” Diameter, 10’ Length – 175°F (79.4°C)

Challenges: Corrosion Under Insulation. Failure of insulation materials, due to moisture penetration.

Solution: 10-12mm or ½ inch dry film of waterborne, non-toxic, non-flammable, ceramic cross linked acrylic based insulation coating applied directly to water bath heaters while in operation.

Desired Results: Corrosion under insulation protection. Significant heat loss reduction. No space for rodents to hide in.



Case Study – Water Bath Heater



Equipment:

Graco GTX EX 2000

Texture Sprayer

Case Study – Water Bath Heater



Before:

Coating application:

Picture taken after NACE 4 surface preparation.

Case Study – Water Bath Heater

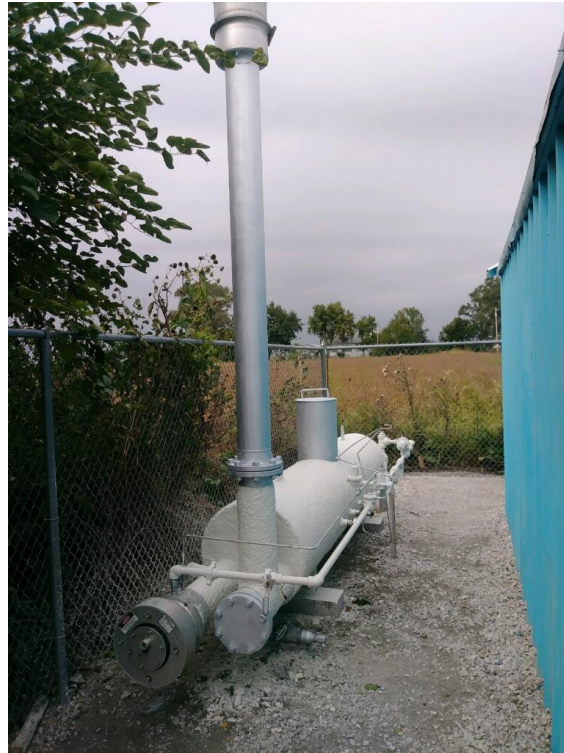


After:

Applied while online

Insulation coating applied in 2 coats,
plus polyurethane top coat

Case Study – Water Bath Heater



After:

Applied while online

Insulation coating applied in 2 coats,
plus polyurethane top coat

Case Study – Water Bath Heater



Details:

Angled profiles using handheld razor to discourage ponding water

Thermal Readings

Before: 174°F (78.8°C)



After: 204°F (95.5°C) Metal Temp.



Skin Temp: 101°F (38.3°C)



Thermal Readings

Before: 85°F (29.4°C) (metal temp)



After: 95°F (35°C) (skin temp)



- Only pilot heat is online, yet heater barrel is holding more heat, correlating in higher skin temperature.

Water Temperature

Before: 99°F (37.2°C) (water temp.)



After: 118°F (47.7°C) (water temp.)



Water Bath Heater # 2



Before:

Picture taken after NACE 4 surface preparation.

Operating surface temperature was 120°F (48.8°C) max without insulation.

Water Bath Heater # 2



After:

Primer, DTM Polyurethane

Primer max temperature limit of 325°F
(163°C)

Water Bath Heater # 2



After:

10-12mm or ½" DFT Insulation Coating

Applied while operating online 120°F
(48.8°C)

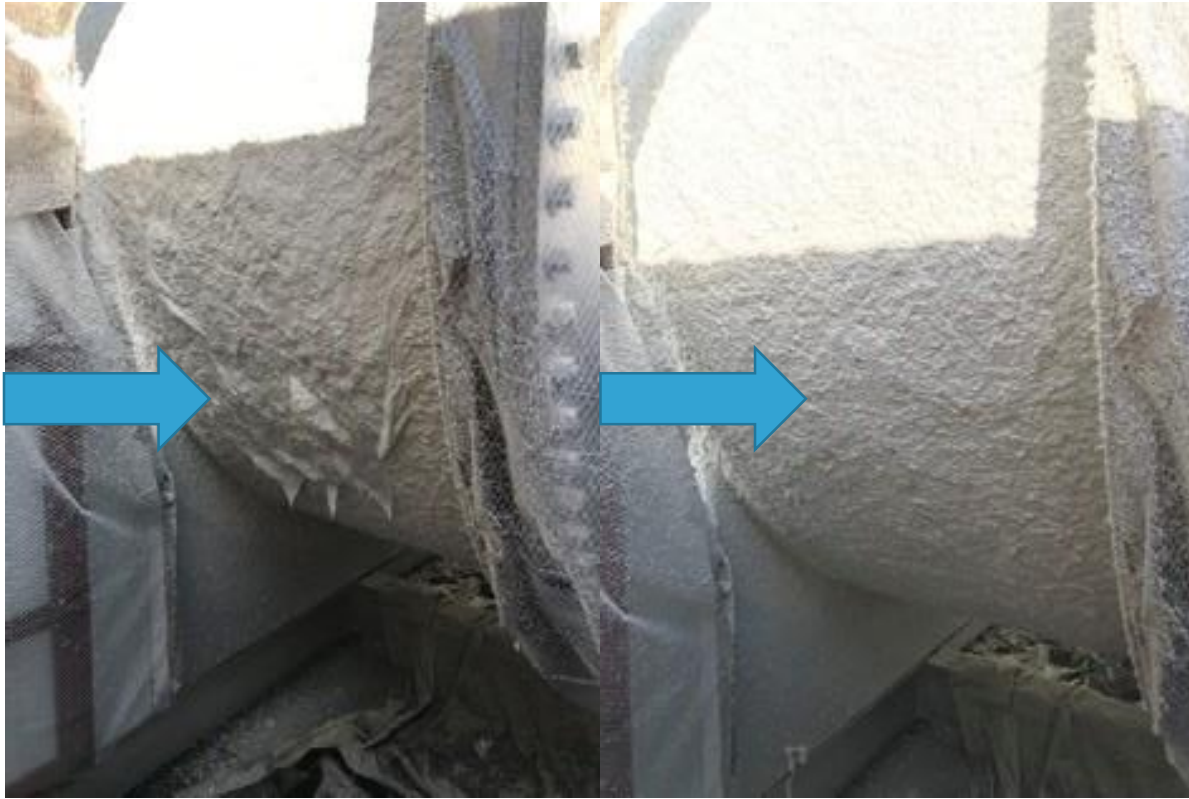
Water Bath Heater # 2



Details:

Piping left uncoated

Water Bath Heater # 2



Over Spray Repair:

Hand trowel

No material lost, advantages of applying acrylic formulations while operating online.

Water Bath Heater # 2



Trash:

Heavy CUI Damage

Water Bath Heater # 3



After:

10-12mm or ½" DFT Insulation Coating

Applied **OFFLINE**

Ambient application

More time needed for curing

LNG Steam Pipes



Steam Pipes

3,500 linear feet (1066.8 meters)

1-14" pipe diameter

Temperature Up to 240°F (115°C)

300 mils (7.62mm) DFT, applied online

Replaces Jacket Insulation for CUI Protection

LNG Steam Pipes



Steam Pipes

Applied online, with recycled steam to heat up the surface of the pipes to accelerate curing.

Surface Preparation – 4,000 psi power wash

Glycol Water Line – Below Grade

Glycol Hot Water Pipes – TWIN 4" Diameter, 275' (83.8 Meter) Length

Challenges: Corrosion Under Insulation. Failure of conventional insulation materials due to cathodic shielding and moisture penetration. Preventing the freezing of glycol lines in winter.

Solution: 300 mils/7.62mm DFT(a little over 1/4") of waterborne, non-toxic, non-flammable, ceramic based cross linked acrylic insulation coating applied directly to pipes precoated with FBE. Applied while recycled hot water raised the pipe temperature above 120°F (49°C) for accelerated curing.

Desired Results: CUI protection. Heat loss reduction. Non cathodic shielding.

Glycol Water Line – Below Grade



Glycol (water) Pipes

Winter Freeze Protection

600 linear feet, (182.8 meters)

4" pipe diameter

300 mils DFT (7.62mm)

Recycled glycol to heat up the pipe for accelerated curing.

Cathodic Shielding Testing



Laboratory Testing:

No Cathodic Shielding

Primer – FBE & 2-part epoxy

300 mils DFT Acrylic Insulative Coating
(7.62mm)

Epoxy top coat for indefinite submersion /
below grade protection

Novel Field/Shop Application



New Fuel Gas Piping

800 linear feet (243.8 meters)

Pre-heat pipes (torch or induction heating)
for field/shop application.

New piping arrives precoated saving time
& labor.

Novel Wrap System For Tie-ins

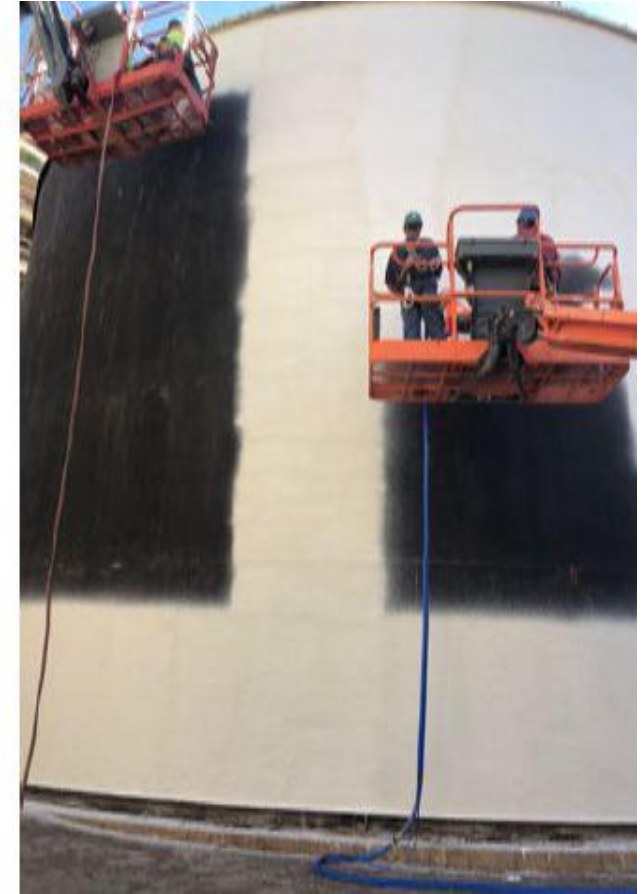


Flexible Pipe Wraps

Flexible Insulative Coating applied to polyester mesh then used for sealing ends once new piping is installed and welded.

No spray application required in the trench.

Heated Black Liquor Tanks



Heated Black Liquor Tanks



200 mils (5mm) DFT Insulative Coating

Top Coat: 4 mils DFT Polyurethane

Before: 180°F (82.2°C)

After: 118.7°F (47.7°C)

Applied while online

Power Generation

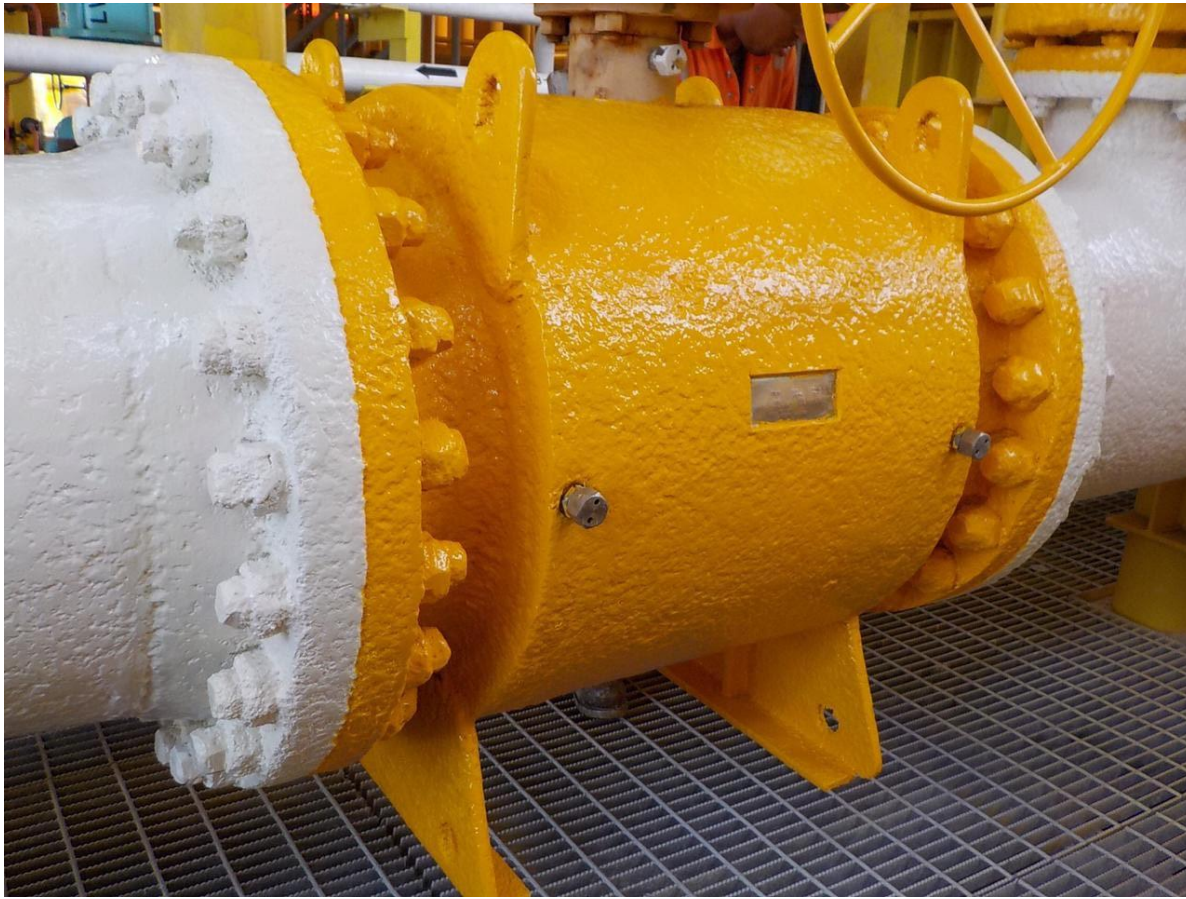


Bag House Ducts

1/4" (6.35mm) DFT Thick Film Insulative Coating

Replace Jacket Insulation

Offshore Crude Pipes



Crude Oil Pipe:

Applied over flanges and bolts

Polyurethane top coat

Acrylic based systems require topcoat for UV and climate protection.

Tricks Of The Trade



In some cases, Insulative Coatings can be applied over fiberglass or rockwool wrapped around bolts which can then be cut to expose the bolts if needed.

Inspection Ports



Inspection windows can be cut out of the coating film over weld joints for repeat non destructive inspection.

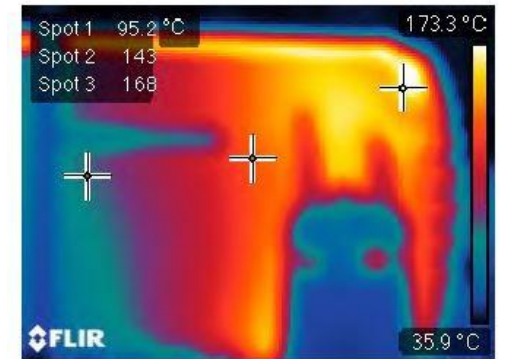
Simply place the square back in and apply silicone to edges until next inspection is required.

Offshore Compressor

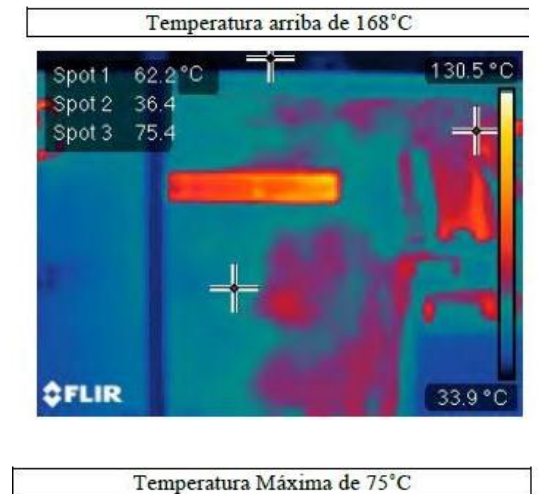


Surface Temperature:

Before: 334°F (168°C)



After: 167°F (75°C)



Steam Pipe



Personnel Protection:

Surface Temperature:

Before: 280°F (137.7°C)

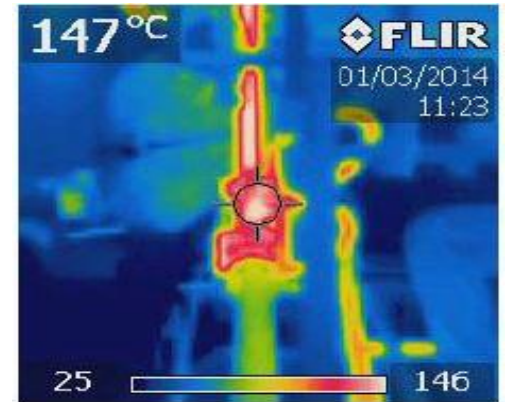
After: 90°F (32.2°C)

16 mm or 5/8" DFT

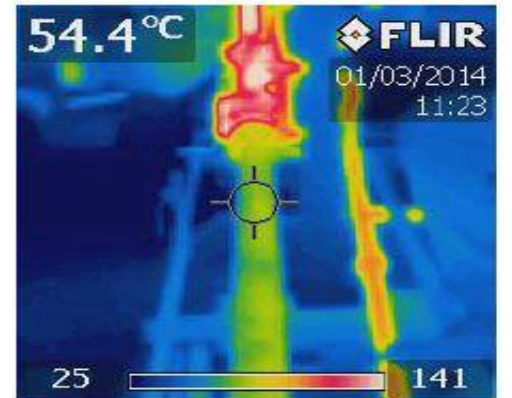
Sulfur Pipe



Uncoated 296°F



Coated 129°F



1/2" DFT (12.7mm)

Ultra High Temperature



Bare Pipe = 517°F
269°C

1" DFT = 177°F
80°C



Advanced Strategies




Advanced Strategies:

Varying thickness on stacked columns.

Prevents condensation inside stacks,
reducing acids etc.

Considerations - Thick Film Insulative Coatings

1. Applying on hot or ambient surfaces
 2. Surface preparation & primers
 3. Inspection / performance monitoring
 4. Testing requirements – lab & field
 5. Equipment / applicator training
 6. Cryogenic use siloxanes > acrylics
 7. Spec according to weather & cure times
 8. Apply over bolts and flanges ?
- 

Fit For Purpose – Solar Heat (Thin Film)

1 Type of Coating

Radiant Heat Insulating Coating System.


2 General Data

2.1 Typical Use

External top-coating system for petroleum tanks, vessels and drums to reduce the solar heat gain and to minimize the evaporation losses. It can be used on cooling water piping, gas and crude piping to reduce the solar heat gain and temperature rise.

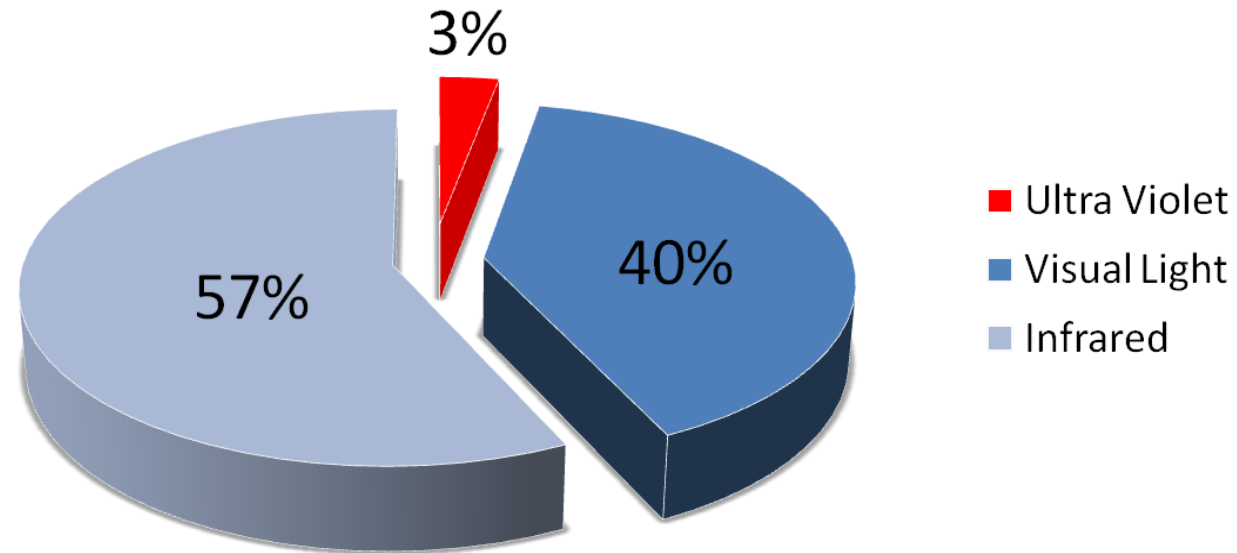
2.2 Service Condition Limitations

Maximum Service Temperature: 350°F (177°C)



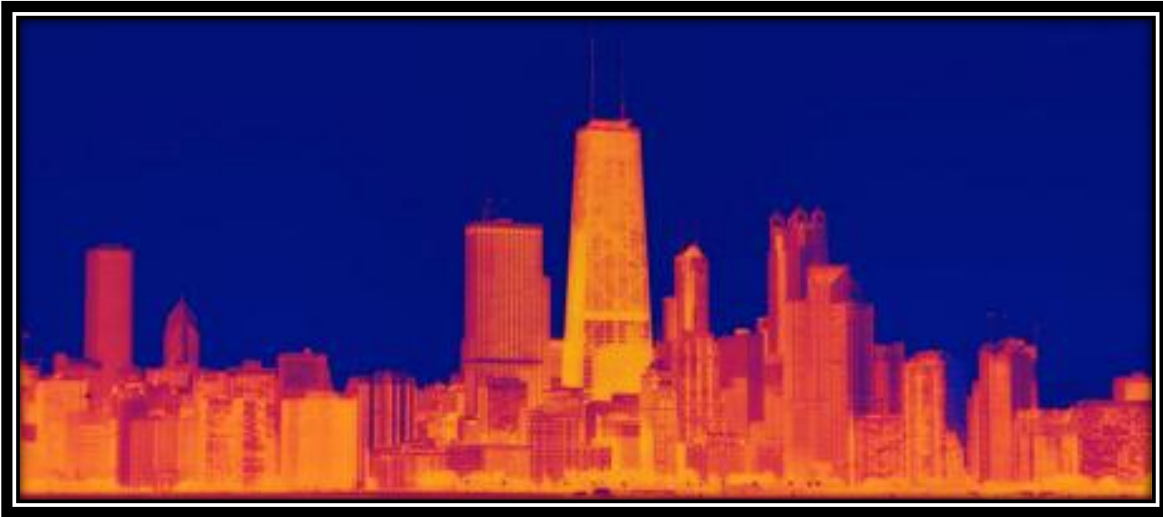
Radiation Heat

Sources of Heat from Radiation



Calculated from data in "[Reference Solar Spectral Irradiance: Air Mass 1.5](#)". National Renewable Energy Laboratory. [Archived](#) from the original on September 28, 2013. Retrieved 2009-11-12.

Heat Load, Heat Transfer



- Heat must load/absorb before it is transferred
- Reduce heat load to reduce heat transfer
- Using extreme low density materials prevents the absorption and loading of heat.

Solar Thermal Barrier Coating

1900's



21st Century



How It Works

- Stops Initial Heat Load By
 - Reflectivity – Blend of low density ceramics
 - Emissivity – Re-radiates heat off the surface
 - Ceramic particle size must match the size of the vibration wave of each heat wave to effectively block and repel it back into the atmosphere

Laboratory Testing - CRRC

Cool Roof Rating Council CRRC

CRRC
COOL ROOF RATING COUNCIL

Test Results Report

173B Excelsior Avenue • Oakland, CA 94602 • Toll-free (888) 465-2523 • Fax (510) 462-4421 • www.coolroofs.org

Section C: 17-24: Accredited Independent Testing Laboratory Test Results and Signature (this section to be filled out by AITL only)

17. Laboratory ID (Initial Ratings) RDS 18. Laboratory ID (Aged Ratings)

19. Lab Report ID (Initial Ratings) R006248 20. Lab report ID (Aged Ratings)

21. Tested Initial Radiative Properties: (Air mass of 1.5 used in reflectance measurements (check for verification))

21a. Group A—MFR. Batch # 012306 21b. Group B—MFR. Batch # 21406

Panel ID	Solar Reflectance	Thermal Emittance	Panel ID	Solar Reflectance	Thermal Emittance
1. <u>2</u>	<u>0.834</u>	<u>0.91</u>	1. <u>6</u>	<u>0.835</u>	<u>0.91</u>
2. <u>3</u>	<u>0.832</u>	<u>0.90</u>	2. <u>7</u>	<u>0.834</u>	<u>0.90</u>
3. <u>4</u>	<u>0.833</u>	<u>0.90</u>	3. <u>5</u>	<u>0.835</u>	<u>0.90</u>
Batch Average	<u>0.833</u>	<u>0.90</u>	Batch Average	<u>0.835</u>	<u>0.90</u>

21c. Results if preparing samples according to CRRC-1 Section 3.5 E (using CRRC-1 Method #1):
Sample 1 (Batch A): 0.833 / 0.90 Sample 2 (Batch B): 0.835 / 0.90 Sample 3 (Batch A/B): _____ / _____

21d. Average for all initial tests (2 decimal places): Solar Reflectance (SR) 0.83 Thermal Emittance (TE) 0.90

21e. Presumed Non-Variagated Particle or Gravel Coated Roofing Product 5-Point Reflectance Test Results: (See CRRC-1 section 3.5.1 E for instructions) Average Reflectance _____

21f. Air mass of 1.5 used in reflectance measurements (check box to confirm)

22. Tested Aged Radiative Properties:

22a. Hot/Humid Climate Exposure 22b. Cold/Temperate Exposure 22c. Hot/Dry Climate Exposure

Panel ID	Solar Reflectance	Thermal Emittance	Panel ID	Solar Reflectance	Thermal Emittance	Panel ID	Solar Reflectance	Thermal Emittance
1. _____	_____	_____	1. _____	_____	_____	1. _____	_____	_____
2. _____	_____	_____	2. _____	_____	_____	2. _____	_____	_____
3. _____	_____	_____	3. _____	_____	_____	3. _____	_____	_____

22d. Results if preparing samples according to CRRC-1 Section 3.5 E (using CRRC-1 Method #1):
Sample 1 (Batch A): _____ / _____ Sample 2 (Batch B): _____ / _____ Sample 3 (Batch A/B): _____ / _____

22e. Average for all initial tests (2 decimal places): Solar Reflectance (SR) _____ Thermal Emittance (TE) _____

22f. Air mass of 1.5 used in reflectance measurements (check box to confirm)

23. Tests conducted:

Type	Initial Test	Aged Test
<input type="checkbox"/> E903 Test	Date _____	Date _____
<input type="checkbox"/> E918 Test	Date _____	Date _____
<input checked="" type="checkbox"/> C1549 Test	Date <u>4/1/06</u>	Date _____
<input checked="" type="checkbox"/> C1371 Test	Date <u>4/1/06</u>	Date _____
<input type="checkbox"/> CRRC-1 Method #1	Date _____	Date _____

24. The undersigned certifies that, to the best of his/her knowledge, the measurements contained herein are true and accurate:
Responsible Person's Printed Name: David J. [Signature]
Responsible Person's Signature (Initial Tests): [Signature] Date: 4/1/06
Responsible Person's Signature (Aged Tests) Date: _____

CRRC-F-2 Test Results Report - 01/10/06 Page 2 of 2

- Reflectivity %
- Emissivity %
- Solar Reflective Index
- ASTM C1549 – Reflectivity
- ASTM C1371 – Emissivity



Laboratory Testing – NACE TM 21431-2020



NACE TM21431-2020
Item No. 21431
Approved Date 2020-01-27

Test Methods to Evaluate Thermal Properties and Performance of Insulative Coatings

This NACE International standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this NACE International standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. NACE International assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official NACE International interpretations issued by NACE International in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

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ABSTRACT

New NACE TEST METHOD! The purpose of this NACE International standard test method is to specify test methods and test conditions used to evaluate thermal properties, insulation values, and performance/integrity before and after thermal aging of insulative coatings. Testing for corrosion resistance is not included in this test method.

The primary intent of this standard is to specify test conditions that would provide a baseline evaluation – one that would allow direct performance comparisons between different insulative coatings. This standard is designed to have practical test procedures and limited test conditions. It also includes five mandatory appendices that describe hot plate designs and thermal test setups, all of which are used in this standard test method.

This standard test method introduces new test methods to determine if, and at what rate, an insulative coating's properties deteriorate with thermal aging. Test methods are given for both organic and inorganic based coatings. This standard test method is intended for use by facility owners, engineers, coating manufacturers, and other interested parties.

KEYWORDS

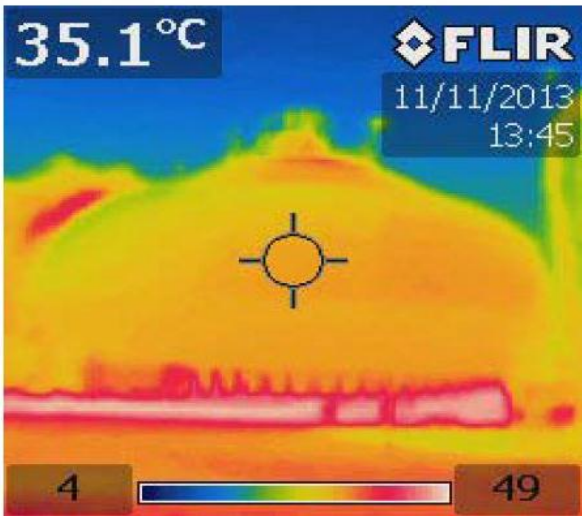
adhesion pull tests, blister resistance, corrosion under insulation (CUI), delamination, disbondment, emissivity, flame spread index, hot plate design, infrared thermometer (IR Meter), inorganic insulative coatings, insulating coating, insulative coatings, insulation values, organic insulative coatings, percent mass loss, proportional-integral-derivative (PID) controller, smoke development index, solar absorptance, TG 525, thermal aging, thermal conductivity, thermocouple wire, thermal efficiency, thermal properties, thermal test, test panel, STG 02.

NACE TM21431-2020

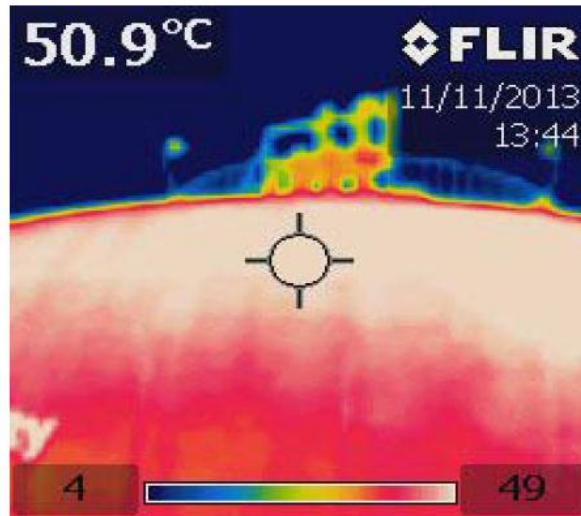
- Reflectivity %
- Emissivity %

- ASTM E903 – Reflectivity
- ASTM E408 – Emissivity

LNG Spheroid Tank – CH₄



95F



124F

Reducing Boil Off:

Winter Temperature

Reduced evaporation of finished petrochemicals including light hydrocarbons.

LNG Storage Tank



Reducing Boil Off:

Reduced evaporation of finished petrochemicals including light hydrocarbons.

Gasoline Tanks



Reducing Boil Off:

Reduced evaporation of finished petrochemicals including light hydrocarbons.

Reduced interior condensation/corrosion

Interior Tank Wall Corrosion



Interior Corrosion:

Reduced interior condensation results in reduced interior corrosion on tank walls.

Cooling Fans



Reduce Solar Heat Load

Improve efficiency by cooling down metal in summer time.

LPG



LPG Tanks:

Reduce heat load

Petrochemical



Application by roller:

Different manufacturers recommend different thicknesses and application methods.

Marine



Reducing Heat Load:

Controlling condensation

Expansion/Contraction

Marine Super Structure



Reducing Heat Load:

10 mils DFT (250 micron)

LNG Carrier



Reducing Heat Load:

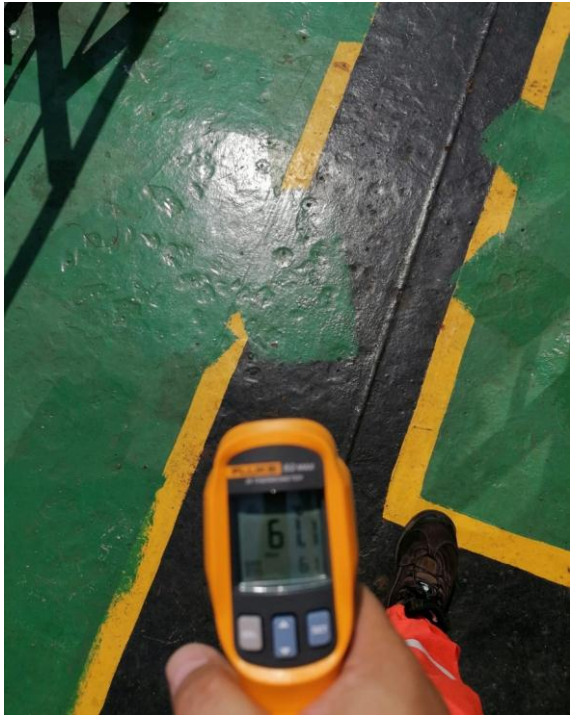
Monkey Island

LNG Tanks

Accommodation Bulk Heads

Marine Surface Temperature Comparison

Normal Paint – 142°F (61°C)



Radiant Barrier – 98°F (37°C)



Back Side – 91F° (33C)



Offshore - Shipping Containers



Reducing Heat Load:

Sent: Saturday, August 11, 2018 4:30 AM

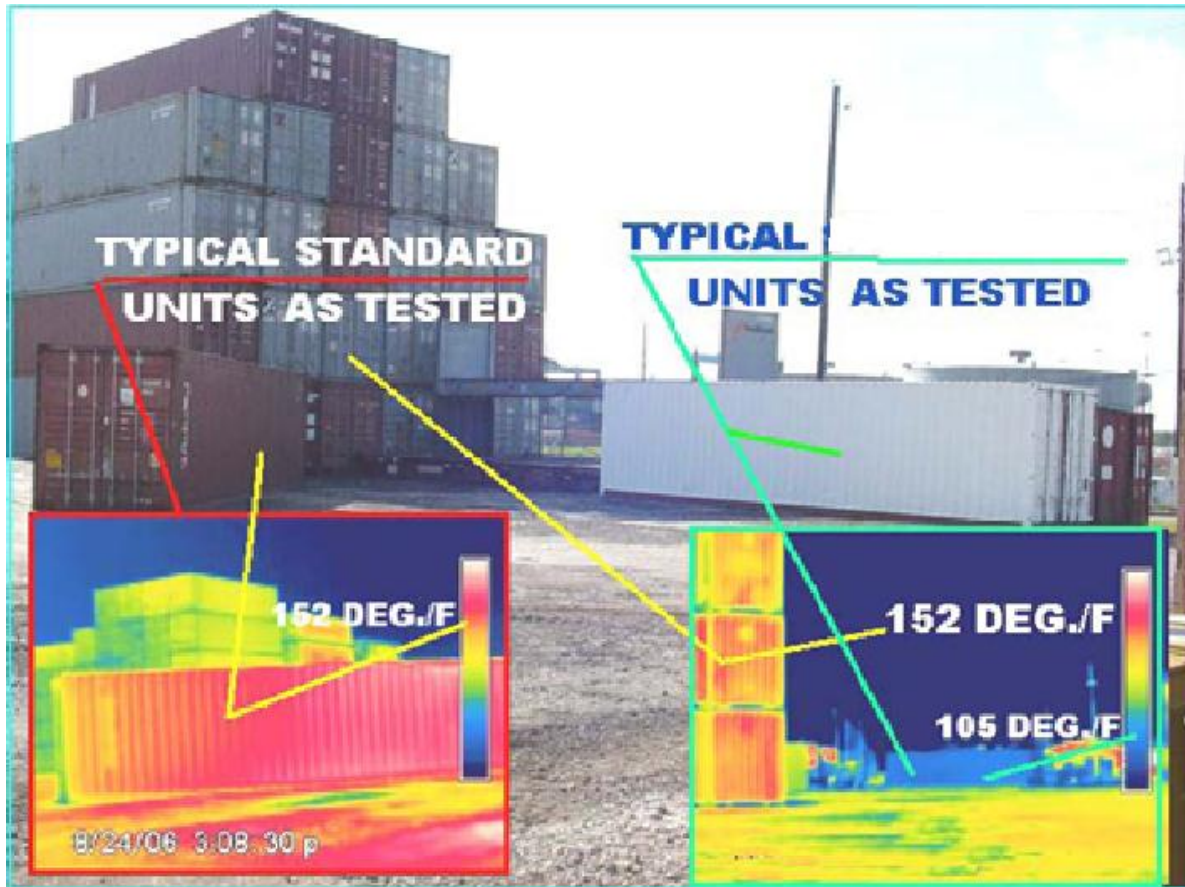
Subject: P34 Container Temperatures

Please find below P34 Container Temperatures Inside and outside.

FLUKE 62MAX IR THERMOMETER used

CONTAINER NO	OUTSIDE TEMPERATURE IN degC	INSIDE TEMPERATURE degC
TRANSFORMER ROOM	37.4	35.3
LV SWITCH ROOM	38	36.6
ISS-06	39.2	34.8
ISS-08	38.9	32.0
ISS-09	36.7	32.2
ISS 13/14	38.4	34.2

US Department Of Energy – Texas



U.S. Dept of Energy:

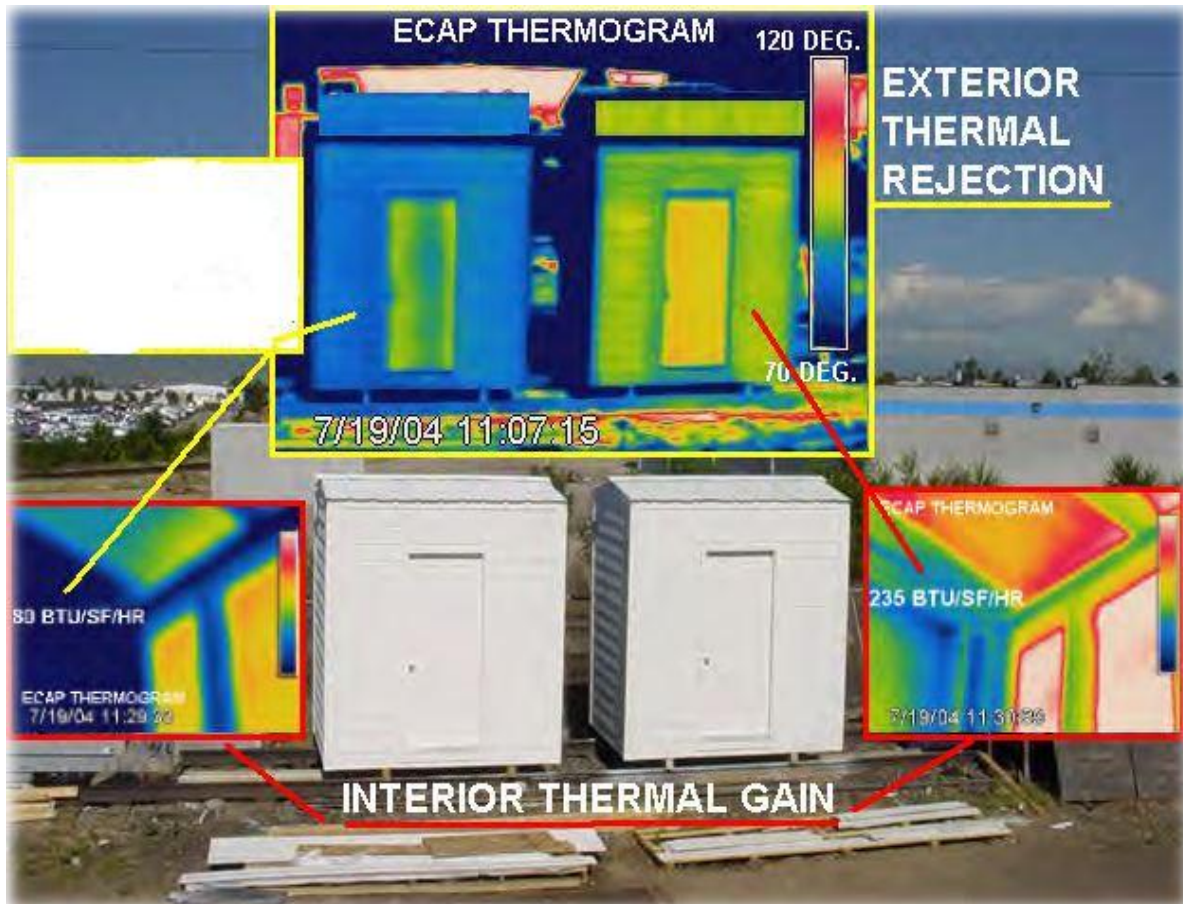
Uncoated: 152°F (66.6°C)

Coated: 105°F (40.5°C)

Ambient: 98°F (36.6°C)

10 mils DFT / 250 micron DFT

US Department Of Energy – Colorado



U.S. Dept of Energy:

White Paint: 235 BTU/SF/HR

Solar Barrier: 80 BTU/SF/HR

Both building assemblies have R13 insulation.

Infrastructure - Airports



Energy Conservation:

Reduce heat load into roof.

Reduce energy consumption from AC units.

Reduced expansion and contraction.

Concrete requires primer

Passenger Boarding Bridges



Reducing Heat Load:

Improve energy efficiency and comfort.

Cool Roofing



Reducing Heat Load:

Improve energy efficiency and comfort.

Surface Preparation:
3,000 psi power wash

Cool Roofing



Reducing Heat Load:

Safety for workers exposed to hot climates.

Blocked re-radiation of a heat loaded metal roof.

Telecommunications Infrastructure



Shell:

Reduce heat load

Save energy,

Extend AC unit life

Concrete Mixing Truck



Reducing Heat Load:

Increase the range of concrete trucks

Transportation Industry



Reducing Heat Load:

Reduce AC for trailers

Reduce time for loading

Los Angeles – Cool Roofs Ordinance

TABLE 4.106.5

ROOF SLOPE	MINIMUM 3-YEAR AGED SOLAR REFLECTANCE	THERMAL EMITTANCE	SOLAR REFLECTANCE INDEX SRI
< 2:12	0.63	0.75	75
≥ 2:12	0.20	0.75	16

City of Los Angeles: Ordinance 183149

- First City in U.S. to make Cool Roofs mandatory on all new buildings, and any new roof retrofit.
- Los Angeles Department of Water & Power gives \$0.20 - \$0.30 rebate per sq. ft.


Fire Safety / Flame Spread



Fire Resistance:

ASTM E84 Flame Spread

Considerations – Thin Film Insulative Coatings

1. White vs Color – Performance tradeoff
 2. Works better in hot desert climates
 3. Inspection / performance monitoring
 4. Testing requirements – lab & field
 5. Equipment / applicator training
 6. Potential government subsidies
 7. Fire/Safety considerations
 8. Condensation reduction
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INSULATIVE COATINGS FIT FOR PURPOSE

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