INSULATIVE COATINGS FIT FOR PURPOSE

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Superior Products International II, Inc.

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 Shop Applied Process
- 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	Conduction	Radiation
The transfer of heat by air.	The transfer of heat through a solid material.	The transfer of heat in the form of electromagnetic waves.
Example: Warm air rises and transfers heat to ceiling.	Example: Heat is transferred from warmer sections of the walls and ceilings to cooler sections	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

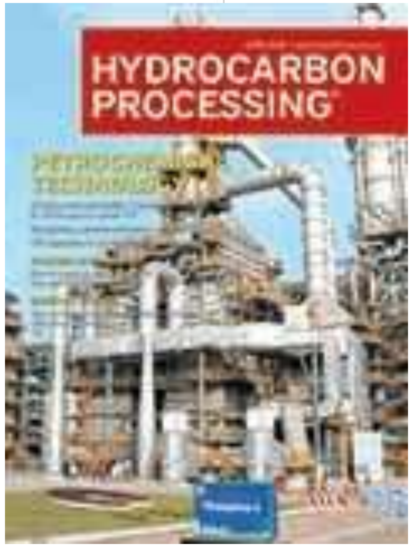
Rockwool, fiberglass, or other traditional types of insulation promote corrosion, and also act as a carrier and spread the corrosion to other areas of the pipeline

- 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

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

<u>After:</u>

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

<u>After:</u>

Primer, DTM Polyurethane

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

Water Bath Heater # 2

<u>After:</u>

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

<u>Over Spray Repair:</u>

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

<u>After:</u>

10-12mm or ½″ DFT Insulation Coating

Applied **OFFLINE**

Ambient application

More time needed for curing

LNG Steam Pipes

<u>Steam Pipes</u>

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

Novel Field/Shop Application

<u>New Fuel Gas Piping</u>

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

<u>Flexible Pipe Wraps</u>

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

¼″ (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

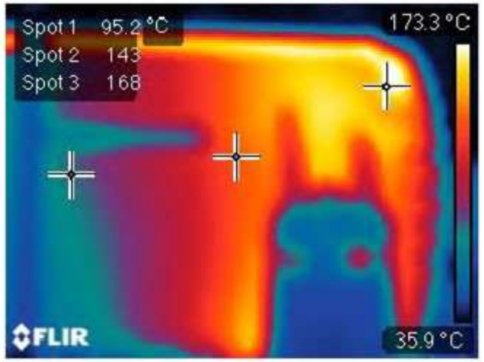
Inspection windows can be cut out of the coating film over weld joints for repeat non destructive inspection.

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

Offshore Compressor

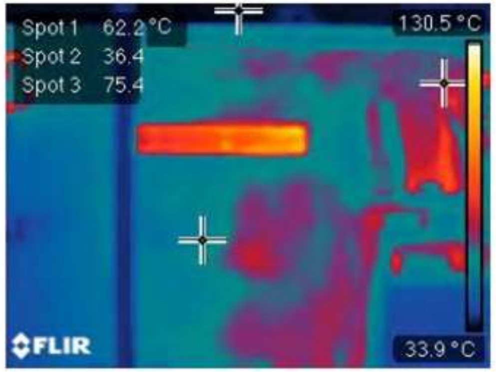
Surface Temperature:

Before: 334°F (168°C)



Temperatura arriba de 168°C

After: 167°F (75°C)



Temperatura Máxima de 75°C

Steam Pipe

Personnel Protection:

Surface Temperature:

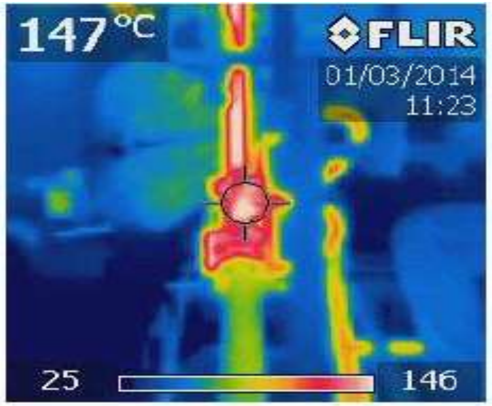
Before: 280°F (137.7°C)

After: 90°F (32.2°C)

16 mm or 5/8″ DFT

Sulfur Pipe

Uncoated 296°F

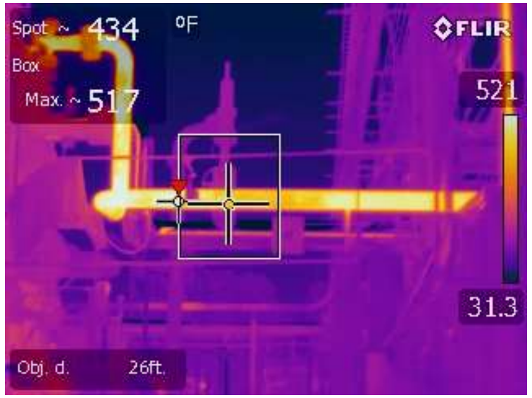


Coated 129°F

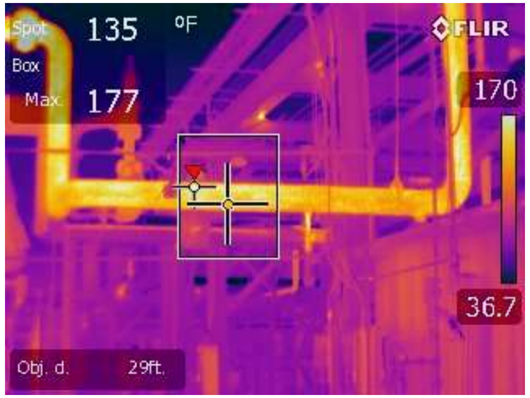
½″ DFT (12.7mm)

Ultra High Temperature

Bare Pipe = 517°F
269°C



1"DFT = 177°F
25mm 80°C



Advanced Strategies

<u>Advanced Strategies:</u>

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

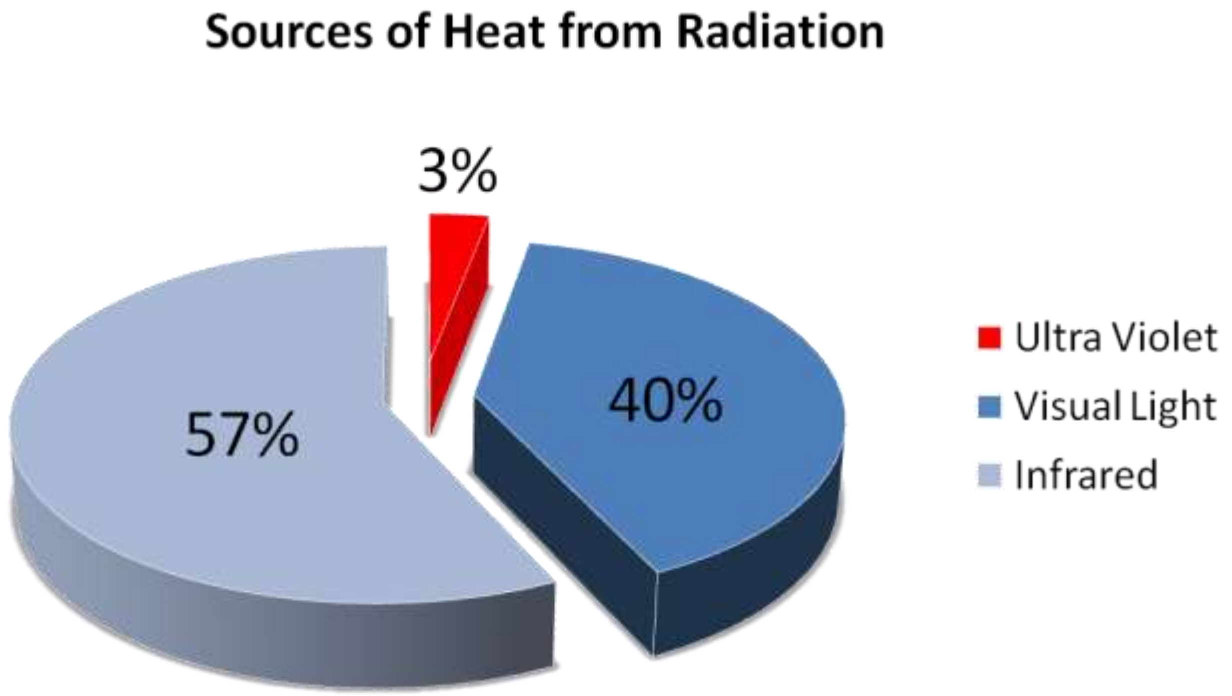
2.1 Typical Use

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

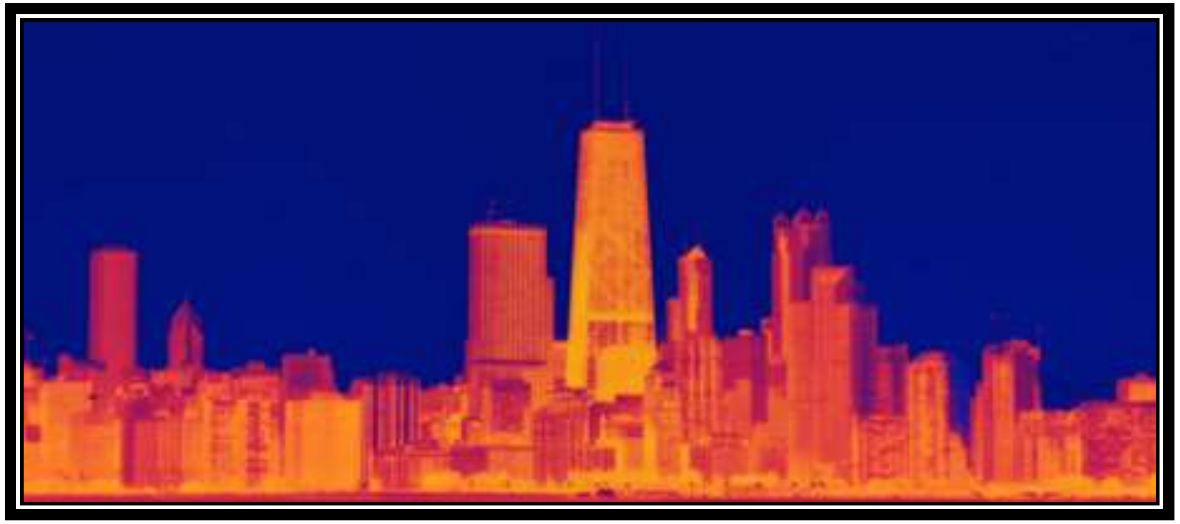
Maximum Service Temperature: 350°F (177°C)

Radiation Heat



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

CRRC COOL ROOF RATING COUNCIL

Test Results Report

1738 Excelsior Avenue • Oakland, CA 94602 • Toll-free (866) 465-2523 • Fax (510) 482-4421 • www.coolroofs.org

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

17. **Laboratory ID** (Initial Ratings) RDS
18. **Laboratory ID** (Aged Ratings)
19. **Lab Report ID** (Initial Ratings) RD06248
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. 2	0.834	0.91	1. 6	0.835	0.91
2. 3	0.832	0.90	2. 7	0.834	0.90
3. 4	0.833	0.90	3. 5	0.835	0.90
Batch Average	0.833	0.90	Batch Average	0.835	0.90

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): ___ / ___ (SR TE)

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

21e. **Presumed Non-Variegated 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): ___ / ___ (SR TE)

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
☐ E903 Test	Date ___	Date ___
☐ E1918 Test	Date ___	Date ___
☑ C1549 Test	Date 4/26/06	Date ___
☑ C1371 Test	Date 4/26/06	Date ___
☐ 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:**
DAVID W. YARBROUGH
Responsible Person's Printed Name
[signature] 4/26/06
Responsible Person's Signature (Initial Tests) Date
Responsible Person's Signature (Aged Tests) Date

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

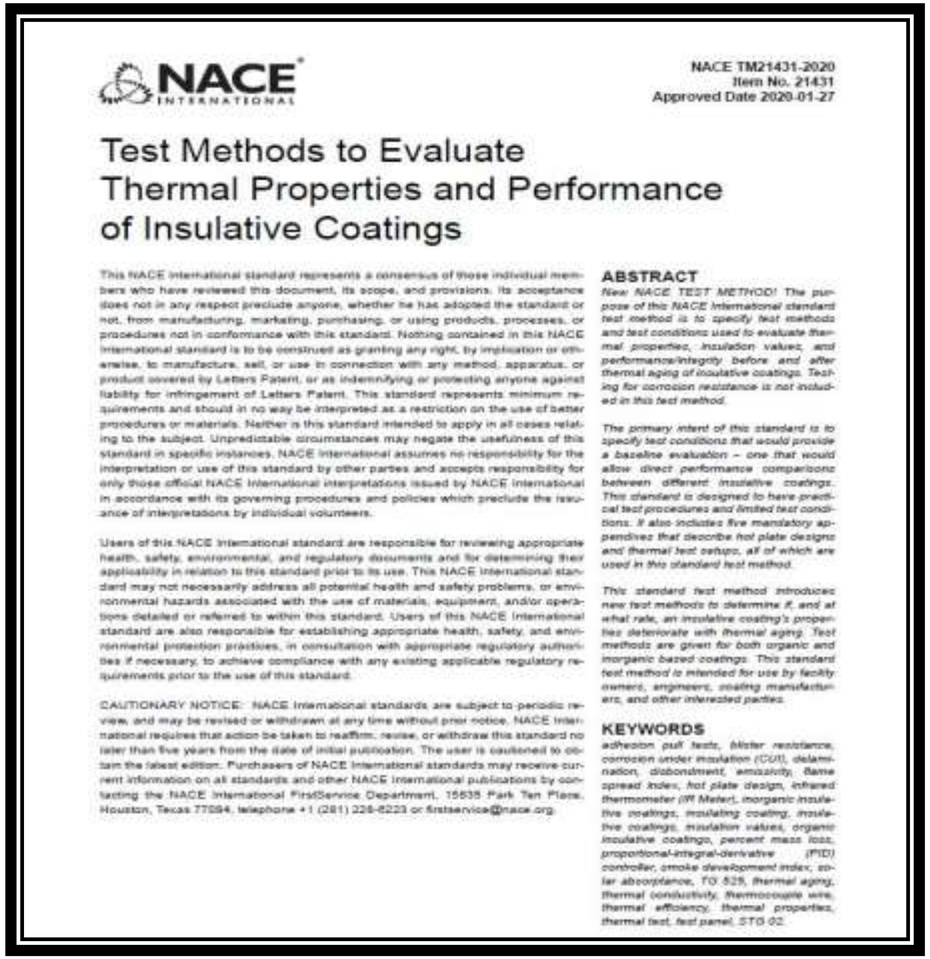
Cool Roof Rating Council CRRC

- Reflectivity %
- Emissivity %
- Solar Reflective Index

- ASTM C1549 – Reflectivity
- ASTM C1371 – Emissivity

ENERGY STAR

Laboratory Testing – NACE TM 21431-2020



NACE INTERNATIONAL

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

Test Methods to Evaluate Thermal Properties and Performance of Insulative Coatings

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 appendixes 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

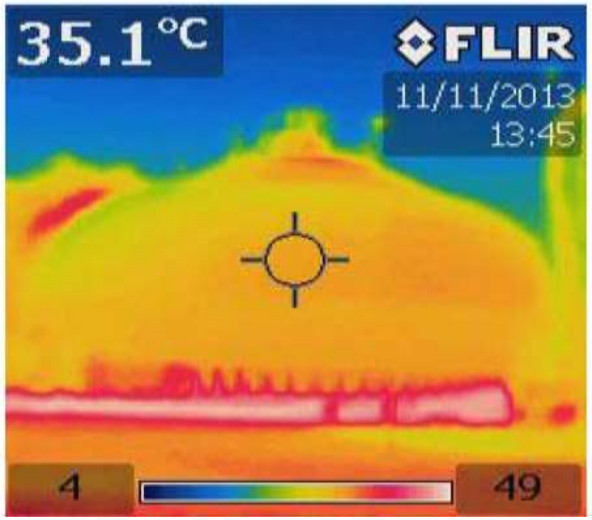
adhesion pull tests, blister resistance, corrosion under insulation (CUI), delamination, disbondment, emissivity, flame spread index, hot plate design, infrared thermometer (IR Meter), inorganic insulative coatings, insulating coating, insulative coatings, insulation values, organic insulative coatings, 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

<u>NACE TM21431-2020</u>

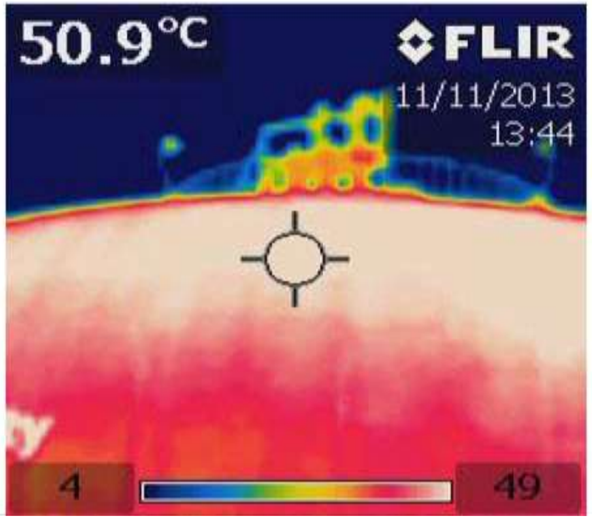
- Reflectivity %
- Emissivity %

- ASTM E903 – Reflectivity
- ASTM E408 – Emissivity

LNG Spheroid Tank – CH4



95F



124F

<u>Reducing Boil Off:</u>

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

<u>Interior Corrosion:</u>

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

Cooling Fans




<u>Reduce Solar Heat Load</u>

Improve efficiency by cooling down metal in summer time.

LPG

<u>LPG Tanks:</u>

Reduce heat load

Petrochemical

<u>Application by roller:</u>

Different manufacturers recommend different thicknesses and application methods.

Marine

Reducing Heat Load:

Controlling condensation

Expansion/Contraction

Marine Super Structure

<u>Reducing Heat Load:</u>

10 mils DFT (250 micron)

LNG Carrier

Reducing Heat Load:

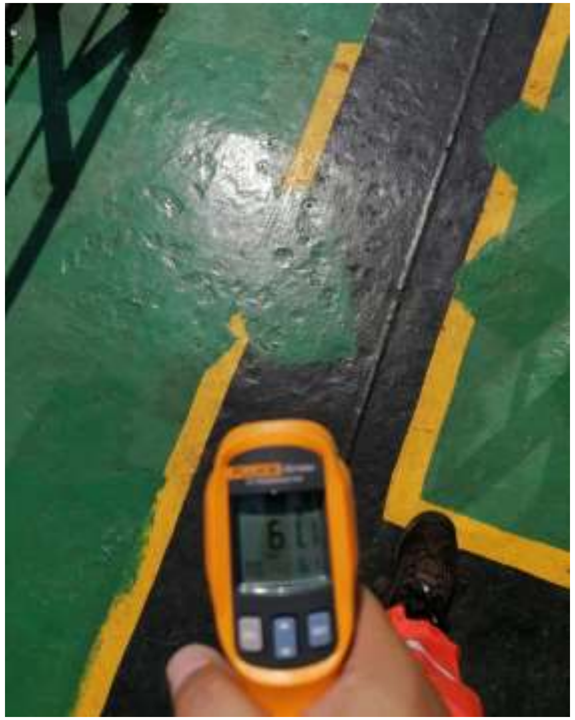
Monkey Island

LNG Tanks

Accommodation Bulk Heads

Marine Surface Temperature Comparison
Super Therm Top Coat

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

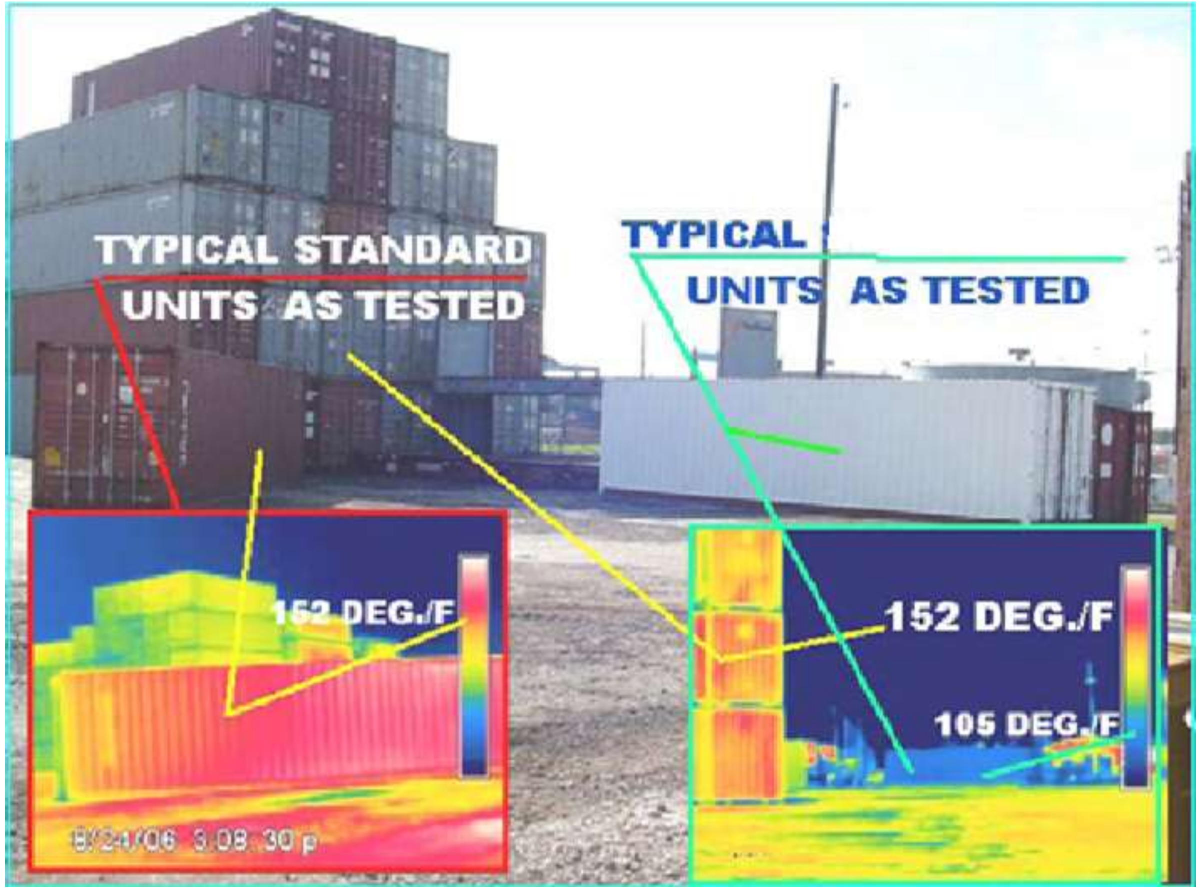
Subject: P34 Container Temperatures

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>U.S. Dept of Energy:</u>

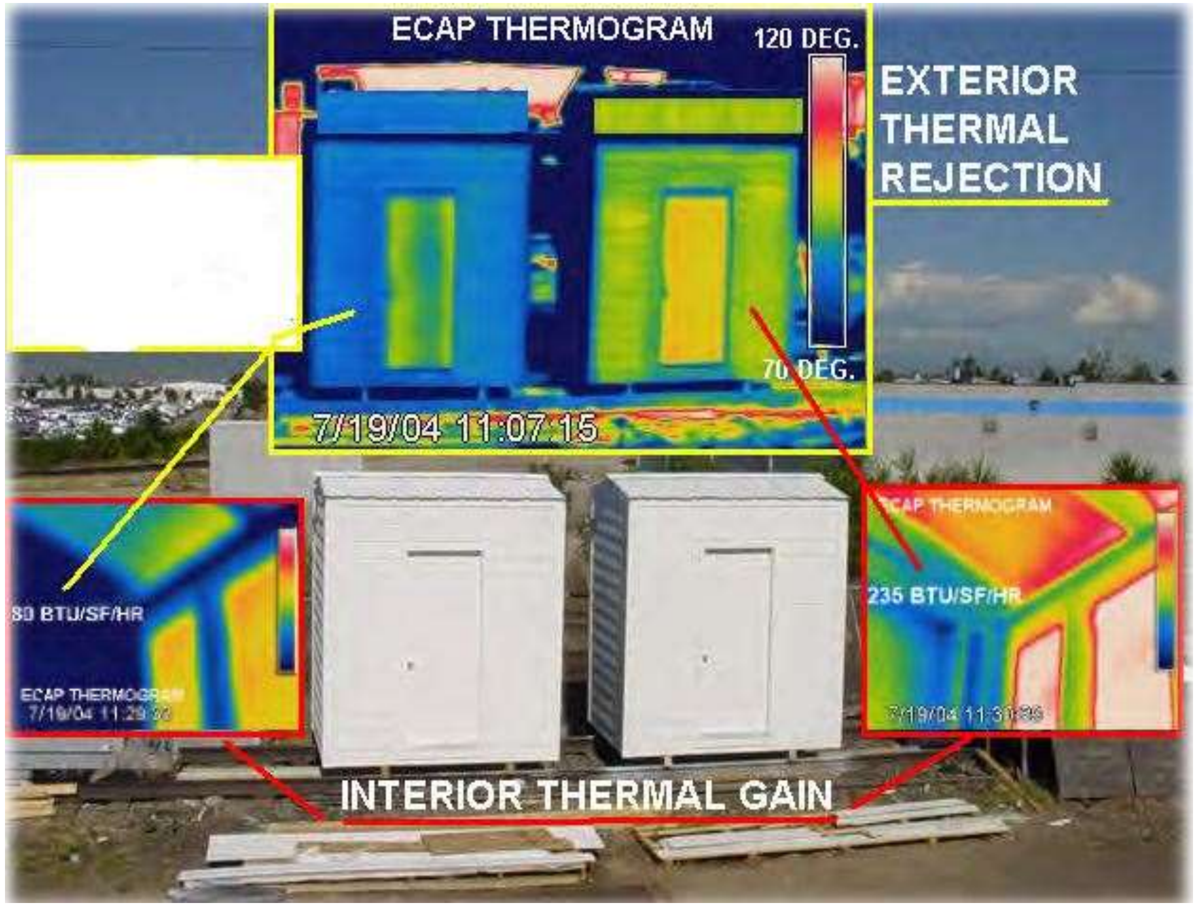
Uncoated: 152°F (66.6°C)

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

<u>Reducing Heat Load:</u>

Improve energy efficiency and comfort.

Cool Roofing

Reducing Heat Load:

Improve energy efficiency and comfort.

Surface Preparation:
3,000 psi power wash

Cool Roofing

<u>Reducing Heat Load:</u>

Safety for workers exposed to hot climates.

Blocked re-radiation of a heat loaded metal roof.

Telecommunications Infrastructure

<u>Shell:</u>

Reduce heat load

Save energy,

Extend AC unit life

Concrete Mixing Truck

Reducing Heat Load:

Increase the range of concrete trucks

Transportation Industry

<u>Reducing Heat Load:</u>

Reduce AC for trailers

Reduce time for loading

Dual Insulation – Thick + Thin Film

<u>Thick Film + Thin Film</u>

Previous foam system causing severe CUI.

In the winter heaters are required, in the summer boil off is required. Using thick film and thin film solves both.

Medford OK

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

<u>City of Los Angeles:</u> 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

INSULATIVE COATINGS FIT FOR PURPOSE

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