

# INSULATIVE COATINGS FIT FOR PURPOSE

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## Agenda

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- 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	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



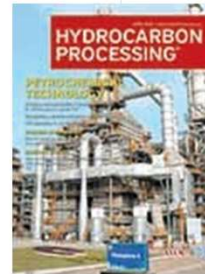
Rockwool, fiberglass, or other traditional types of insulation promote corrosion, and also act as a carrier and spread the corrosion to other areas of the pipeline

- 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 Rabeih**, 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)

463°C (865°F)



AFTER (30mm thickness)

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 1<sup>st</sup> 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

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- 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

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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)  
(38.3°C)



After: 204°F (95.5°C) Metal Temp.



Skin Temp: 101°F



## 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

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Before:

Picture taken after NACE 4 surface preparation.

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

## Water Bath Heater # 2

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After:

Primer, DTM Polyurethane

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



## Water Bath Heater # 2

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After:

10-12mm or ½" DFT Insulation Coating

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

## Water Bath Heater # 2

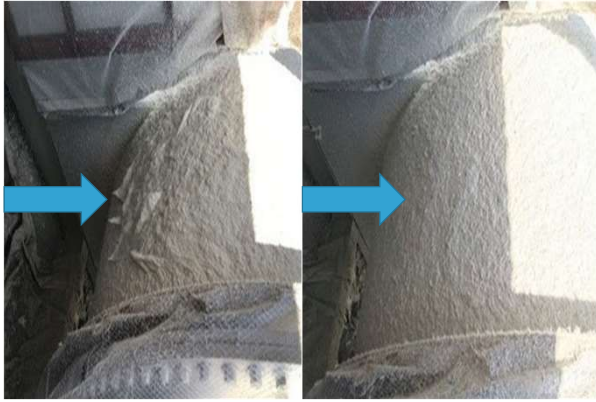
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Details:

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 pre-coated 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 pre-coated 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

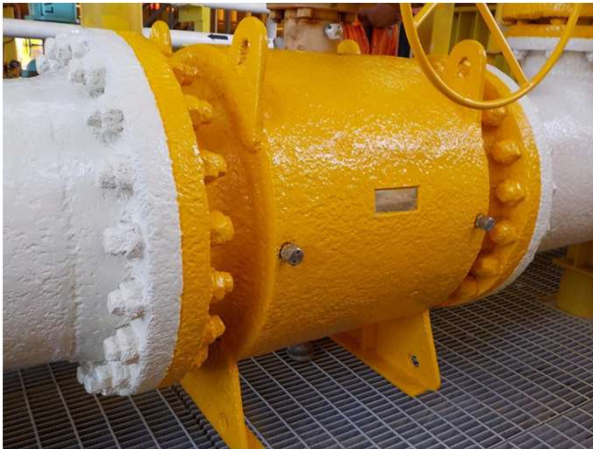


Bag House Ducts

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.

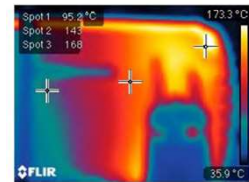
## Offshore Compressor



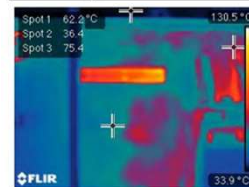
Surface Temperature:

Before: 334°F (168°C)

After: 167°F (75°C)



Temperatura arriba de 168°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

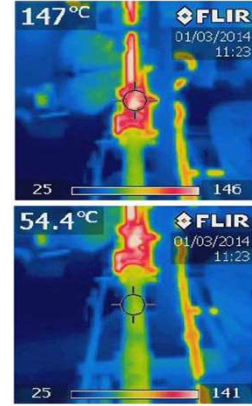
## Sulfur Pipe



Uncoated 296°F

Coated 129°F

½" DFT (12.7mm)

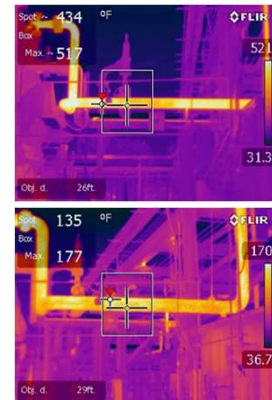


## Ultra High Temperature

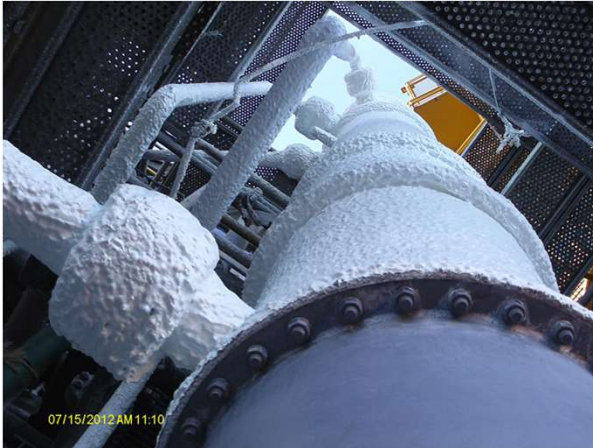


Bare Pipe = 517°F  
269°C

1" DFT = 177°F  
25mm 80°C



## Advanced Strategies



### 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

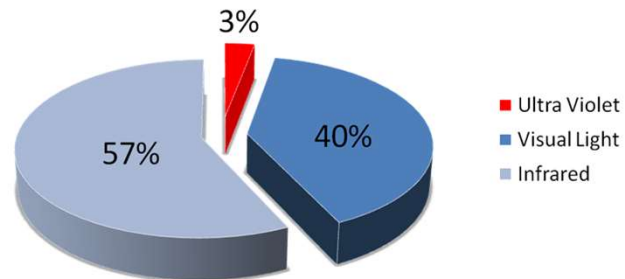
External top-coating system for petroleum tanks, vessels and drums to reduce the solar heat gain and to minimize the evaporation losses. It can be used on cooling water piping, gas and crude piping to reduce the solar heat gain and temperature rise.

#### 2.2 Service Condition Limitations

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

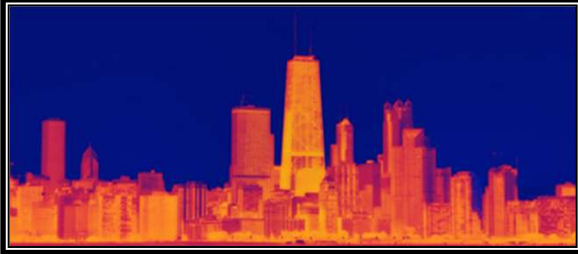
## Radiation Heat

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



21<sup>st</sup> Century









## 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 Super Therm Top Coat

Normal Paint – 142°F (61°C)



Radiant Barrier – 98°F (37°C)



Back Side – 91°F (33°C)



## Offshore - Shipping Containers



### Reducing Heat Load:

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

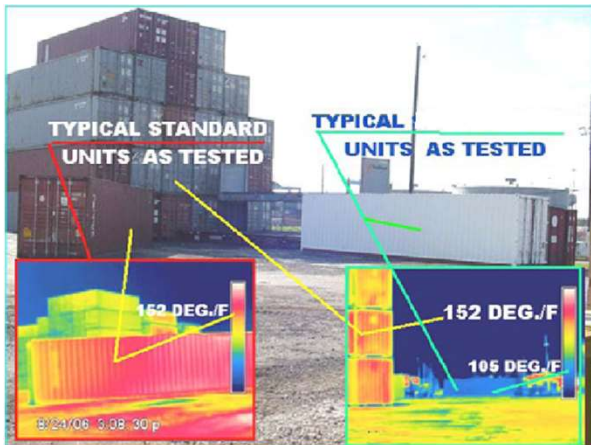
Subject: P34 Container Temperatures

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:

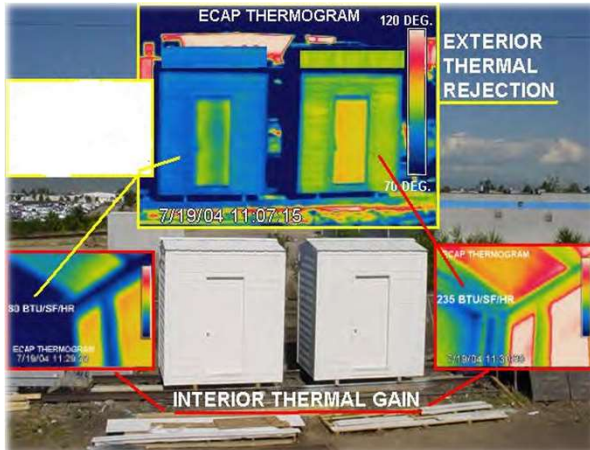
Uncoated: 152°F (66.6°C)

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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