Storage Tank
Temperature Control Model

Heat Gain and Reduction with
SUPER THERM® Coating Application
ARAMCO TANK FARM

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1. INTRODUCTION AND OBJECTIVE:

Objective of this tank model is to show three main points:

1) the radiation heat load over a tank top and exposed shell using the worst case ambient day temperature and the heat load absorbed into the metal skin.
2) the heat load is then related to BTU transfer to the interior of the tanks which affects the bulk temperature and evaporation rate along the surface level of the bulk.
3) control the rise in bulk temperature and tank atmosphere causing the psia to reach a critical 13.

2. HEAT LOAD FROM RADIATION HEAT DURING OPERATIONAL HOURS (7am-6pm) BEING THE MAIN HEAT HOURS. Using as an example, tank 1144 NG A-180 and having a size of 40,270 sq.ft. The summer months are the concern as indicated by the charted months from 4000 to 6200 as reference points.

Tank coated with Aluminum Alkyd coating
- Given worst case of ambient temperature being 110F (43C) and the related radiation heat striking the tank roof and shell would be approximately 190F (88C) heat load onto surface. The radiation waves are made up of heat represented by UV-3%, Visual Light – 40% and Infrared – 57%.
- Tank roof and shell will load the 190F (88C) heat over the surface. The transfer of this heat through the existing aluminum alkyd coating and metal to the interior surface of the roof would be 180F (82C).
- The specific heat transfer to the interior ambient of the tank would be given as Q=AU/(T¹-T²) or Q=1 x 0.13 x / (190F-180F) x 40,270 = 523 BTU entering the tank per hour.

Single Lined Tank over coated with SUPER THERM®
- Ambient 110F (43C) giving radiation onto surface of coated tank.
- Temperature on top of SUPER THERM® surface is 115F (46C). The transfer of heat through SUPER THERM® and metal to the interior surface of the roof would be 88F (31.1C).
- The specific heat transfer to the interior ambient of the tank would be given as Q=AU/(T¹-T²) or Q=1 x 0.13 / (190F-88F) x 40,270 = 51.32 BTU entering the tank per hour (based on the surface of the uncoated tank being 190F and showing this difference to interior when coated with SUPER THERM).

Double Lined Tank over coated with SUPER THERM®
- Ambient 110F (43C) giving radiation onto surface of coated tank.
- Temperature on top of SUPER THERM® surface is 115F (46C). The transfer of heat through SUPER THERM® and metal to the interior surface of the roof would be 88F (31.1C) on the first liner. The temperature on top of the second liner roof would be 85F (29.4C). The transfer of heat through the second liner to the interior surface of the roof would be 79F (26.1C).
• The specific heat transfer to the interior ambient of the tank would be given as
  \[ Q = AU/(T_1 - T_2) \] or
  \[ Q = 1 \times 0.13 / (190F - 79F) \times 40,270 = 47.59 \text{ BTU} \]
  entering the tank per hour (based on the surface of the uncoated tank being 190F on
  the surface as compared to the coated tank’s interior double hull temperature of 79F.

3. Results:

• The reduction of BTU loading from a tank coated only with the Aluminum Alkyd coating allows 523 BTU’s to load per hour.
• The reduction of BTU loading from a single hull tank coated with SUPER THERM® allows 51 BTU’s to load per hour.
• The reduction of BTU loading from a double hull tank coated with SUPER THERM® allows 48 (rounded) BTU’s to load per hour.
• The tanks coated with SUPER THERM® for both the single and double hull will hold the interior temperature of the bulk product below the 95F that is required to maintain the psia below 13 which is the objective of coating the exterior of the tanks with SUPER THERM®.
• The evaporation of the product from the tanks is limited to no more than 5% of the amount currently allowed to evaporate under the current coating system.
• SUPER THERM® is applied to all exterior surfaces to block radiation heat load. Bulk product will only absorb the heat that is allowed inside the tank. Blocking and controlling the amount of heat being absorbed and transferred to the interior is the key to stopping evaporation and reducing pressures.
• SUPER THERM® is applied at 9 sq.m per gallon (400 microns wet / 250 microns dry) with an overcoat of ENAMO GRIP applied in two applications at 22 sq.m per gallon (125 microns wet / 62 microns dry) to give a gloss finish.
• The results are based on facts given to SPI for this model and, therefore, SPI cannot be held liable for unknown incorrect information as presented.

4. HEAT testing comparisons as tested by ASTM procedures:

• Test Procedures from ASTM E1269 (differential scanning calorimeter) and ASTM E1461-92 (laser flash technique) were used to find the BTU load and conduction through a metal shell and then retest the steel shell coated with SUPER THERM®.
• Results were for the Metal Shell alone at 100C allowed 367.20 BTUs to absorb and conduct.
• Results for SUPER THERM® coated Metal Shell at 100C allowed 3.99 BTUs to absorb and conduct.

FORMULA: \[ \text{BTU} = \text{Watt per hour conduction} \]

Steel Shell allowed 367.20 BTU = \textbf{108.00 Watts per hour to enter tank.}

SUPER THERM® coated Steel Shell allowed 3.99 BTU = \textbf{1.17 Watts per hour to enter tank.}

FORMULA: \[ \text{BTU} = \text{W/m}^2\text{K per hour} \]
Steel Shell allowed 367.20 BTU = 2082.02 W/m²K per hour to enter tank.

SUPER THERM® coated Steel Shell allowed 3.99 BTU = 22.62 W/m²K per hour to enter tank.

5. Liquid Surface Temperature:

The liquid surface temperature may differ from the bulk temperature. Because evaporation takes place at the surface level, the liquid surface temperature should provide a more accurate measure of evaporation than bulk temperature. The liquid surface temperature could differ from the average temperature of the liquid (bulk temperature) when heat flows into or out of the product. The liquid surface temperature might also vary over the surface of the liquid, since different thermal conditions exist at the rim seal, the peripheral pontoons, and the center deck area.

6. Ambient Temperature:

Ambient temperature has no relationship to the heat load onto the surface of a tank. Therefore, the heat build up on the interior cannot be predicted, nor how it will affect the surface evaporation, bulk heat load, or resulting pressure levels reached. This is a direct relationship of radiation heat load onto the surface and resulting heat load conduction to the interior of the tank. Ambient temperature is a result of radiation heating objects, sand and equipment which in turn heats the atmosphere. By the time the atmosphere is heated, the objects have early on reached their maximum temperatures early on, and ambient is only the resulting re-radiation from these objects.

7. SUMMARY:

This report:

- Analyzes the typical heat load from radiation heat onto the surface of a tank shell.
- Compares a tank coated with the standard Aluminum Alkyd coating and the radiation heat load on the exterior skin of this tank that is released to the interior of the tank compared to a single hull or double hull tank coated with SUPER THERM® insulation coating.
- Shows after the application of SUPER THERM®, the drop in temperature load to the exterior/interior of the tank and the resulting drop in BTU and W/m²K transferred to the interior.
- Displays the heat break to the shell of a tank, to lower heat load to the interior.
- Describes the reduction of critical heat build-up on the interior of the tank below 95F to maintain the psia below 13.