

Hauling **Hot** Products

John F Cannon

Cargo Tank 101

2011 NTTC CTMSeminar



The Situation

- Large company
- 500° F product
- Standard stainless steel tank
- Really?

BRENNER

BULK

WALKER

The Second Situation

- Ambitious carrier
- Load hot product ...
- ... in a tank 200° F cooler ...
- ... without temperature loss ...
- ... AND deliver the product 'hotter'!
- Then, again, maybe not!



The Bottom Line

- Or, at least, not without ...
- Understanding (laws of physics),
- Special processes, and/or
- Special features.



Objective

- Create (refresh) your awareness of successful strategies for the carriage of temperature sensitive products.



Scope

- We will focus on **hot** products, but, many of these strategies apply to **cold** products.



Key Strategies

- Understand – the task before you.
- Project temperature performance.
- Assess potential processes.
- Know applicable regulations.
- Consider specifications options.
- Become aware of risks.
- Draw on resources.



Understand

- Gather as much information as possible!
- Share and discuss this information with your tank supplier, or an engineer with expertise in heat transfer.



Understand - Variables

- Tank capacity (gallons)
- Amount of product loaded in tank (gallons)
- Product weight (lb/gal)
- **Specific heat of product (BTU/lb-°F)**
- Tank inside diameter (in)
- Shell length (in)



Understand - Variables

- Shell thickness (in)
- Head thickness (in)
- Vessel material
- Insulation thickness on shell (in)
- Insulation thickness on heads (in)
- Insulation material



Understand - Variables

- Average outside temperature during the period of carriage or storage (°F)
- Name and UN (if known) of product
- Product temperature **after** loading (°F)
- Critical product temperature(s) (°F)
- Time of carriage or storage (hr)



Project Temperature Performance

- Three modes of heat transfer ...
 - Conduction
 - Convection
 - Radiation
- Complicated equations!
- Use a computer program, or other analytical tool.





Heat Transfer Inputs



System

Air Velocity mph
 Ambient Temperature °F
 Product Loading Temperature °F
 Event Length hrs
 Time Increment min

Air

k (cond. coeff.) Btu/hr-ft-°F
 Kinematic Viscosity ft²/s
 Prandtl Number

Insulation

in Btu/hr-ft-°F
 Trymer k-value Btu/hr-ft-°F
 Ins. Thickness at Heads in

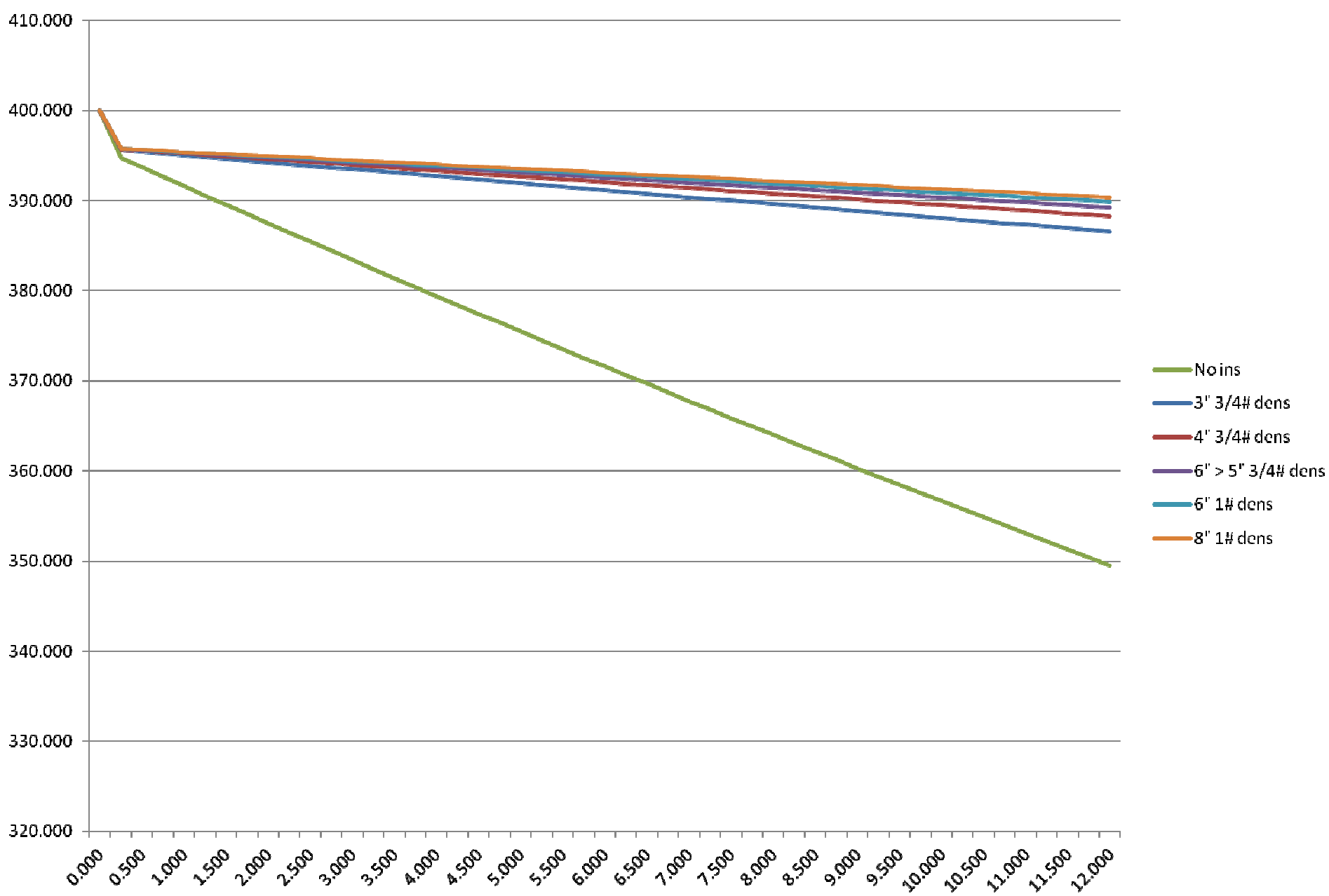
Tank

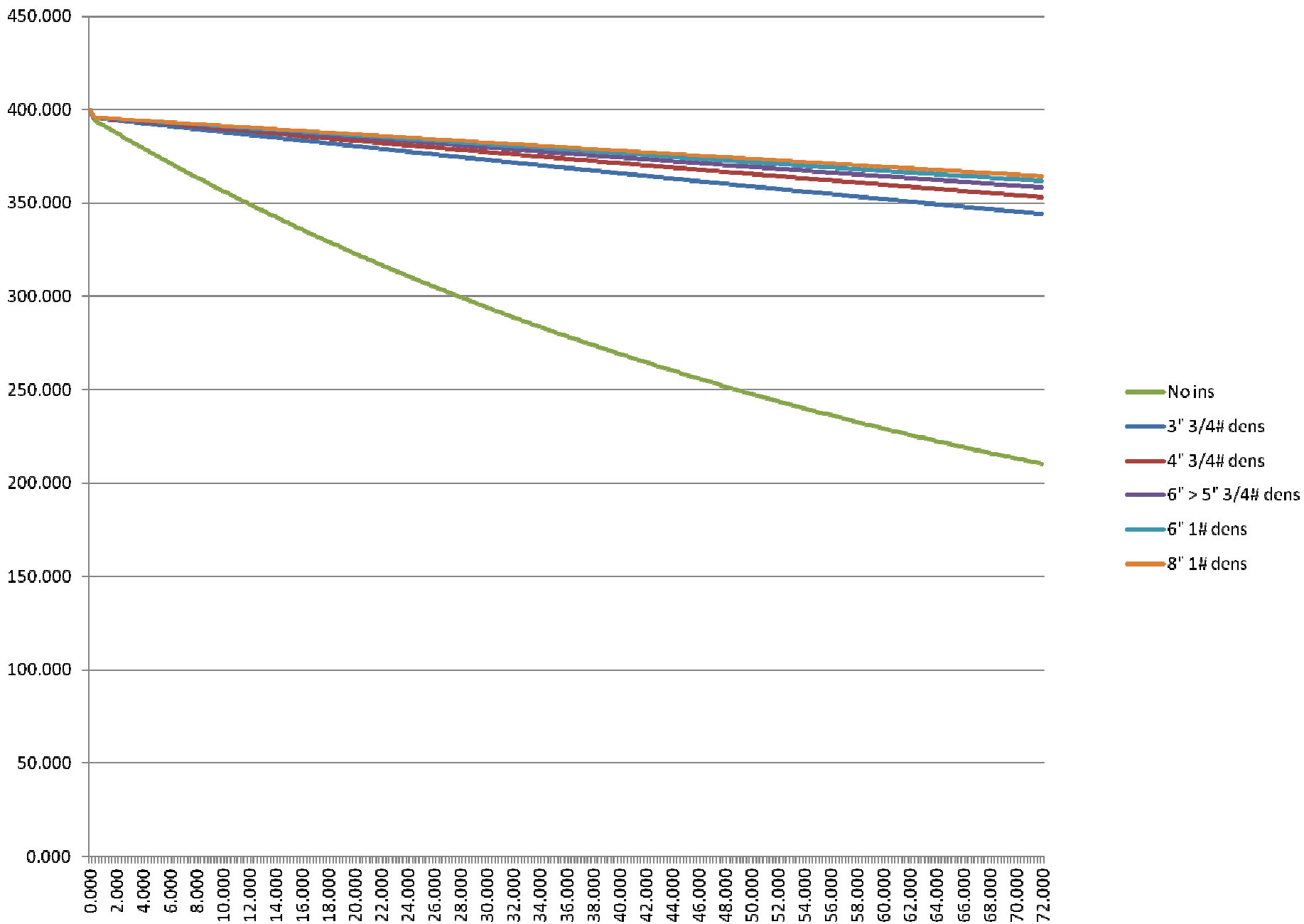
Shell Length in
 Shell ID in
 Shell Thickness in
 Number of Rings
 Ring Height in
 Ring Thickness in
 Ring Width in
 Front Frame Stick-Out in
 Rear Frame Stick-Out in
 Tank Weight lb
 Tank Material

Product

Specific Heat Btu/lbm-°F
 Density lb/gal
 Volume gal

Heat-Saving Option
 Non-insulated
 Create Output File





Project Temperature Performance

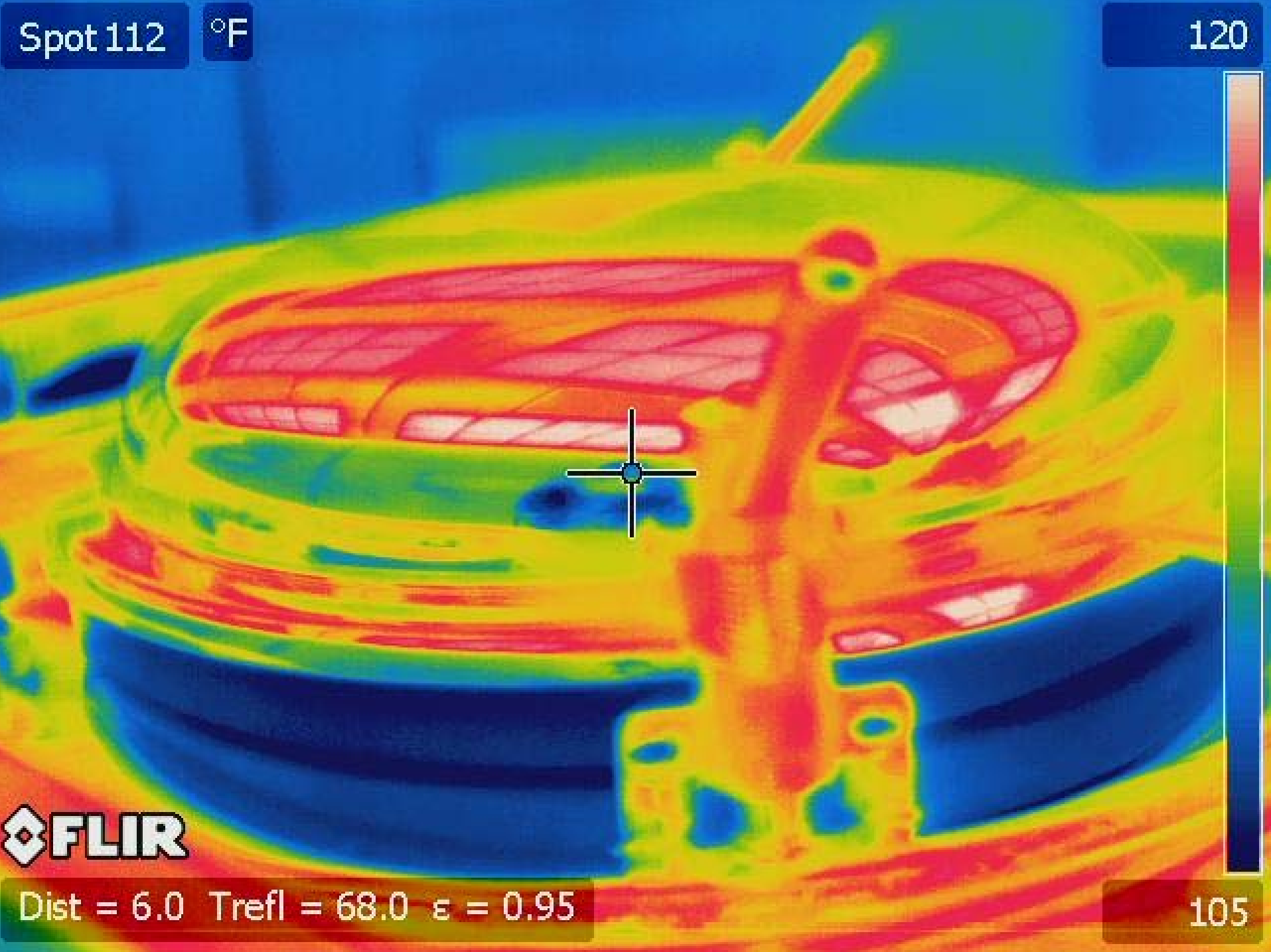
- Solid modeling with finite element analysis
- Thermal imaging cameras
 - Existing units
 - Prototype units
 - Identifies opportunities for improvement



Spot 112

°F

120



FLIR

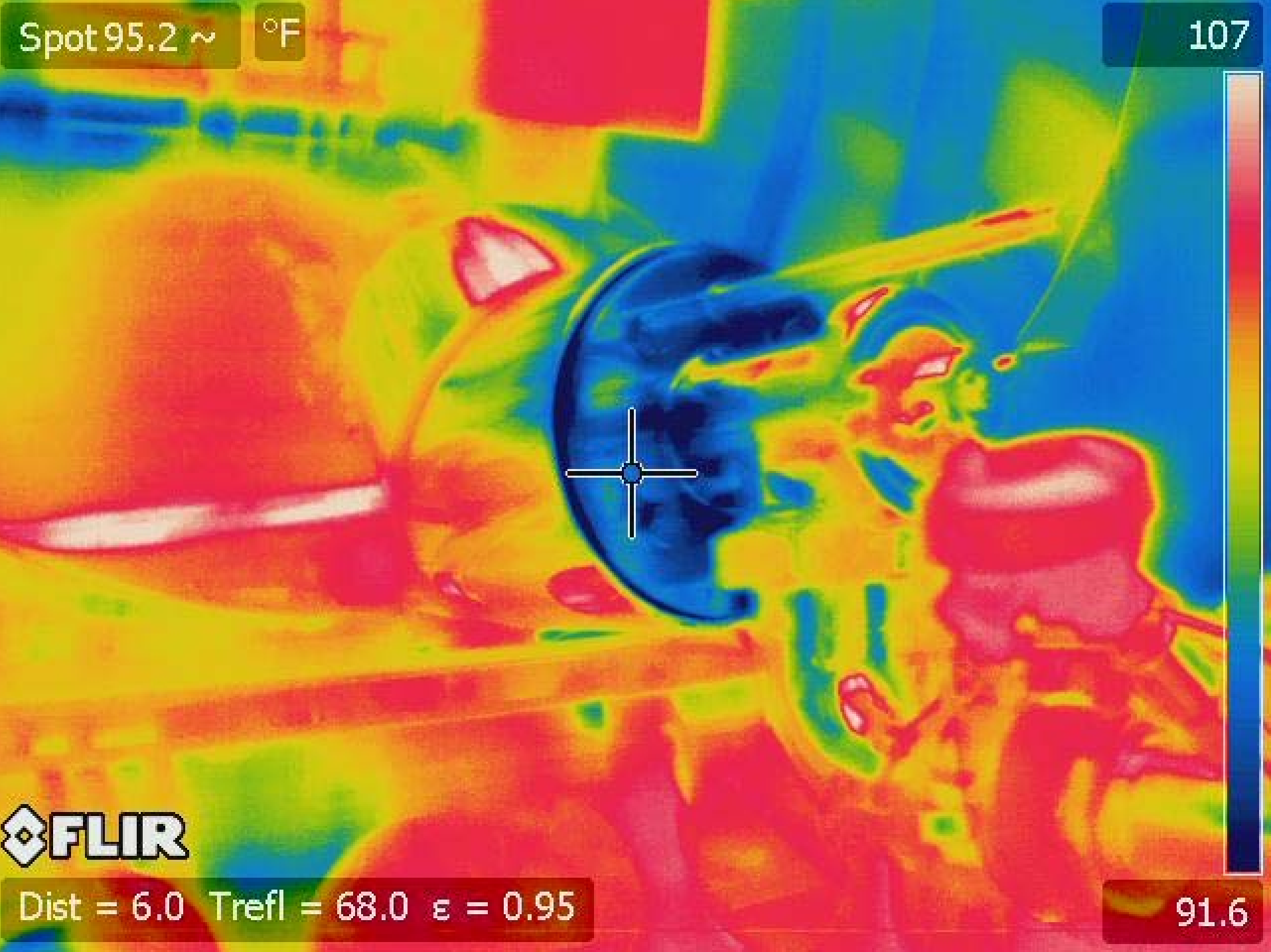
Dist = 6.0 Trefl = 68.0 ϵ = 0.95

105

Spot 95.2 ~

°F

107



FLIR

Dist = 6.0 Trefl = 68.0 $\epsilon = 0.95$

91.6

Assess Potential Processes

- Pre-warming (not pre-steaming!)
- Pre-trip heating (of the loaded tank)
- In-transit heating
 - Tractor glycol
 - Single loop
 - Multiple loop heat exchanger
 - Electrical with trailer mounted generator
- Post-trip, pre-unloading heating

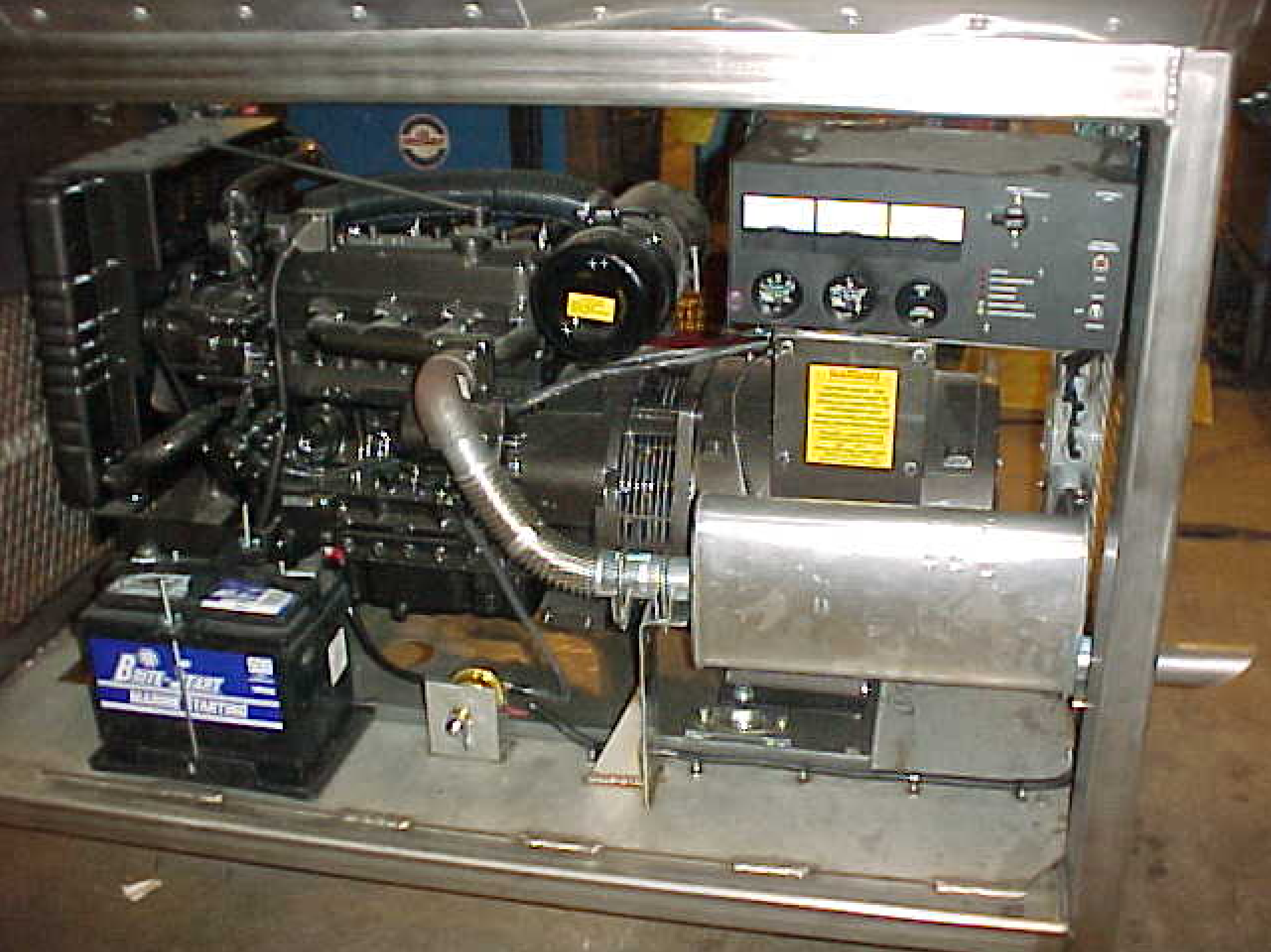


STEAM OR
INTRANSIT
HEAT RETURN

OPEN VALVE FOR
STEAM HEAT
CLOSE VALVE FOR
INTRANSIT HEAT

CAUTION
HOT SURFACES
DANGER OF BURNING
DO NOT TOUCH
OR APPROACH
THIS EQUIPMENT
WHILE IT IS
OPERATING
OR IMMEDIATELY
AFTER IT HAS
STOPPED





Know Applicable Regulations

- Start with the definition of an *elevated temperature material (ETM)* in 49 CFR 171.8.
- ... a material which, when offered for transportation ... is in a liquid phase and at a temperature at or above 212 °F ...



Know Applicable Regulations

- Continue with 49 CFR 173.247, *Bulk packaging for certain elevated temperature materials.*
- Covers ...
 - Authorized cargo tanks,
 - Pressure and vacuum control equipment,
 - Accident damage protection, and
 - More.



Consider Specifications Options

- Vessel material
- Insulation
 - Type
 - Thickness
 - Temperature rating
- Minimizing ‘thermal bridges’
 - Framing
 - Manhole area, and tank top fittings
 - Outlet



Consider Specifications Options

- Heating systems
 - Electrical
 - In-transit (glycol)
 - Steam
 - Combination
- Temperature monitoring and recording
- Remote communication



Become Aware of Risks

- Human injury
- Damage to cargo tank parts
- False temperature readings
- Pressure increase due to heating
- Thermal shock
- Accelerated corrosion



Draw on Resources

- Shipper
- Cargo tank manufacturer
- Equipment and systems suppliers
- Design certifying engineer



Conclusion

- Hauling **hot** products requires additional ...
- Understanding (of challenges)
- Projecting (of performance)
- Assessment (of potential processes)
- Knowledge (of regulations)
- Consideration (of specifications)
- Awareness (of risks)



Questions

