NORA Fuel Performance Research Update
Industry Practices

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Objective

The overall goal is to improve reliability of oil-powered equipment; this project focuses on maximizing fuel performance in residential heating systems by identifying specific ways to reduce fuel-related service calls.

Major Elements of Initial Study

- Industry field survey of service histories
- Field sample collection and fuel analysis
- Review of heating fuel performance R&D and practices from other middle distillate users
- Studies focusing on better designs for fuel storage and delivery systems

A Work in Progress with the NORA Education and Training Committee

Highlights

This talk highlights the following,

- Other industry's take on fuel quality problems and their solutions
- Some information on fuel storage practices, regulations (Germany, Canada, US, Maine)
- Role of copper in tubing and observed effects
- Minimizing problems associated with contaminants in tanks and piping

Sludge

- Fuel degradation (fine solid particles, gums)
- Sand, dirt
- Corrosion, rust from tank
- Water
- Microbes

Sludge is very corrosive and will cause internal corrosion on bottom of steel tanks if allowed to accumulate. Current accepted criteria for steel tanks include bottom outlet to prevent accumulation; tank is sloped towards the outlet. Non-corrodible tanks are popular in Germany.

Standard Piping Configuration (Germany)

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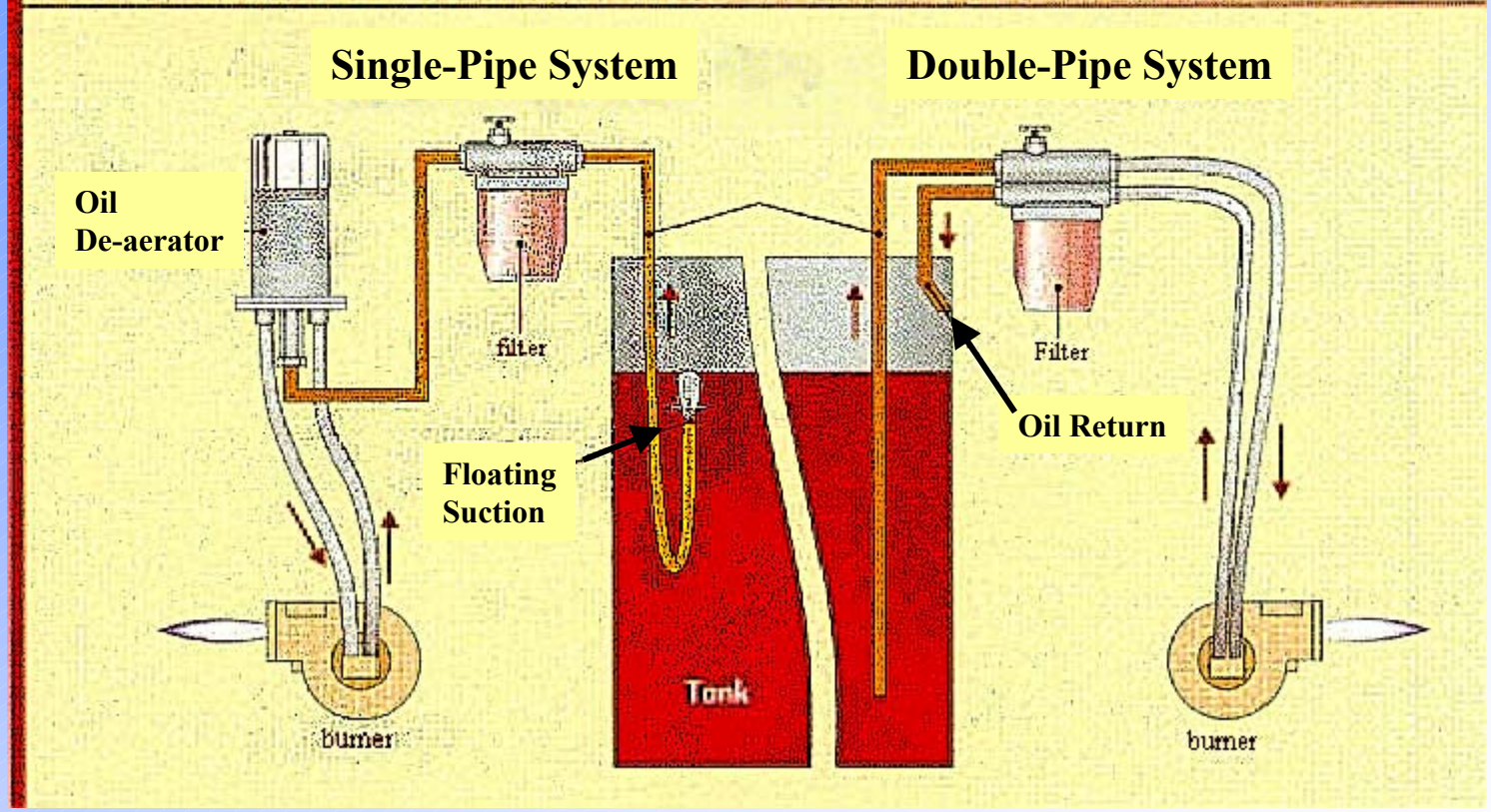
Single/ Double- Pipe Systems



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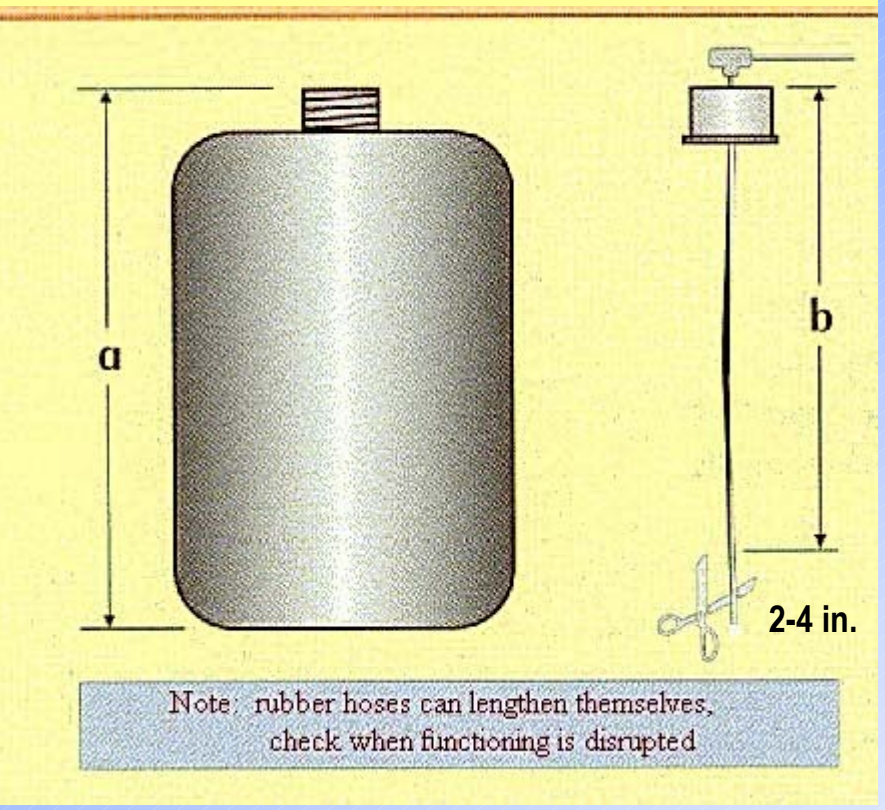
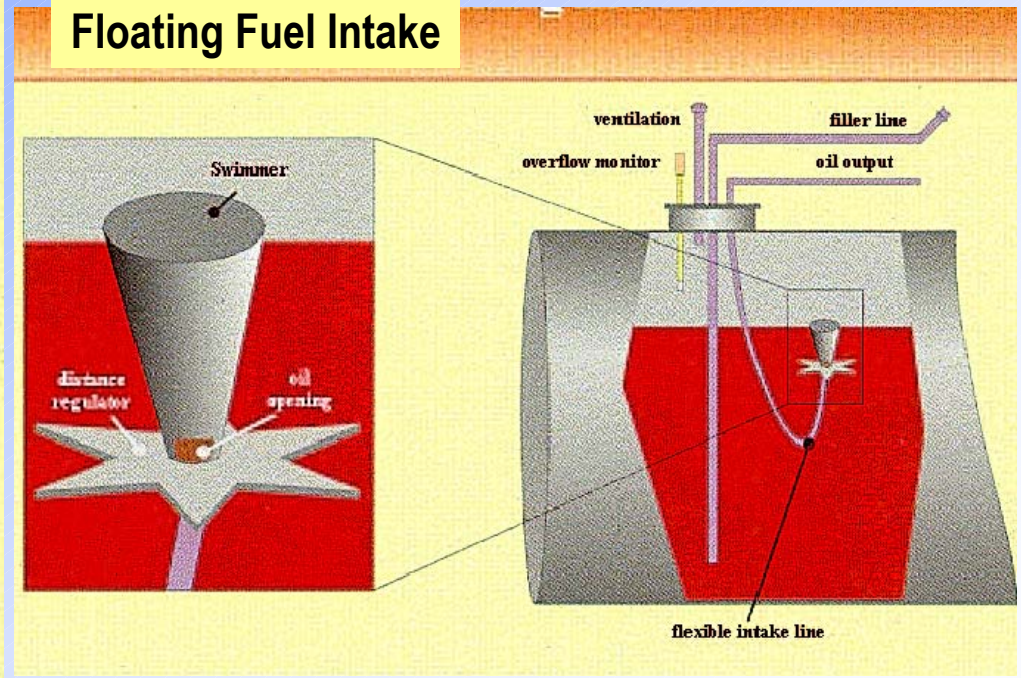
Preventing sediment from entering fuel line

Fuel Inlet Height from Tank Bottom



Floating Fuel Intake



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Minimizing Sludge Accumulation and Corrosion

Criteria for Aboveground Tanks

- Storage in Germany
  - Corrosion resistant tanks- plastic, fiberglass-reinforced have largely replaced steel tanks (160 gal – 1100 gal cap.) for indoor use. (Typical single family – 800 gal total capacity)
  - Steel welded tanks are equipped with opening used for inspection, maintenance and cleaning of interior
- US, CAN aboveground tanks
  - Mostly steel tanks (UL 80)
  - Bottom-draw
  - 12 gauge min. wall
  - Outdoor tanks to have light color paint to minimize condensation

Minimizing Fuel Degradation in Storage

- Fuels naturally degrade and form sediment
- Influences on Storage Stability (heat, oxygen, microbes, non-ferrous metals)
  - General use of stability improver additives (premium)
  - Protection from light (transparent plastic tanks, FRP)
  - Single-pipe* preferred over double-pipe (less oxygen)
  - Do not use aqueous corrosion protection agents, sacrificial anodes inside tank
  - Avoid long piping between tank and burner. Use steel or aluminum for very long lines instead of copper.

***Due to slower fuel flow in 1-pipe, potential cold-flow problems (waxing/gelling) must be considered.**

Advantages/Disadvantages of Tank Configurations

- Plastic tanks w/ containment (gal. steel shroud) have fuel supply from the top of tank
- Sediment and water tend to accumulate
- Light can degrade fuel in transparent tanks
- Corrosion and rust is eliminated
- Steel tanks with bottom supply must be installed to allow for water removal and good filtration; accumulation of water could lead to icing problems.
- Indoor installations are preferred over outdoor AG to minimize moisture and temperature extremes

General Guidelines

Industry: Financial processing center; hospitals, airports that use emergency diesel generators

Fuel quality monitoring programs incorporate:

- Analyses of fuel quality quarterly for water, algae, oxidation
- Treatment with antioxidants, algaecides, biocides
- Inspects tanks periodically for proper maintenance
- Filters (polishes) stored fuel to remove water, dirt, contaminants, and algae if evidence of contamination is found

Clogging of copper fuel lines are a problem.

Before

After

Copper tubing in fuel oil stored in warm oven at 110 °F, 18 weeks

Solid, black particles form that adhere to tube surfaces and the bottom of glass container.

Copper has been known to accelerate the fuel degradation process forming particulates.

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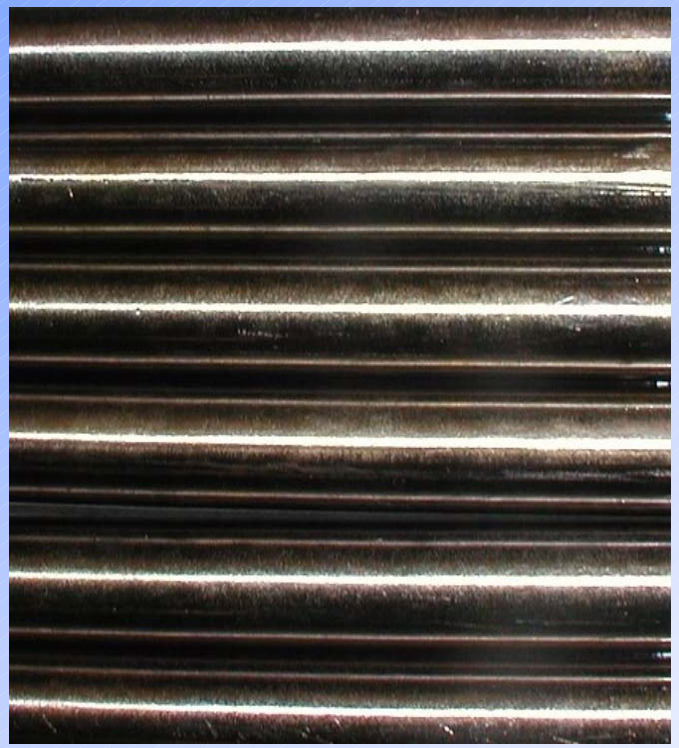
Fuels in Stainless Steel tubing is more stable.

Before



After

S.S. tubing in fuel oil stored in warm oven at 110 °F, 18 weeks

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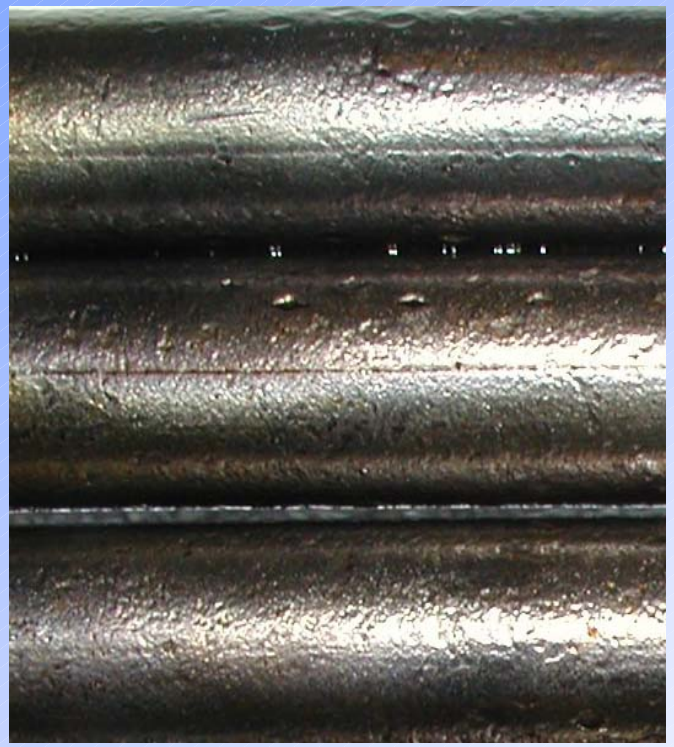
Fuels exposed to steel pipes generated less sediment

Before



After

Black steel pipes in fuel oil stored in oven at 110 °F, 18 wks

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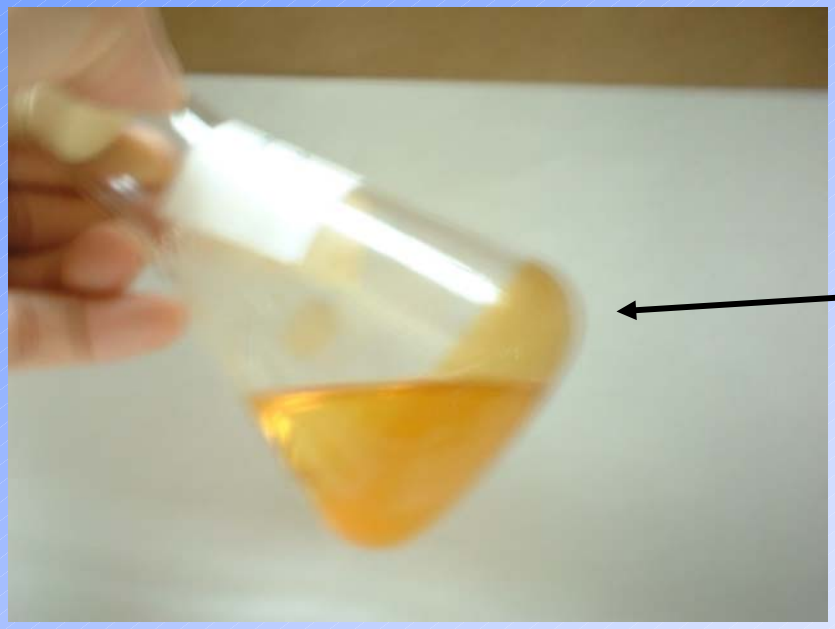
Gum Formation in Fuel



Fuel exposed to light and oxygen darkens in color and forms gum.

Gum coats the inside surface of flask

Ultra-low sulfur fuel

Contains negligible sulfur and nitrogen compounds, tends to produce less solid dark particles but will form gum.

Some Results with No. 2 Oil

- Copper ions can speed up reactions in the fuel that cause solid particles and gums to form.
- Initial results show that the amount of solid particles and gum produced by the fuel when exposed to copper is much higher than base fuel or other tested metals (steel and s.s. steel)

	Filterable Solids mg/ L	Gum mg/ L	Total Deposits mg/ L
Base fuel	10	7	17
Steel	4	11	15
Copper	63	39	102

Some Results (cont'd)

- The solid particles produced are very fine (few microns) and would not normally clog the filter.
- If water is present, sludge and gums can form large clumps >100 um and will dramatically increase filter plugging
- The heavy, dark colored deposits settle out of the fuel, forming sludge that can accumulate in slow moving streams; this can contribute to the problem with fuel lines clogging.

Solutions

Next steps – improve and evaluate better fuel system configurations:

- Water removal (important for bottom draw tanks)
- Good filtration (coarse tank filters, 130 um; finer filters at the burner)
- Other piping materials (steel pipe) with short runs of copper where needed
- Assess the effectiveness of fuel additives (metal deactivators) with copper systems

Water traps help to keep water out of tanks and fuel lines (bottom-draw)

- Commercial water traps, coalescers, oil/water separator, clear plastic bowl, separate water by density allowing the water to settle to the bottom.
- Works better with low-flow of oil in single-pipe systems; not as effective in double-pipe
- Put the trap at the low-point of the system when the tank is tilted toward the fuel supply line

Water Removal Setup

Some Initial Results

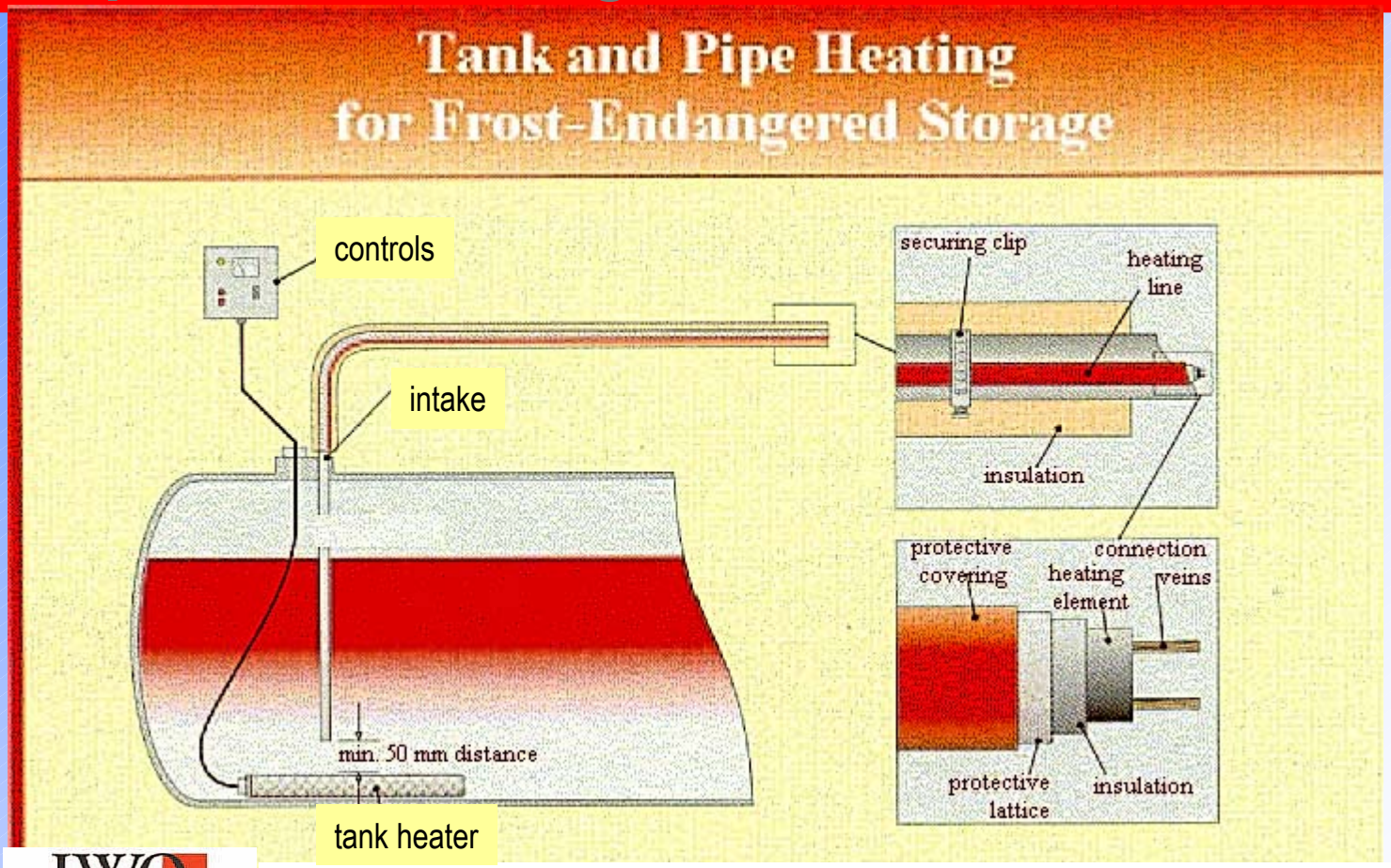
- Single-line (water trap)
  Efficient, >95% removal
- Double-line (water trap)
  Less efficient, ~30%
- Filter/w. separator
  Efficient, >95%

Cold Storage Requirements (Germany)

Cold flow protection (≤ 37 °F)

- Thermal insulation for exposed tank surfaces, valves
- Flow improver additives
- Pipe and/or tank heater

Pipe/ Tank Heating for Frost Protection



Typical for larger commercial-sized tanks; applicable for smaller systems where insulation is not enough

Approach

Maximizing fuel performance must consider a multi-pronged approach:

- Mechanical system (storage tank, piping, filtration)
- Sound maintenance program
- Adequate fuel specifications
- Use of additives where applicable

Upcoming Plans (SOW)

- Field study
  - Hoffman Fuel (CT)
    - 15 test sites to assess fuel changes in storage
    - Observations of additive effects
  - Brookhaven Lab Site (NY)
    - 4 to 5 large outdoor tanks to be instrumented and monitored for fuel quality changes, filter life
    - Introduce commercial additives for observations
- Lab evaluations of additive effects- storage, thermal stability, others? Correlation with actual service needs.
- Effects of additive (stabilizer/metal deactivator) in systems with copper

Upcoming Plans (SOW)

- Evaluate potential improvements in tank/piping schemes
- Continue developing Fuels Manual
- Continue active participation with ASTM, research organizations

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