# What do these items have in common?

# Overview of Thermal Fluid Heaters

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of the National Board

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# Purpose

- Compared to Power Boilers and Heating Boilers, there are a limited number of installations of thermal fluid heaters.
- Minimal guidance is available on these heaters and systems.
- Jurisdictions vary in how these heaters and systems are regulated.

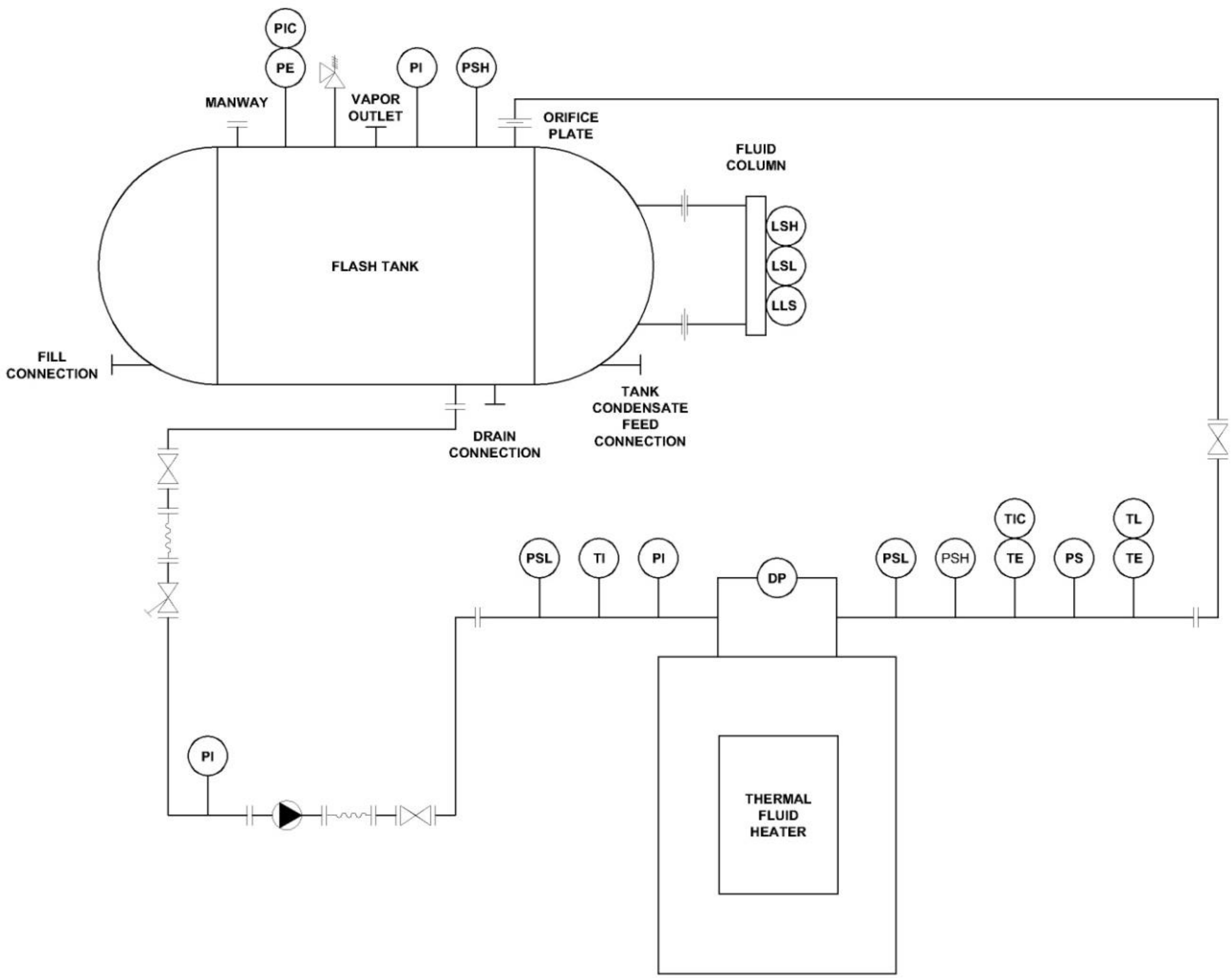
# Overview

- Description of a thermal fluid system
- Comparison of thermal fluid to steam
- Critical system components
- System and safety considerations
- Installation
- Codes and Standards

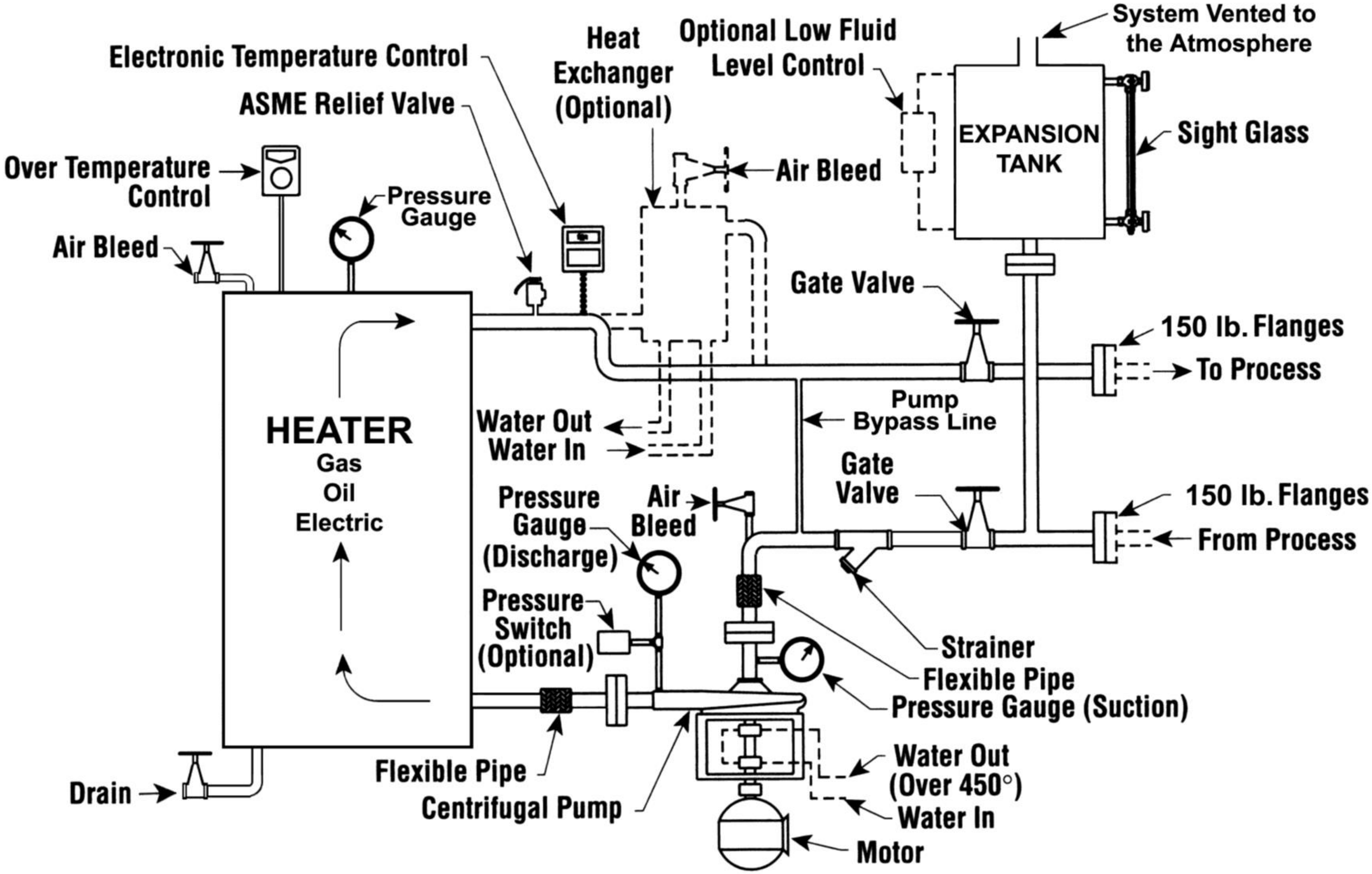
# What is a thermal fluid system?

- Thermal fluid (also known as hot oil) systems may be liquid or vapor.
  - Vapor phase systems may either incorporate a heater in which vaporization of the fluid takes place within the vessel, or a flooded heater where the fluid is vaporized externally through a flash drum.
    - Vapor systems with condensing vapor provide a uniform heat source than liquid phase systems.
  - A liquid phase thermal fluid system uses a flooded pressure vessel (heater) in which the heat transfer media (fluid) is heated but no vaporization takes place within the vessel.
    - Closed loop systems which may be open or closed to the atmosphere
    - Similar in concept to hot water boiler systems

# Vapor Phase System



## Typical Hot Oil Heat Transfer System
## Designed to Operate at Atmospheric Pressure



# Design Features

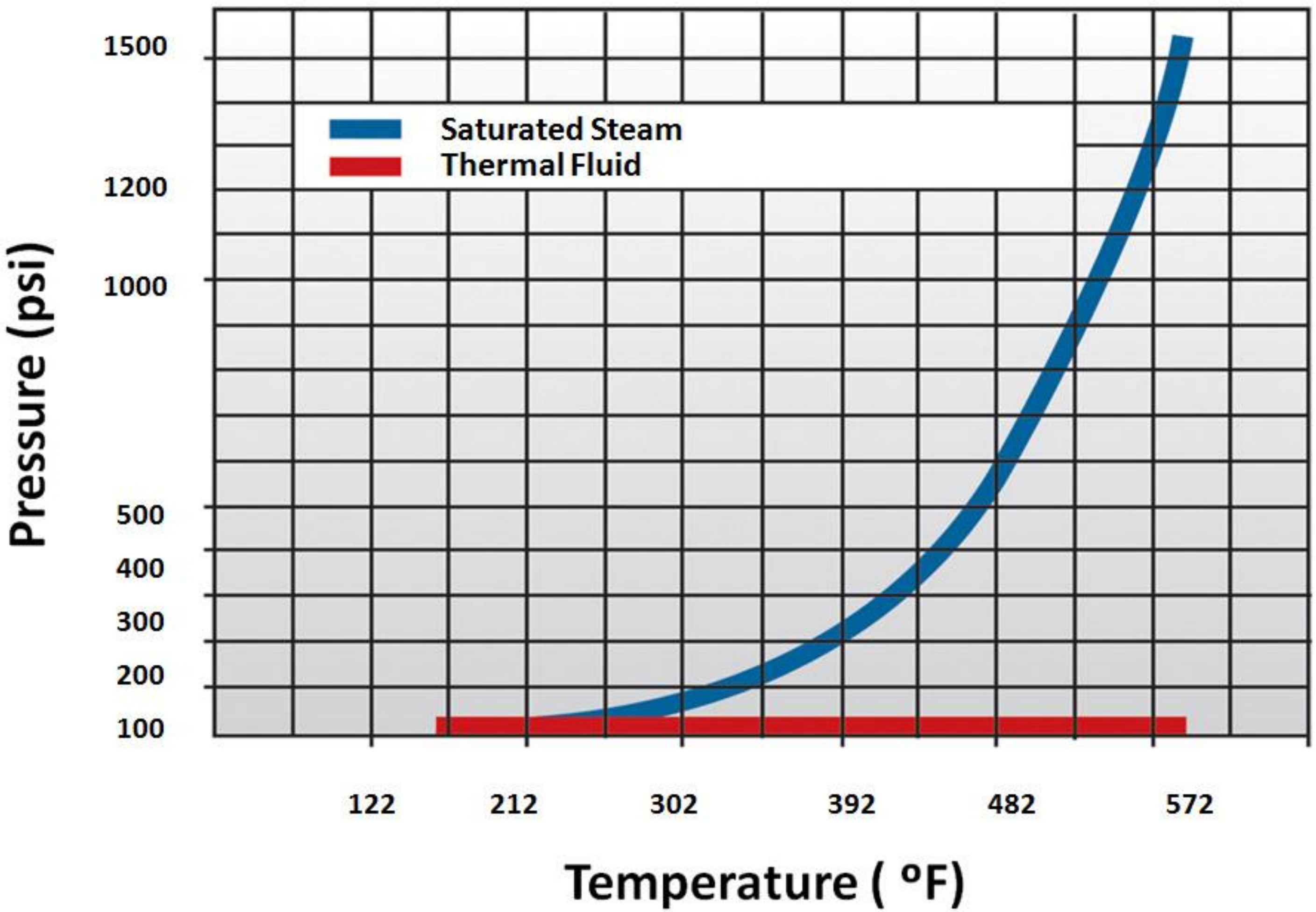
- Heaters are commonly direct-fired by combustion of a fuel, or electric resistance elements can be used.
- Heater design may be similar to a fire-tube boiler, electric resistance heated boiler, or a water tube boiler.
- Heaters may operate at temperatures up to 750°F depending on the process requirements and fluid selection.
- Large heaters may be field erected; however, heaters less than 30,000,000 BTU/hr are similar to packaged boilers utilized in a variety of process applications and may be found in typical “boiler room” installations.

# Thermal Fluid Heaters

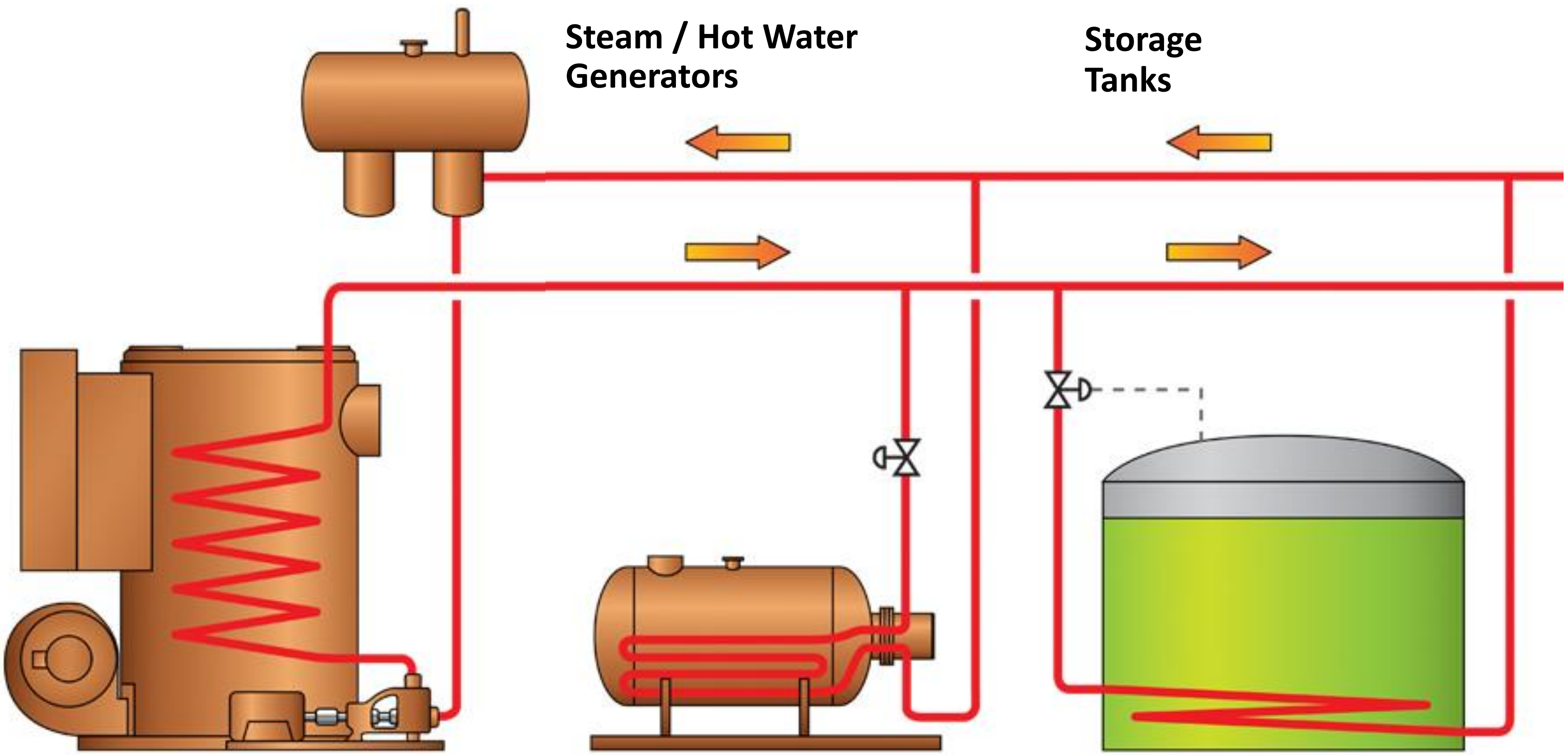
# Why use thermal fluid instead of steam?

- No corrosion or freezing concerns
- Simple circuit; no blow downs, steam traps, or condensate return systems
- Minimal maintenance
  - No hand-hole gasket replacement
  - No re-tubing
- No water treatment requirements
- High operating temperatures obtained with minimal system pressures (system pressure drop only).
- If a process requires heating and cooling, it may be done with a single fluid.

# Steam Pressure Comparison
# Steam vs. Thermal Fluid



# Hot oil can be utilized with the following types of equipment:



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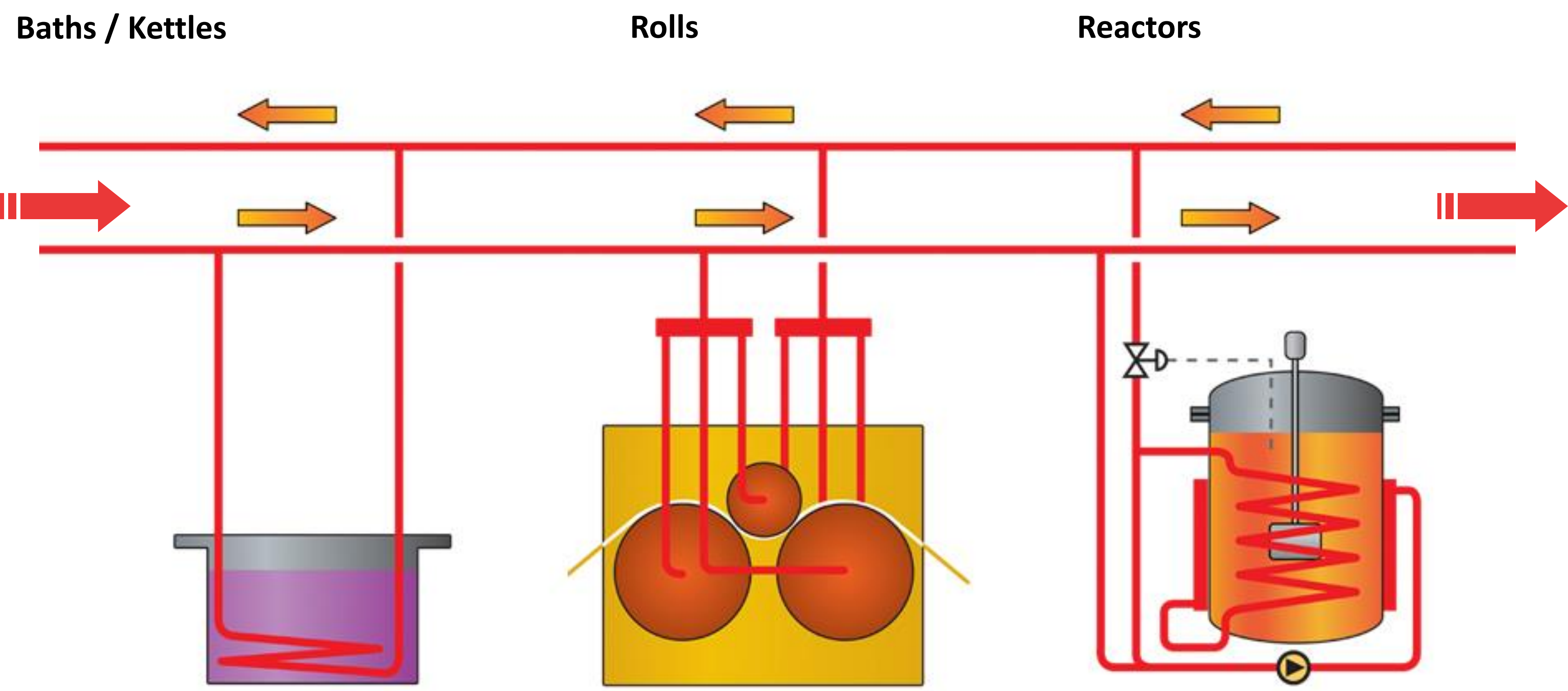

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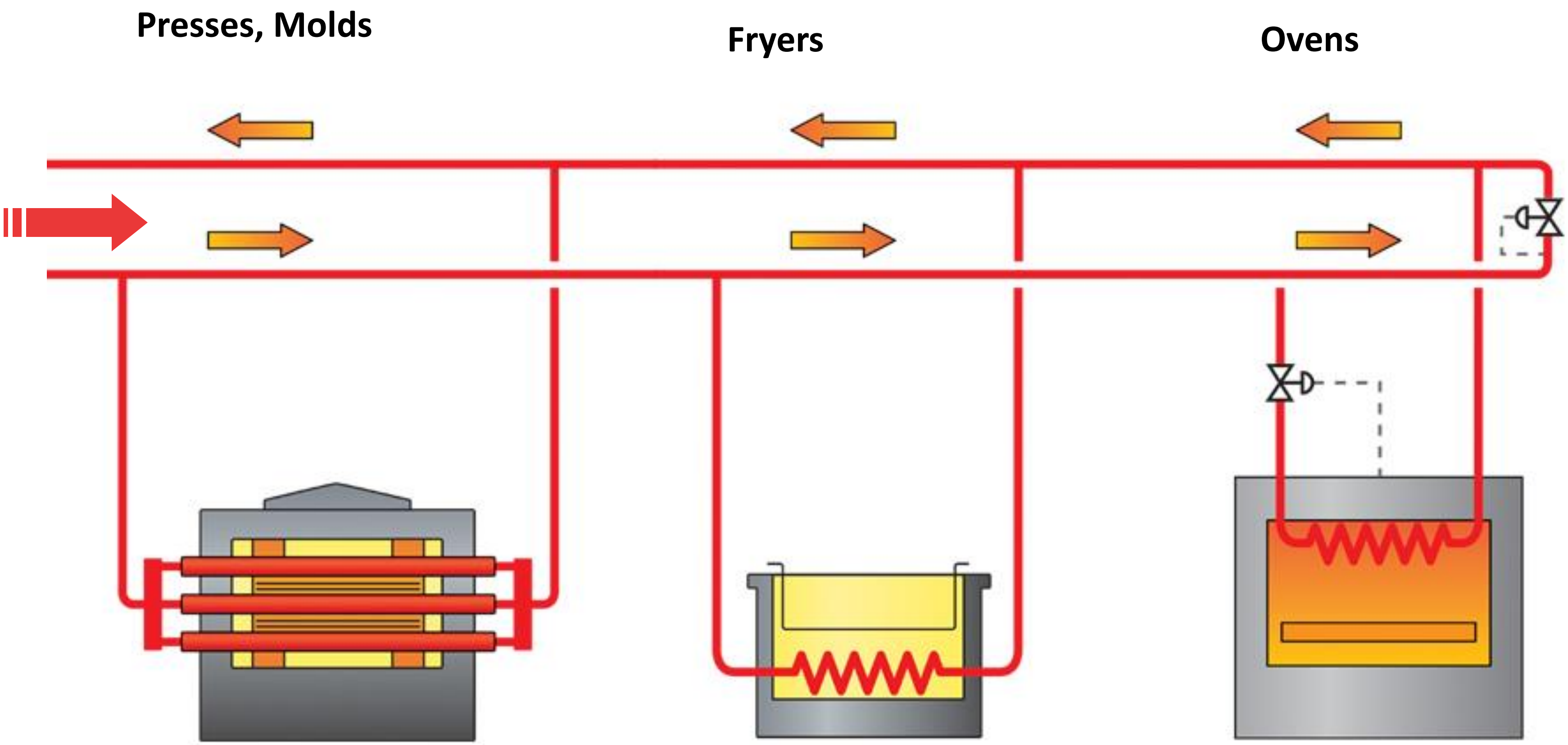


# Applications using thermal fluid heaters


# System Components

A typical thermal fluid system is comprised of four main components:

- Thermal fluid heater
- Thermal fluid circulating pump
- Expansion tank
- User

# System and Safety Considerations

- Thermal fluid selection
- Pump and proof of flow
- Fluid excess temperature protection
- Stack excess temperature limit
- Expansion tank design and fluid level

# Thermal Fluid Selection

- Any fluid specifically designed for heat transfer use may be considered.
  - Lubricating or hydraulic oils are not acceptable.
  - Fluids must have physical property data at elevated temperatures.
- Factors to consider include:
  - Maximum  recommended bulk temperature
    - System operation should never exceed the maximum bulk temperature of the fluid.
  - Minimum operating temperature.
    - Is cooling required?
  - Minimum start-up temperature.
    - Outdoor or indoor application.

# Thermal Fluid Selection

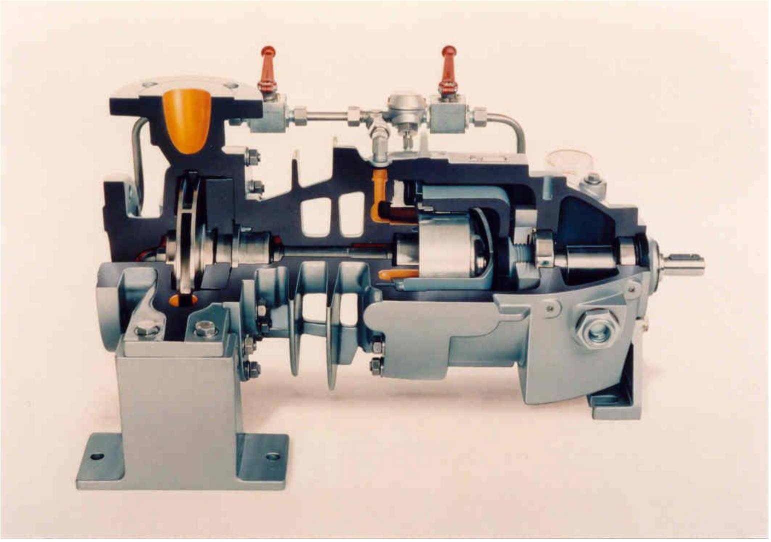
- Vapor pressure/boiling point
  - Special construction requirements if the operating temperature exceeds the boiling point .
- Some common thermal fluids include:
  - Dow — Dowtherm A, G, RP
  - Monsanto — Therminol 55, 59, 66
  - Paratherm — NF, HE
  - Petro Canada — Calfo AF, Purity FG

# Thermal Fluid Maintenance

- Fluids should be tested annually.
- Lubricating oil tests that include dissolved metals are not adequate.
- Do not top off with different thermal fluid chemistry.
  - Mineral oil/petroleum vs. synthetic/aromatic.
- Track heater inlet and outlet temperatures and pressures.
- Always record the date and the amount of fluid addition.
- Changing the type of fluid used in a system may require a change in the system components (pump, expansion tank etc.).
  - Chemical cleaners may also be required.

# Thermal Fluid Pump

- Must be designed for use with thermal fluids at temperature
  - Standard hot water and boiler feed pumps are not appropriate.
- Pumps may be air cooled, water cooled, canned or mag drive designs.
- The pumps are sized to overcome the pressure drop in the system and must be sized based on the specific gravity of the fluid at operating temperature.



# Proof of Fluid Flow

- Proof of fluid flow is critical for vessel longevity and system integrity.
- Means should be provided to prove minimum fluid flow through the heater at all operating conditions to ensure proper velocities and film temperatures.
- A low flow condition can cause overheating, degradation of the fluid, or heater coil/tube failure.
- Proof of flow is typically interlocked into the combustion circuitry
- Means to prove flow may include vortex shedding meters, flow switches, pressure switches, an orifice or a differential pressure switch.

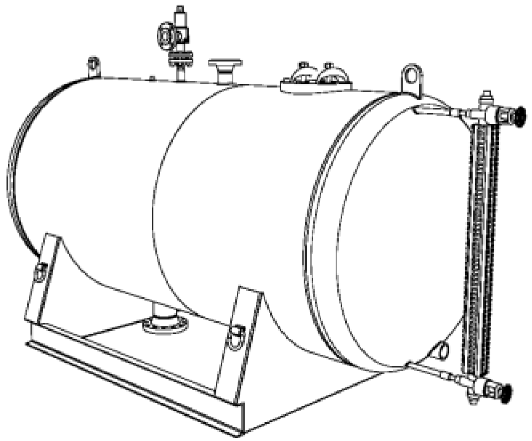
# Fluid Excess Temperature Protection

- This limit prevents the fluid temperature from exceeding the maximum allowable temperature of the specific fluid.  It should be set no higher than the maximum bulk temperature of the fluid.
- The temperature sensing device should be compatible with the fluid and the system operating temperature and pressure and located at the heater outlet.
- It is generally interlocked into the combustion safety circuitry and often incorporates a manual reset functionality.

# Stack Excess Temperature Limit

- Many installations include a high stack temperature switch interlock.
- In the event of a high stack temperature this device shuts off the burner and circulating pump.
- The manufacturer of the heater determines the acceptable stack temperature for the heater.
- A high stack temperature indicates improper combustion (or soot build up) or a failed coil.
- Manual reset is recommended.
- The stack limit may be part of an inert gas smothering system.

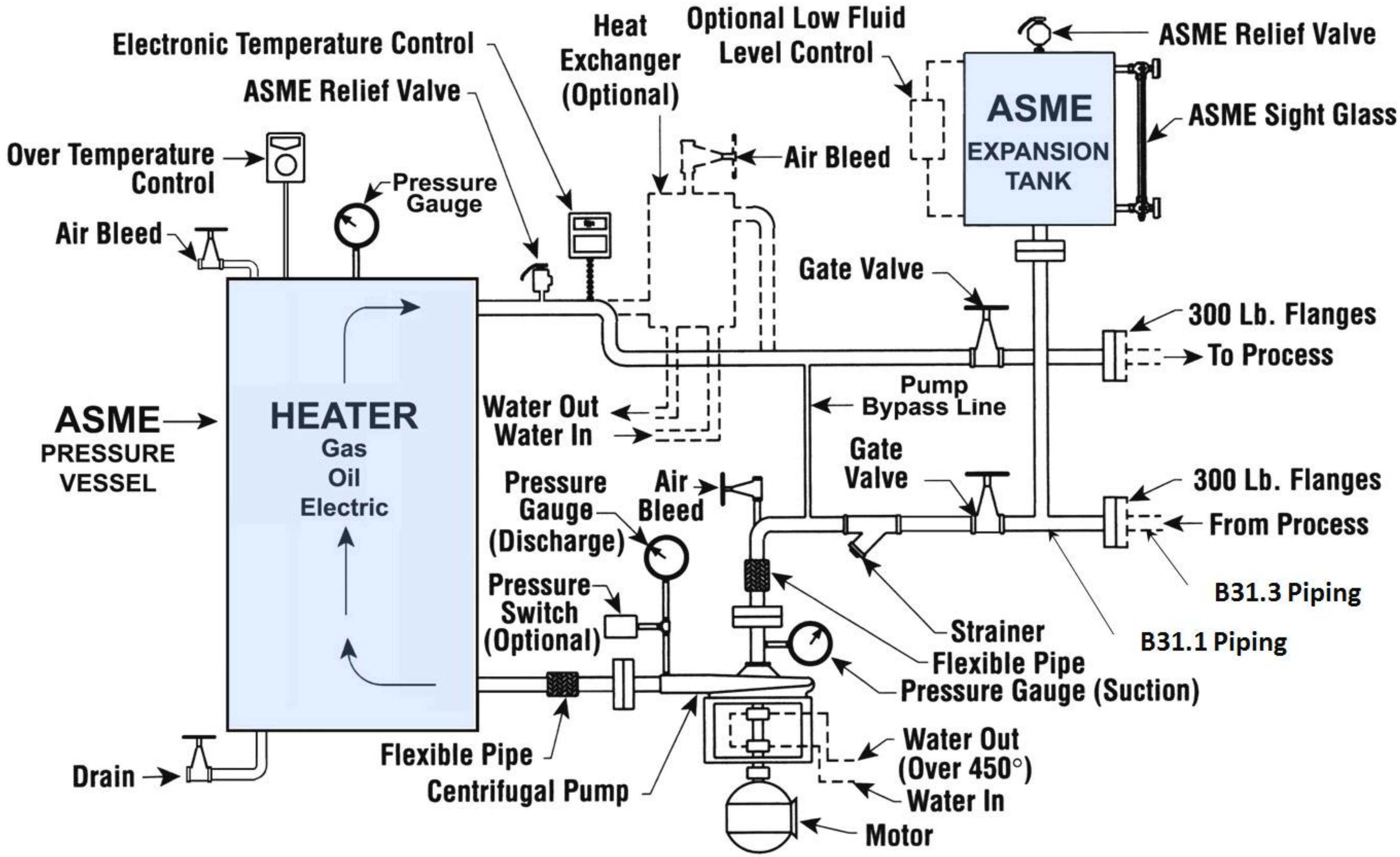
# Expansion Tank Design



- Fluid selection, system volume and operating temperature will impact expansion tank size.
- Depending on the fluid selection and operating parameters, systems may be open or closed to the atmosphere.
- Closed systems may be pressurized with an inert gas blanket.
- An ASME tank may be required.

# When should a pressurized expansion tank be used?

- The tank is not the highest point in the piping system.
- The tank contents can be at a temperature such that exposure of the fluid to the air would cause degradation of the fluid.
- The fluid is operated above its atmospheric boiling point.
- The fluid manufacturer recommends the use of an inert blanket.




# TYPICAL ASME HOT OIL HEAT TRANSFER PRESSURIZED SYSTEM (OVER 15 PSIG)

# Expansion Tank – Fluid Level

- A minimum liquid level must be maintained in the expansion tank to prevent pump cavitation.
- A liquid level switch or similar device is typically provided and interlocked with the pump and burner to shut them down in the event of a low fluid level condition.
- The switch should be satisfied before the pump can start.

# Installation

- Combustion air and ventilation requirements are similar to those of power or heating boilers and determined by the manufacturer.
- A containment curb or seal welded drip lip on the heater skid should be considered.
- Piping, valves and system components are rated for the temperature and pressure of the system
  - Brass, bronze, aluminum and cast iron components are not recommended.
  - Any sign of leaking piping  is a safety concern, as the fluid or its vapors can be hazardous or flammable.
  - Piping should be welded or flanged where possible and **pneumatically** tested for leaks.

# Installation

- Pressure relief devices
  - The pressure relief valves should be a totally enclosed type with no lifting lever.
  - The discharge piping of the pressure relief valve should be connected to a closed vented storage tank.
- Insulation
  - The insulation should be selected for the intended purpose.
  - Where there is a potential for fluid leaks, the insulation should be non-absorbent.

# Codes and Standards

- Jurisdictions have varying requirements for thermal fluid systems.
- Until recently, limited guidance has been available.
- What resources are available?
  - National Board Inspection Code
  - ASME Boiler Pressure Vessel Code
  - Controls and Safety Devices for Automatically Fired Boilers
  - National Fire Protection Association, NFPA-87

# National Board Inspection Code (NBIC)

- The NBIC Part 2 Inspection provides some information on thermal fluid systems.
- Part 1 of NBIC Installation covers the requirements for power boilers, heating boilers, and pressure vessels.
- There is an open item to provide guidance for the installation of thermal fluid heaters as a new supplement to Part 1.
- Requirements such as clearances, ladders, electrical, ventilation and combustion air are consistent with steam boilers, hot water boilers and other pressure vessels.
- Additional requirements regarding expansion tanks, pumps, piping and controls are included.

# ASME Boiler and Pressure Vessel Code

- Some Jurisdictions may require ASME Section I or ASME Section VIII Div. 1 construction.
- The specific requirements outlined in the construction codes must be met.

# ASME Section I Requirements

- Organic Fluid (thermal fluid) Vaporizers
  - Rules in Part PVG are applicable and are used in conjunction with the general requirements of Part PG.
  - Part PVG addresses the pressure relief valves, gage glasses and drain valves.
- Liquid phase thermal fluid heaters
  - Applicable requirements for liquid phase heaters are not clearly identified.
  - There is an open item in progress to define the Section I rules for these heaters.

# ASME Section VIII Div. 1 Requirements

- Subject to Paragraph UW-2(d) for pressure vessels subject to direct firing.
  - Category A welds must be in accordance with Type No. (1) of Table UW-12.
  - Welded joints in Category B (for thicknesses exceeding 5/8”) must be Type No. (1) or No. (2) of Table UW-12.
  - Post weld heat treatment may be required depending on the material used and weld size.
  - Stamping of the pressure vessel shall include DF for direct firings and the Manufacturer’s Data Report will indicate the special service requirements.
- Safety relief valves may be based on the flow through the heater, operating temperature, fluid and set pressure.

# Controls and Safety Devices for Automatically Fired Boilers (CSD-1)

- CSD-1 applies to Power Boilers and Heating Boilers with inputs less than 12,500,000 BTU/hr. It includes requirements for combustion controls as well as steam and waterside control (including pressure, temperature and water level).
- With the current Standard, questions exist regarding the applicability of CSD-1 to thermal fluid systems.
  - Combustion controls covered in CSD-1 are applicable to thermal fluid heaters.
  - However, Part CW, Steam and Waterside Control, does not cover the requirements for thermal fluid systems.
- A task group was formed in CSD-1 to review and define the specific requirements for thermal fluid systems.

# National Fire Protection Association, NFPA-87

- While NFPA 85 (boilers) and NFPA 86 (ovens) provide excellent information regarding combustion controls, neither Standard was directly applicable to thermal fluid heaters.
- Recommended Practice for Fluid Heaters, NFPA 87, was developed.
  - Topics covered include:
    - Location and Construction
    - Heating Systems
    - Commissioning, Operations, Maintenance, Inspection and Testing
    - Heating System Safety Equipment and Application (combustion & temperature control)
    - Chapters specific to thermal fluid heaters (pumps, expansion tanks etc.)
    - Fire Protection

# In Summary, Thermal Fluid Systems…

- Obtain high temperatures with low system pressures
- Are commonly used in a variety of applications
- Design/safety considerations include:
  - Fluid, flow and temperature
- Codes and Standards are under development to provide additional guidance