Heat Trace Fundamentals

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### Contents

**Introduction** ............................................................................................................................................. 3

**Purpose of Heat Trace** ......................................................................................................................... 3

**Types of Heat Trace** ............................................................................................................................. 4
  - Steam Trace vs. Electric Trace ............................................................................................................. 4
  - Types of Electric Heat Trace Cable .................................................................................................. 4

**Electric Heat Trace Monitoring Options** ............................................................................................ 5
  - Current Transmitters ......................................................................................................................... 5
  - Temperature Transmitters ............................................................................................................... 5
  - Heat Trace Control Options ............................................................................................................. 5
  - Self-Regulating – No Control ............................................................................................................. 6
  - Ambient Thermostat ........................................................................................................................... 6
  - Field Located Thermostats .............................................................................................................. 6
  - Full Feature Control Panels ............................................................................................................ 6

**Heat Trace Audit Process and Project Advantages** ............................................................................... 6
  - Meggar Testing ................................................................................................................................. 7
  - Capacitance Testing .......................................................................................................................... 7
  - Optimal Time to Execute a Heat Trace Project .................................................................................. 7

**Implementation Examples** ................................................................................................................... 7
  - Ethanol Plant ......................................................................................................................................... 8
  - Vegetable Oil Refinery ...................................................................................................................... 8

**Conclusion** .............................................................................................................................................. 8

**Biography** .............................................................................................................................................. 8
Introduction
Heat trace is often an overlooked part of a plant’s process systems. In many situations heat trace is a major headache for operators and maintenance staff. A single frozen line on a cold January night can result in hours or even days of lost production. However, it does not need to be that way. A well-designed heat trace system can function without operator or maintenance efforts. Interstates provides expert heat trace design and installation services.
This paper outlines the fundamental uses of heat trace and many of the available options that one can consider for use in their facility.

Purpose of Heat Trace
Heat trace provides a way to add heat to a pipe, vessel, tank, or equipment using a line of heat transfer fluid or an electrically heated cable. For simplicity, we will limit our heat transfer fluid to steam and compare steam and electric trace.

Heat trace is primarily used to prevent freezing by keeping a liquid above 32 degrees (or whatever temperature necessary to keep the material flowing through the piping). Heat trace can be used to reduce viscosity of a fluid to allow for effective pumping. Heat trace may also be used to maintain a specific temperature for a material (process maintain). Other uses of heat trace include compensation for heat loss, raising piping temperature to recover from outages, eliminate formation of liquids in gas or powder lines, and minimize the formation of solids in liquid pipes.

As an example, cooling water lines usually have enough velocity to not freeze very often because there is enough flow through the line to prevent freezing. Steam lines have high potential to freeze because the condensation does not move. In a hot water application, lines maybe need to be kept warm so water does not have to be reheated for use in a process.

Generally speaking, a freeze protection application is typically easier to engineer. A system to maintain a specific temperature to support a process is more critical and requires more complex engineering.

Knowing the function of the trace is critical when selecting the type of trace, heat trace monitoring methods, and the control scenarios for the trace. Heat trace does not come in a one size fits all package. It is recommended that you consult with process designers and engineers that understand your process in order to size and design the heat trace system that is right for your needs.
Types of Heat Trace

Steam Trace vs. Electric Trace
Process lines, vessels, and tanks can be traced with either electric trace or steam trace. Electric trace has become increasing popular over steam tracing for several reasons.

Steam Trace Disadvantages:
1. Steam leaks
2. Poor temperature control resulting in overheating
3. High operating costs, due to cost of steam
4. Trap maintenance
5. Water treatment costs

Electric Trace Disadvantages:
1. Limited lifetime – replacement costs

Alternatives to electric trace for tanks and large vessels include steam coils inside the tank; a heat exchanger and recycle pump external to the tank; or use of an electric element inserted directly into the tank (typically referred to as an immersion heater). The heating element in an electric water heater is a type of immersion heater. Industrial immersion heaters are typically installed in a well that allows for maintenance and replacement without emptying the tank. Immersion heaters are often more cost effective from both a capital and operating perspective than steam coils, heat exchangers, or electric heat trace cable.

These alternatives add complexity to your solution and are reasons why you should consult a designer or engineer to help you determine best available heat trace options, especially in the case of tank heating.

Heat Trace and Insulation
Heat trace and insulation work hand in hand. Therefore, it is important to evaluate the insulation and the heat trace together as a system to determine the optimal combination. Too little insulation or the wrong type of insulation could result in a larger heat trace requirement and extra operating costs. Too much insulation may not generate the desired payback from saved operating costs.

Tank and Large Vessel Heating
Tank and large vessel heating presents unique challenges due to the size of the tank or vessel and potential for heat loss. Using electric trace requires multiple passes spaced equally (typically around 8” to 12”) on the lower 1/3 to ½ of the tank. Installing this trace is difficult and expensive. Further, once the tank is insulated, repairing or replacing a portion of the trace is both time consuming and expensive.
Types of Electric Heat Trace Cable

Self-Regulating
Self-regulating heat trace cable is the most popular method used for heat trace. Self-regulating cables vary their heat output based on the heat requirements of the system and can be cut to the exact length needed. However, self-regulating cable can be damaged when exposed to high temperatures such as 150# steam while energized.

Constant Wattage
Constant wattage heat trace cable is used when high heat output or high temperature exposures are required. Constant wattage trace can maintain temperatures up to 300°F and withstand exposure to temperatures nearing 500°F. Constant wattage trace can be cut to length. However, constant wattage heat trace uses the same wattage along the entire length of trace and could potentially overheat.

Mineral Insulated
Mineral Insulated (MI) trace is used when there is even higher heat output, higher exposure temperatures, or resistance to environmental corrosives or abrasives. MI cable is encased in a metal sheath to increase its ruggedness. MI cable can maintain temperatures in excess of 1000°F and withstand exposure to temperatures in excess of 1200°F. MI cable cannot be cut to length; it must be engineered and manufactured to required lengths.

Series Resistance & Skin Tracing
Series resistance and skin tracing are typically used in pipeline applications requiring long runs of pipe.

Electric Heat Trace Monitoring Options
Electric Heat trace can run as a standalone system. As the costs to troubleshoot, fix, or replace heat trace increases, more industrial facilities are adding monitoring capabilities to their heat trace system. Monitoring can be designed during original plant construction or added years later. Like most systems, electric heat trace circuits and components are subject to eventual failure. Monitoring these systems allows for preventative and predictive maintenance of the heat trace components.

Current Transmitters
Current transmitters provide a cost effective option to monitor heat trace. Current transmitters will provide maintenance staff and operators indication of which heat trace circuits are energized and if they are drawing more or less current than anticipated.

Temperature Transmitters
Temperature transmitters in process lines and vessels provide excellent feedback regarding heat trace performance. Operators and maintenance staff can see the actual temperature of the monitored lines. High and low temperature alarms indicate when heat trace is not functioning as designed.
Heat Trace Control Options

Heat trace control scenarios range from simple to complex based on the type of trace used and the process requirements. Freeze protection for water lines may only require a single ambient temperature sensor where process-maintain applications will likely require a well-designed control scheme.

Self-Regulating – No Control

With the implementation of self-regulating heat trace, a heat trace control method is not required. The heat trace can be left on and will increase or decrease the heating based on the temperature. This is the simplest and least costly method of control. However, it results in increased energy consumption and the possibility of freezing due to human error when the heat trace is not turned on as ambient temperatures begin to fall.

Ambient Thermostat

Adding an ambient thermostat for control reduces the chance that operators will fail to remember to energize heat trace circuits when the ambient temperature falls below freezing. Ambient thermostats are most useful in applications where heat trace is installed primarily for freeze protection.

Field Located Thermostats

Field located thermostats allow for control of each process line based on the temperature of the line. As the line temperature drops, the heat trace is energized and the line is heated. Field thermostats are a cost effective method to allow for process maintain temperatures greater than freezing. Field thermostats also improve heat trace energy consumption by turning off heat trace when heating is not required.

Full Feature Control Panels

Full feature control panels leverage current transmitters and line and vessel temperature sensors to monitor and control the heat trace. Operator set points energize the heat trace based upon line and vessel temperatures. The control panels will typically display what heat trace is energized, temperature, and current. Some control panels will log and display this information for the operator. Heat trace control panels come with higher installation costs, but can reduce the total cost of ownership of a heat trace system though energy conservation and preventative maintenance processes.
Heat Trace Audit Process and Project Advantages

Early heat trace audits will help you predict when your trace may fail. You know on day one when your heat trace system is installed what the voltage, capacitance, and resistance is for the system. With regular audits you can trend the readings and see what changes are taking place. Using this data, you can see if something is happening to the system and estimate the remaining life of your system. This allows you to plan your maintenance budget to replace the system according to your timeline.

Meggar Testing
Insulation breakdown is one of the most common issues that will cause heat trace to malfunction. Meggar testing is one way that teams can check the condition of your system. Meggar testing checks the resistance of the heat trace core to the shield and will indicate if the insulation is breaking down.

Capacitance Testing
Another test is a capacitance test which will indicate the length of the trace. It serves as a troubleshooting tool to test if there is a segment of heat trace that has failed. This allows you to see where the breakdown is and then replace just that piece of the system. Instead of replacing an entire line of heat trace, you can pinpoint the break and replace just the section that has malfunctioned.

Optimal Time to Execute a Heat Trace Project
The best time to execute a heat trace project is before heat trace fails. Planned projects are always best since you can control the conditions of the project. With regular auditing, you can identify non-functioning or potentially problematic heat trace, avoiding a painful plant outage to replace heat trace and the damage resulting from frozen pipe. It is possible to upgrade or repair portions of your system rather than replace an entire heat trace system, allowing you to plan for budgeting as well.
Implementation Examples

Ethanol Plant
In two different locations, ethanol plants were experiencing frequent dryer shut downs during cold weather. Operators were not able to determine what was causing the issue and asked Interstates to troubleshoot the situation. Interstates found that the dryer shut downs were caused by frozen sensing lines that would trip alarms, which in turn would shut down the dryer. The solution was to replace the sensing lines with bundled tubing, a pre-insulated and pre-traced product. Since installing the new sensing lines, the site has had no similar shutdowns due to frozen lines and false alarms.

Vegetable Oil Refinery
A vegetable oil refinery was experiencing problems with the longevity of their heat trace solution. Systems would fail long before their end of life expectancy. After a full review of the system, it was determined that steam in excess of 350 degrees was used regularly to clean the lines to prevent cross contamination of oil. This was more heat than the existing heat trace was rated to withstand. The solution was to remove the self-regulated trace and replace it with Mineral Insulated trace which is more applicable for the environment. At the same time, the owners added PLC based temperature controls with a redundant local mechanical control.

Conclusion
Heat trace systems can either be a major headache or a plant asset that provides years of dependable service. Understanding your options and consulting with process designers and engineers will help you make educated decisions for your heat trace system. Good choices during the design process will help you maximizing process performance and reduce your overall cost of ownership.
Biography
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Monte Vander Velde, PE is President of Interstates Instrumentation, a company that specializes in industrial instrumentation for processing facilities in industries such as bio-energy, oilseed, food & beverage and value-added agriculture. Monte has a strong background as a professional engineer and experience in plant engineering, automation, and instrumentation. He has been with the Interstates Companies since 1994 and played a significant role in the launching of Interstates Instrumentation as a separate company in 2006. Monte is a licensed professional engineer, with degrees in chemistry from Northwestern College and chemical engineering from Washington University.

His skills of setting direction and implementing strategy will provide continual future growth and development of Interstates Instrumentation services.

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