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Cape Coral, Florida
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SUBJECT: HEATER SELECTION FOR DEKORON/UNITHERM ELECTRIC TRACED BUNDLES

Furon Unitherm electric heat traced products are designed with a variety of heating elements. Heating element selection is a function of the product and application requirements. The four main types of heating elements used in Unitherm bundles are the parallel constant wattage heater, the self-regulating heating element, the series resistance heating wire, and the mineral insulated heating cable.

Parallel Constant Wattage Heating Cable

This heater, commonly called the Constant Power Density or CPD heater, is comprised of two parallel insulated bus conductors. The insulation is removed from alternate bus wires at fixed lengths along the heater. A fine gauge nickel alloy heater wire is wound around the insulated conductors and joined to the bus wires where the insulation has been removed. This creates fixed zones of constant power output. The output is governed by the heater wire size and alloy, the zone length and the voltage. The wire size and alloy are selected by Furon to provide a range of power outputs at common voltages. Since the heater zones are connected in parallel along the bus wires, this heater can be cut to length without loss of power or the need to vary the voltage. Care must be taken, however, not to cut the heater in the center of a zone. If a zone is not connected at both ends, it will not heat. As the name implies, this heater provides the same output regardless of the process temperature. This heater can maintain tube temperatures in excess of 385°F (196°C), and can withstand short term upsets greater then 400°F (204°). The maximum allowable heater surface temperature is 446°F (230°C).
A temperature controller or thermostat should always be used with this type heater to prevent overheating due to process upsets or ambient changes. These controllers will also allow the user to control the temperature within a narrow range over a wide span of ambient conditions. Since this heater uses a resistance wire to provide heat, there is no appreciable surge or inrush current on startup.

Self-Regulating Heating Element

This heater, called SR (or SL) heater, has parallel bus conductors similar to the CPD heater outlined above but of a smaller diameter. These wires are coated with a special semiconductive polymer that creates the heater. This polymer has a positive temperature coefficient of resistance, which means that the resistance of the heater increases in proportion to the temperature of the heater. The end result is a heating element that reduces its output as the heater temperature increases. This allows the engineer to design a product that maintains a minimum tube temperature at low ambient temperatures, but limits overheating at high ambient

temperatures. This heater does not have zones like the CPD heater described above, so it can be cut to very short lengths.
Two styles of SR heater are presently used, Low Temperature SR (LTSR) and High Temperature SR (HTSR) heater.

LTSR is generally used for freeze protection applications or those applications requiring tube maintenance temperatures below 70°F. It's output is close to zero at heater surface temperatures above 100°F. LTSR can handle tube upset temperatures up to 185°F. This means that this heater can be used to provide shut-down freeze protection to tubes that operate at temperatures up to 185°F. If the tube operates at a higher temperature, or is cleaned with steam, HTSR must be used.
HTSR is used where higher maintenance temperatures are required or where the tube is cleaned with steam. This heater can maintain tube temperatures in the 150°F range for most bundles, and up to 200°F for certain single tube bundles. Since the heater is self-regulating, a bundle designed around it requires more insulation to maintain the higher tube temperatures than a similar bundle designed around a CPD heater.
HTSR can withstand steam cleaning of the tube at steam pressures up to 150 PSIG, or 366°F. Temperatures greater than this will damage the heater.
HTSR is generally more expensive than the other heaters due to the materials used in its construction. One characteristic of SR heaters that is of importance in the design stage is called inrush current. These heaters are what is known as "active resistors". They have a very low resistance when unpowered. When voltage is applied to the heater, the resistance rises rapidly as heat is generated, becoming fairly stable in about two minutes. During this period of time the current can be many times higher than the stable current. This is the inrush current.
A series of tests have been developed by the heater industry to determine the size of the circuit breakers required to handle SR heaters in response to the need to handle the inrush current. You will notice that the heater manufacturers call out maximum heater circuit lengths in terms of the circuit breaker sizes. The downside to this is that most electric codes require the branch circuit and associated equipment to be sized to handle the maximum load on any component. In the case of SR heater, the branch circuit wiring, ducts, transformers and service may have to be sized to handle 40 or 50 Amps instead of 20 Amps; because a larger circuit breaker is required to handle the inrush current.

Series Resistance Heating Wire

A series resistance heating wire heater is comprised of an alloy wire with a dielectric insulation and outer braid. The wire is generally a nickel-chrome alloy. The alloy type and conductor diameter determines the linear resistance of the heater at a specified voltage. Some alloys have a slight positive temperature coefficient of resistance and exhibit minor self-limiting properties. Other alloy, notably "Balco" wire, have larger coefficients and are used for high temperature (>300°F) self-limiting applications.

The series resistance heating wire is an extremely rugged heater and can withstand thermal shock and movement better than either of the heaters outlined above. It also has little inrush current similar to the CPD heater, so branch circuit wiring can be designed for the heater output.
This heater does have its down sides, though. The greatest detractor is the need to size the heater to the length of the application. Since it is a constant resistance, any change of length with a constant voltage will cause a change in power output. For example, a bundle with a length of 250 feet is designed for 24 watts per linear foot at 240 VAC. This will result in a total power of 6000 watts, or 25 amps current draw. If the bundle is shortened to 175 feet, the total power increases to 8571 watts (49 watts per linear foot) and 35.7 amps current draw. The current draw will require heavier branch circuits, and the high linear power of the heater may damage the process fluid.
Furon Unitherm has 40 combinations of heater alloy and size to allow for varying product lengths. Controllers and other accessories are also available to limit current draw and temperature.
A second problem with series resistance heating cables is the inability to use them in hazardous locations. Heaters for use in a flammable or explosive area must meet minimum mechanical protection standards. At this time, series resistance heating wires will not meet these standards.

Mineral Insulated Heating Cables

MI heating cables are high temperature, ruggedized resistance wire heaters. They are composed of a resistance wire element, magnesium oxide dielectric and a continuous metallic outer sheath. Heaters can be designed for power outputs exceeding 50 watts per linear foots, and for operating temperatures exceeding 1000°F.
Like other series resistance heaters, they must be designed for specific applications. These heaters should not be cut or terminated in the field unless the installer is specially trained by the heater manufacturer. Care must be taken to prevent any moisture from entering the dielectric as certain heater failure will result.
MI heating cables can be designed for use in hazardous locations.

Summary

The following list shows some relative advantages and disadvantages between the five heaters listed above. If in doubt concerning the use of a specific heater in your application, contact your Furon/Unitherm representative.

Property	**Heater Type**				
	LTSR	HTSR	CPD	Res Wire	MI Cable
Max Exposure Temperature	185°F	366°F	430°F	450°F	1000°F
Max Steam Blow Down Pressure	N/A	150 PSIG	335 PSIG	400 PSIG	any
Parallel Zone Length	Cont.	Cont.	2 Ft	N/A	N/A
Max Output @ 50°F	10 W/Ft	15 W/Ft	18 W/Ft	50 W/Ft	85 W/Ft***
Max Output @ 200°F	<1 W/Ft	7 W/Ft	18 W/Ft	50 W/Ft	80 W/Ft
Max Circuit Length @ 120 VAC*	180 Ft	135 Ft	260 Ft	75 Ft	45 Ft
Max Circuit Length @ 208 VAC*	360 Ft	200 Ft	450 Ft	125 Ft	78 Ft
Circuit Rating @ Max Circuit Length	30 Amps	30 Amps	25 Amps	30 Amps	30 Amps
Flexibility	Excellent	Good	Good	Excellent	Poor
Maximum Tube Maintenance Temp 3 tube 3/8" PFA bundle (no temp control)					
@-20F with Standard Insulation	103°F	155°F	229°F	400+°F	400+°F
@-20F with Double Insulation	116°F	192°F	317°F	400+°F	400+°F
@100F with Standard Insulation	132°F	195°F	284°F	400+°F	400+°F
@100F with Double Insulation	134°F	224°F	363°F	400+°F	400+°F
Chemical Resistance	Good	Excellent	Excellent	Excellent	Good
Low Temperature Handling	Good	Very Good	Very Good	Excellent	Good
Inrush Current Factor**	2:1	1.7:1	1:1	1:1	1:1

* Maximum Circuit Length is determined from published literature for SR heater startup at 50°F, for CPD, Resistance Wire and MI heaters it is based on maximum current at the stated maximum output. Other factors may lengthen or shorten the circuit length for a specific application.

**Inrush Current Factor is the ratio of the circuit breaker sizing at the maximum circuit length to the current at nominal output. This factor gives an indication of the amount of upsizing required in the branch circuit and equipment to handle heater inrush current.

*** Maximum power output for MI cables varies with the type of heater and the pipe temperature. Refer to published data for further information.

Shading in temperature maintenance columns indicates bundle must have temperature control to prevent overheating and damage to tubing and heater.