

THIRD GENERATION HEAT TRACERS IMPROVE SAFETY

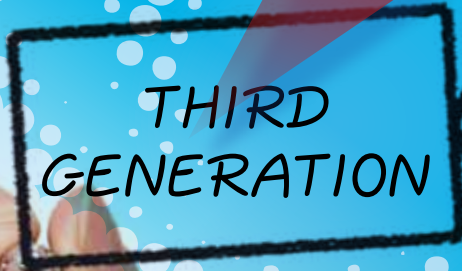
Electric heat tracing first became popular around the 1930s, with the advent of the first generation of heat tracing cables, the metal sheathed, mineral insulated type, or, as they are popularly known, M.I. heating cables; they reigned supreme for three or four decades. Then, although they possessed a number of outstanding attributes, the popularity of M.I. cables diminished with the development and introduction of second generation, more user friendly cut to length heating cables after the 1970s.

All M.I. heating circuits, being of the series resistance type, had to be individually designed in order to arrive at a required heating load for a given length. A further significant drawback is the degree of expertise, time and cost required to terminate circuits (Figure 1).

NEIL MALONE, HEAT TRACE LIMITED, UK, EXPLAINS HOW THIRD GENERATION HEAT TRACERS CAN IMPROVE SAFETY.

Hence, the emergence of polymeric parallel resistance heaters with a constant watts/metre output, enabling them to be simply cut to length then easily and quickly terminated, saw this type quickly gain ground at the expense of M.I. cables (Figure 2a). Freedom from the design and installation constraints of M.I. cables also led to a growth in electric heat tracing, which gained in popularity against steam tracing.

Electric heat tracing further evolved with the advent of parallel, semi conductive, self regulating heating cables, which first appeared at the start of the 1980s (Figure 2b). As



with the constant power, parallel heating cables, they could be cut to length and were easily terminated; but crucially, such devices are often inherently temperature safe and do not require the design consideration of temperature safety. As a result, they are ideal for hazardous area use. This feature has resulted in self regulating heaters becoming the most popular generic heating cable type.

During the past 30 or 40 years, old style M.I. heating cables have become largely redundant, appearing just occasionally where a specific characteristic unique to M.I. cables is desirable for a particular heating application.

It is worth noting those unique M.I. attributes that are not available with the more popular polymeric parallel resistance self regulating or constant power heating cables:

- ▶ High temperature capability, beyond the limits of polymeric materials.
- ▶ Mechanical strength, again beyond the limits of polymers.
- ▶ Potential for multi kilometre heating circuits.
- ▶ Resistance to the effects of radiation.

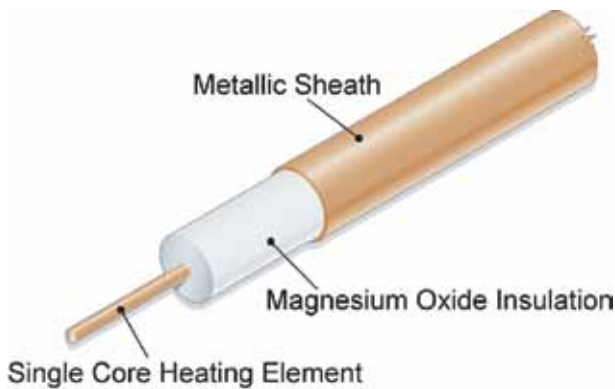


Figure 1. Typical MI cable.

Individually, such characteristics may be required only occasionally. Collectively however, one or more of these features may be desirable in, for example, 15% of all heat tracing duties.

In view of this, it is perhaps unsurprising that the heat tracing industry has developed new third generation heat tracers, which combine the virtues of both first generation M.I. cables with second generation parallel self regulating and constant power heat tracers. Suddenly, the heat tracing market has the availability of:

- ▶ A high temperature (425 °C) metal sheathed, mineral insulated, parallel resistance, cut to length constant power heating cable (Figure 2c).
- ▶ A high temperature (300 °C) metal sheathed, mineral insulated, parallel resistance, cut to length self regulating heating cable (Figure 2d).
- ▶ Metal sheathed, mineral insulated, series resistance high temperature heating cable for the heating of very long pipelines (Figure 2e).
- ▶ A metal sheathed, mineral insulated, parallel resistance, three phase cut to length self regulating heating cable for long circuit lengths (Figure 2f).
- ▶ Metal jacketing for a full range of polymeric heating cables, where additional mechanical strength is needed, or where heaters are required to be formed to a particular shape.
- ▶ Metal jacketing to provide resistance to the effects of radiation.

It is worth reviewing some of these new third generation products and the heating applications to which they are most appropriately suited.

Third generation heating cables

M.I. heating cables are necessary whenever process temperatures can exceed the limits of thermoplastics, for duties where cable must be resistant to radiation and for applications requiring heaters of high mechanical strength. These may typically be in exposed areas or where polymeric insulation could be attractive to rodents, or other forms of animal life.

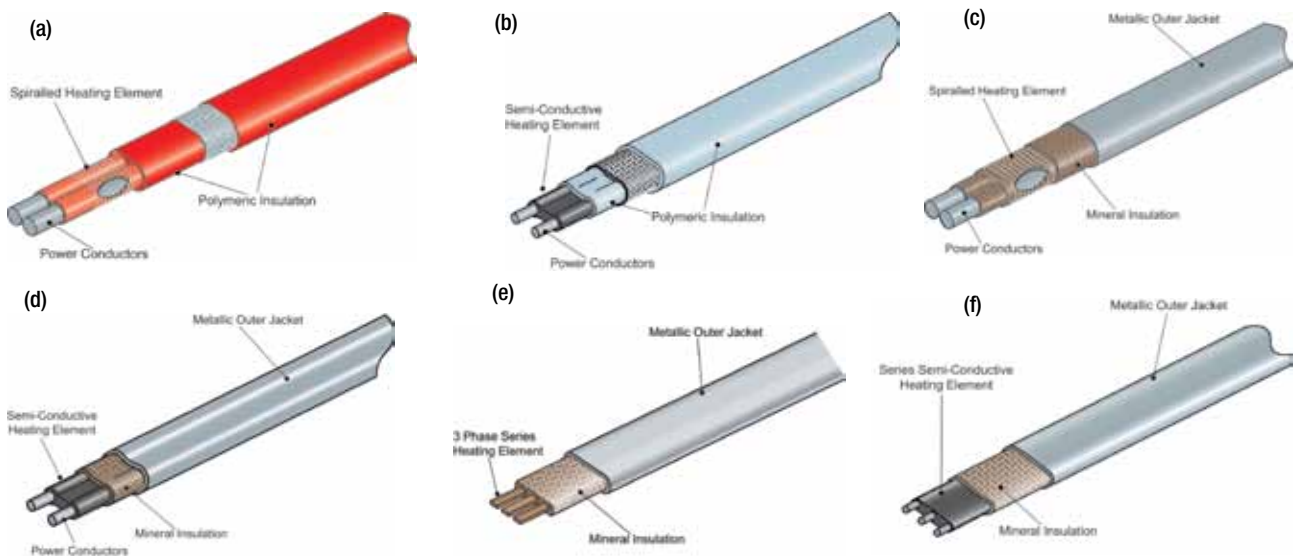


Figure 2. (a) Parallel constant power heater; (b) parallel self regulating heater; (c) high temp cut to length mineral insulated heater; (d) high temp cut to length self regulating heater; (e) high temp, mineral insulated, longline series heater with metal jacket; (f) high temp, mineral insulated, longline series self regulating heater with metal jacket.



Figure 3. Typical subsea pipeline layout.

Assessments of applications where new third generation heating cables are the most appropriate selection are detailed below.

High temperature installations

When heaters can be exposed to high process temperatures, M.I. heating cables are often necessary.

It has been explained that the original series type were often a necessary evil, being temperature resistant, but requiring individual circuit designs and being difficult to terminate. Additionally, their round section resulted in point contact only with the heated surface, poor heat transfer and undesirably high operating sheath temperatures. This restricted the power that could be delivered and caused control difficulties and expense when used in hazardous environments.

The problem of individual circuit designs was further exacerbated when heating short pipe lengths, because available cable resistances were insufficiently high for the low power requirements and short cable lengths. To overcome this, transformers were required for every length of pipe, making an installation prohibitively expensive.

Such an application is the heat tracing of instrument impulse lines. There are many such short lengths of instrument tubing in refineries, chemical plants, power stations, and the like. Here, the instrument line is usually field run, often from a pipe bridge down to a conveniently positioned instrument. Line lengths may typically be from 5 to 25 m. There may be many hundreds or even thousands in a plant.

Using series type M.I. heating cables, every single heating circuit must be individually designed, most requiring their own transformer to achieve the low power requirement.

A solution has been found for this difficult application. Heat Trace Limited has developed and patented a parallel resistance M.I. heating cable with a constant power output per unit length (Figure 2c). This can be cut to length at site to suit the tube length and terminated easily. Such devices can withstand 425 °C, well beyond the limits of polymers (usually around 280 °C) and usually within the requirements of the application. The cable's flat section maximises heat transfer, lowers operating sheath temperature and optimises power capability.

As with most constant output heat tracing systems, temperature controls will generally be needed to ensure T classes are not exceeded.

Of course, self regulating heaters are usually preferred, where possible, as such devices are often inherently temperature safe. Until now, the highest rating from the major

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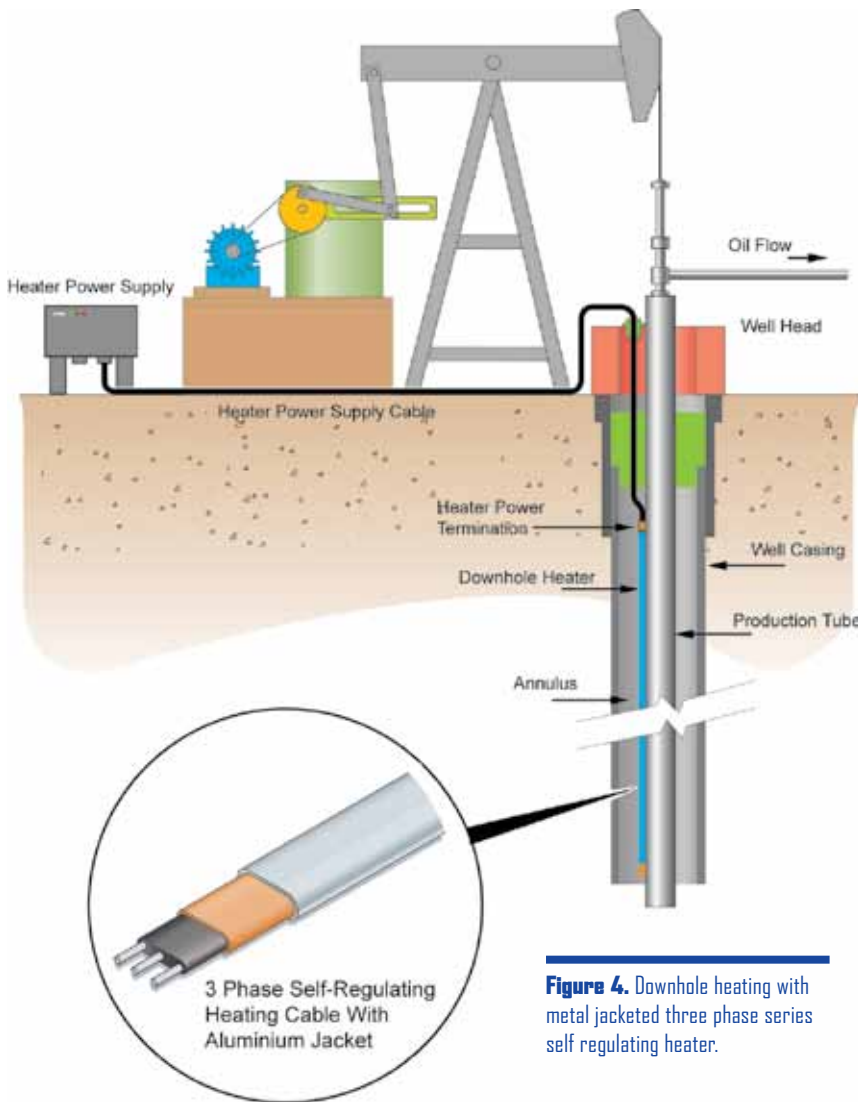


Figure 4. Downhole heating with metal jacketed three phase series self regulating heater.

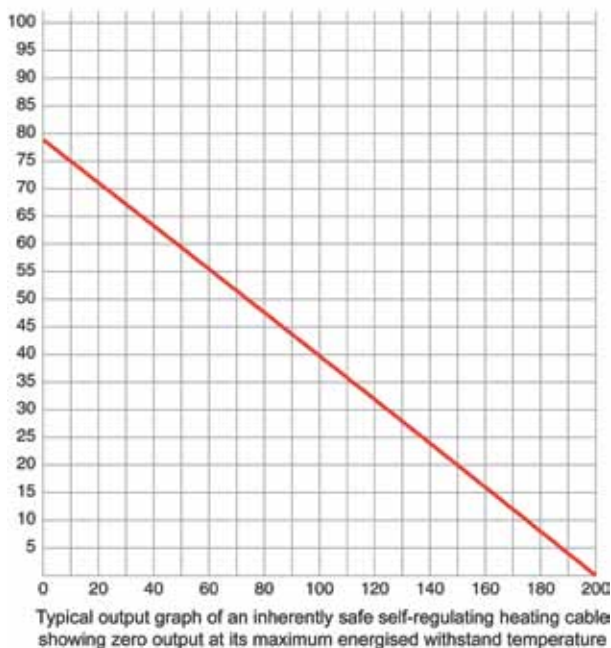


Figure 5. Output graph of inherently temperature safe self regulating heater.

manufacturers has been around 150 °C when energised and 200 °C when switched off. But now, a new metal sheathed, cut to length, mineral insulated, self regulating heater has been introduced with a temperature capability of 300 °C whether energised or not, thus exceeding the limits of known polymers (Figure 2d). Whilst this temperature limit will not satisfy every process limit, it will meet more than 90%.

Heaters can be installed onto fixed pipes or within tubing bundles that are now popular for this type of application.

Now, almost all short and medium length heat tracing duties can be satisfied by user friendly cut to length heating cables of either the self regulating or constant power types.

Long pipeline heating

Until the 1990s, series resistance M.I. heating cables were most commonly used for the heating of long oil pipelines from a single electrical supply point. The limitation of low resistance conductors and voltage withstand (usually 600 V) resulted in maximum heating circuits of approximately 1 – 2 km.

Over the past two decades or so, skin effect heating systems have become popular, as they are able to provide much longer heating circuits of 10 km or more.

The skin effect circuit usually comprises a carbon steel heat tube into which an insulated conductor is pulled and connected at the remote end. The tube and the conductor connect to a

transformer at the start of the circuit. The conductor and heat tube size, the circuit length, and the applied voltage (typically up to 3 kV) determine the power output.

Skin effect systems are reliable, but involve a high installation cost, as the heat tube is often welded to the pipe, typically every 5 cm. With a power factor of about 0.85, efficiency could most certainly be improved upon.

In view of this, M.I. heating cables have been reincarnated without the constraints indicated in the opening paragraph. Now, low resistance conductors, insulated to operate at similar voltages as skin effect systems, are able to satisfy pipeline heating circuits of, for example, 10 km from a single power supply point. They operate at a lower cost than an equivalent skin effect system and with a unity power factor, i.e. energy costs may be 15% less.

Heat Trace Limited is currently undertaking a number of such projects, including a multi kilometre subsea project, the world's first of its type (Figure 3).

Installations requiring high mechanical strength

Numerous heat tracing applications demand additional mechanical protection to prevent damage to the heat tracer, either during installation or in operation.

One such heating duty is that known as 'downhole heating.' Oil exits the reservoir into the production tube at high temperature, cooling as it rises to the surface. The upper sections of the tube may be heated to prevent the oil temperature falling below its pour point, where waxing can occur on the walls of the production tube.

The heater is installed to the outside of the tube as it is assembled and lowered into place. The space in the annulus between the outer tube wall and the well casing into which the heater is located is small and the potential for damage to the heater during assembly is high.

A number of different forms of heating have been tried in the past, including skin effect and self regulating. The principle of self regulating is attractive because progressively more heat is produced as the oil cools and the temperature falls. A challenge has been to supply a parallel resistance self regulating heater with a sufficiently long circuit length (typically the uppermost 700 m of the production tube is heated) and in a construction that can withstand the likely mechanical abuse during the lowering of the tube.

A recent innovation from Heat Trace Limited is a novel three phase self regulating heating cable; this increases the potential circuit length to three times the limit of a single phase heater. This is further increased by connection to an operating voltage of 600 V three phase (though designs for even higher voltages are available). The achievement of a balanced three phase load is the novelty of this patent applied for product (Figure 4). The necessary mechanical protection to prevent damage to the heater during installation is provided by the patented Heat Trace Limited extruded metal jacket.

Just a few of the applications that can be addressed by new third generation heat tracing technology products developed, patented, and introduced by Heat Trace Limited have been outlined here. These new products have been made possible by the company's £ 1 million investment in a continuous metal extrusion facility in a second UK manufacturing site.

Inherent temperature safety

It was mentioned earlier that semi conductive, self regulating trace cables have become the most popular generic type as they are often inherently temperature safe.

This additional safety is apparent when the heater has effectively zero power output at the cables' limiting temperature, i.e. it is incapable of overheating itself (Figure 5).

This means that temperature controls are not needed to ensure temperature safety of the cable. Any controls are therefore provided purely in the interests of energy efficiency. This is a particularly desirable feature in hazardous areas, often ensuring that temperature classes are not compromised.

Unfortunately, until recently, self regulating heaters were only available for freeze protection and low/medium temperature process heating duties and even then, some manufacturers' products are not inherently temperature safe, still relying on thermostats to ensure that limiting temperatures are not exceeded.

Now, however, Heat Trace Limited has developed a third generation, complete range of inherently temperature safe, self regulating heaters, extending the existing low temperature range to a high temperature range as follows:

- ▶ Type FSS: maximum temperature 200 °C either energised or switched off.
- ▶ Type FSU: maximum temperature 250 °C either energised or switched off.
- ▶ Type AFS: maximum temperature 300 °C either energised or switched off.

Almost any heat tracing application can be satisfied by inherently temperature safe, self regulating heaters. The improvement in safety will be appreciated.

- ▶ No need to rely on temperature controls for safety purposes.
- ▶ Ambient sensing controllers can optimise energy efficiency.
- ▶ The number of heating circuits can be minimised.
- ▶ Heating circuits can traverse flow and no flow sections of pipework.
- ▶ Overall system costs are less.

In the very rare cases where process temperatures exceed 300 °C, user friendly, cut to length, parallel constant power heating cables are still available for temperatures up to 425 °C. Only above this temperature is it necessary to resort to the first generation M.I. heaters, remembering however, that being non-inherently temperature safe, temperature controls must be employed to ensure temperature safety, the circuits must be especially designed, and that termination and installation skills and costs will be substantial.

However, for the specifier of heat tracing systems, where system safety is a prime consideration, third generation, inherently temperature safe tracers now fulfil almost every heat tracing duty. 