SULPHUR
SULPHUR 98 CONFERENCE ISSUE
SEPTEMBER • OCTOBER 1998

Sulphur

The Magazine for the World Sulphur and Sulphuric Acid Industries

September-October 1998
Number 258

"Solving problems with bolt-on jackets"

SPECIAL CONFERENCE ISSUE

Solving problems with bolt-on jackets

Bolt-on systems have evolved over the past 25 years and are used throughout the molten sulphur processing and sulphur transport industry. **H. Gaines** of Controls Southeast, Inc. and **P. C. Wielatz** of PME Enterprises, Inc. compare bolt-on systems with the traditional fabricated weld-on systems and discuss what to look for in the design, fabrication and installation of a bolt-on system.

Thermal maintenance of molten sulphur is a difficult problem frequently faced by engineers in the sulphur industry. In a refinery, maintaining a temperature window of 280-310°F (138-154°C) is critical (*Fig. 1*). Below 280°F, hydrogen sulphide can be emitted if vapour space exists, creating a potentially hazardous situation. Above 320°F (160°C) the viscosity of molten sulphur rises exponentially. Temperature maintenance problems can shut down an entire unit or bring a marine terminal's discharge operations to a standstill. When cross-contamination occurs, the results are usually even more devastating.

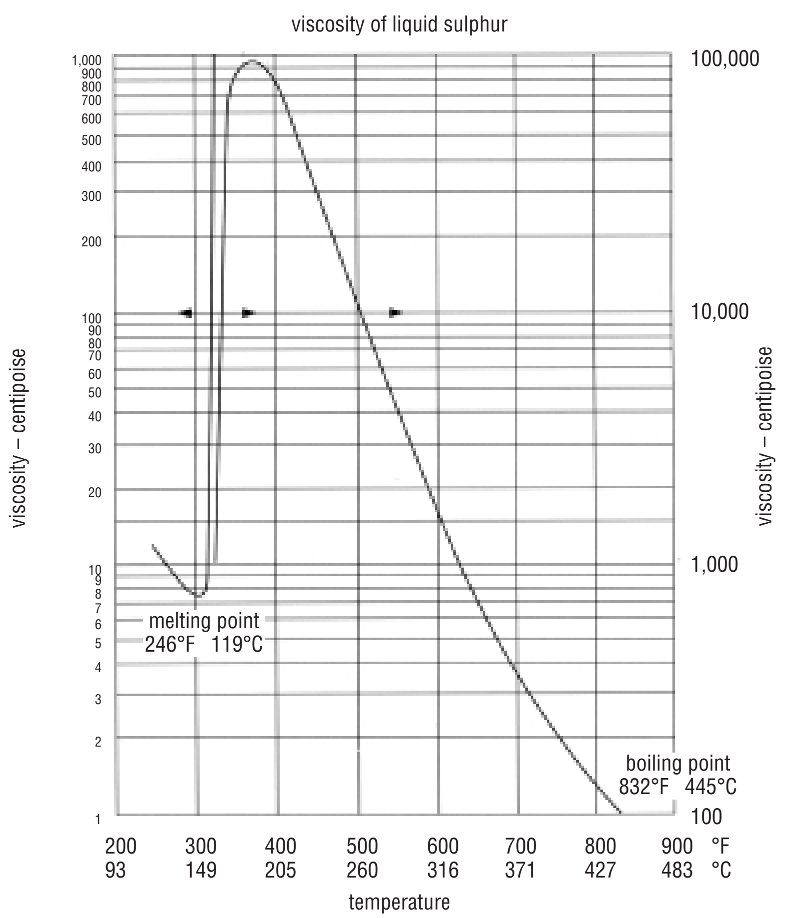
These problems are all too well known, as are the traditional solutions. The sulphur processing and transport industry has tried several methods of maintaining process temperatures over the years. Gut lines have been installed in transfer and transport piping with some success. However, the risk of cross-contamination associated with gut tracing has led to alternative means of thermal maintenance being sought. Tube tracing schemes of many varieties have been installed on molten sulphur core piping, pumps, valves and other components, but with very limited success. A track record of freeze-ups has indicated that tube tracing provides inadequate thermal maintenance for sulphur handling. "Blistered pipe" has been generally effective but is quite expensive because it is difficult to manufacture and install.

Fully fabricated, weld-on jacketed systems have done a good job of maintaining molten sulphur temperatures and are the traditional thermal maintenance system of choice.

Today, fabricated weld-on jackets have many loyal adherents who are quick to advocate that approach to the exclusion of all others.

However, there is another approach to maintaining molten sulphur temperatures that has proven success-

Fig. 1: **Viscosity of liquid sulphur**



ful in practice. That approach is the installation of bolt-on thermal maintenance technology for both pipe and individual process components – valves, pumps and instruments.

Bolt-ons

Bolt-on jackets, in practical terms, match fully fabricated weld-on jackets at maintaining sulphur between 280°F and 310°F. They can also provide up to 25% savings in initial investment costs versus a fully fabricated system, reduce inventory carrying costs and eliminate the risk of cross-contamination.

Thermally, there is little a fabricated system can do in sulphur handling that a bolt-on system cannot. The real question should be: Which is more cost-effective for a particular application, and is the benefit of marginally faster heat recovery after shutdown enough to off-set the risk of cross-contamination?

This article takes a look at actual service experience in key areas of application within sulphur handling and recovery. It describes the principles of operation for both bolt-on and fabricated weld-on systems. It also discusses what to look for in the design, fabrication and installation of a bolt-on thermal maintenance system that can make the difference between a successful operation and a problematic one.

Note: The phrase "thermal maintenance" system rather than the usual "process heating" system has been used because it more accurately represents the system's true purpose – to maintain consistent process temperature. Jacketing systems should be evaluated on their ability to reliably maintain process temperature levels, not their heat-up or recovery capability. Even after a shutdown, it is CSI's experience that temperature recovery in the piping is rarely the bottleneck to resuming production.

Case studies

Refinery tail gas service

Bolt-on jackets have been used for over 25 years in tail gas service on various components with remarkable success. For example, earlier this year bolt-on technology solved a tail gas thermal maintenance problem for a Far Eastern petroleum refinery. The refinery had a 20 inch (51 cm) butterfly valve in tail gas service with a heated stem and disk and a conventional weld-on jacket. Because a large portion of the adjacent flanges, including the perimeter were exposed, the valve froze regularly. However, since the exposed flanges were covered with ControHeat bolt-on component jackets six months ago the valve has been operating without any problems.

Fig. 2: Approximately four miles of Controls Southeast ControTrace® type bolt-on jacketing has been installed on this terminal's main sulphur transfer line.

Sulphur terminal main transfer line

At the sulphur terminal shown in *Figure 2*, the 3,500 ft (1067 m) main 18 inch (46 cm) transfer line is heated with six ControTrace bolt-on heating elements. That amounts to approximately four miles of bolt-on trace. Compared with a fully fabricated system, the processor saved about $100,000 in capital costs (savings of about 25%). The line has been operating trouble free for more than two years with no freeze-ups and no risk of cross-contamination.

Ship piping

The M/V Sulphur Enterprise, owned by Sulphur Carriers, Inc., a subsidiary of International Shipholding Corporation, was launched in 1994. She measures 524 ft long with a design loaded draft of 33 ft (10 m), carrying 24,000 tons of molten sulphur (*Fig. 3 and 4*). The ship has 6,300 ft (1920 m) of ControTrace on more than 1,300 ft (396 m) of piping. Most of the pipe ranges in size from 8 inch (20 cm) to 14 inch (36 cm) with heating panels of four and six heating elements. Over 30 elbows and ten valves were jacketed with ControHeat bolt-on jackets.

Fig. 3: The M/V Sulphur Enterprise carries 24,000 tons of molten sulphur weekly from Texas and Louisiana to Florida.

Fig. 4: Bolt-on thermal maintenance systems have operated trouble-free on the Sulphur Enterprise *since the ship's launch in 1994.*

Thermal maintenance was specified at 278°F (137°C) operating hot oil at a maximum operating temperature of 320°F (160°C) and a flow rate of 87 gallons/min. Specified insulation was 2 inch (5 cm) Cal-Sil. Ambient was specified to be 20°F (-7°C).

Molten sulphur is loaded at Galveston, Texas or Port Sulfur, Louisiana and transported to Tampa, Florida where it is offloaded at a rate of 2,300 t/h.

When the Sulphur Enterprise was designed, a fully jacketed thermal maintenance system was specified. However, such a system would have cost 25% more than a comparable ControTrace bolt-on system. Achieving equivalent thermal performance at a lower cost was the essential reason for selecting bolt-on technology over a fully fabricated system. Another key consideration was the elimination of cross-contamination, a problem that plagued the Enterprise's predecessor.

The officers of the Sulphur Enterprise couldn't be happier with the decision to install a bolt-on system. After four rigorous years at sea, the insulation surrounding the ControTrace and ControHeat remains untouched. There have been no problems with the lines or components that are maintained thermally by the bolt-on technology.

The conventional fully fabricated jacketing system

In the traditional thermal maintenance approach, a fabricated jacket surrounds the core pipe or component with an outer wall. The heating medium flows through the annulus and directly heats the core pipe or component and the process stream within. There are many variations of the "types" of fully fabricated jacketed pipe and jacketed components available. Traditionally, much of the sulphur industry has opted for "standard" jacketed pipe and components which utilize oversize flanges to enable heat to come in intimate contact with the flange thereby optimizing uniform temperature distribution (*Fig. 5*). For valves, this generally requires machining off the original flanges, extending the face-to-face, welding the oversize flanges to the valve, and then attaching the jacket.

Bolt-on systems for valves, pumps, flow meters

Bolt-on component jackets are made to fit closely around valves, pumps and components. These patented heating jackets are aluminum, cast-to-fit pieces that match the contours of the component to be heated. Embedded in the casting is a fabricated, pressure-containing chamber through which flows the heating medium, in the case of sulphur, water/glycol, steam or hot oil. Heat passes from the medium through the pressure chamber. The aluminum casting conducts the heat from the pressure chamber to surround the core components (*Figs 6 and 7*). In this way, the jacket acts as a heat shield under normal operating conditions (*Fig. 8*). In the event of a process upset or other shutdown condition, there is enough surface area coverage to efficiently melt out the process and return to normal operating conditions.

Independent pressure boundaries isolate the process stream from the heating medium to eliminate the possibility of cross-contamination. This type of bolt-on jacket fits standard valves, instruments and pumps like a glove with no modification to the original equipment necessary. Electrically heated bolt-on jackets are also available.

ControHeat jackets have been used successfully in more than 50,000 applications worldwide in many process services. With over 4000 patterns for valves, pumps and meters in inventory, most standard process equipment can be readily jacketed.

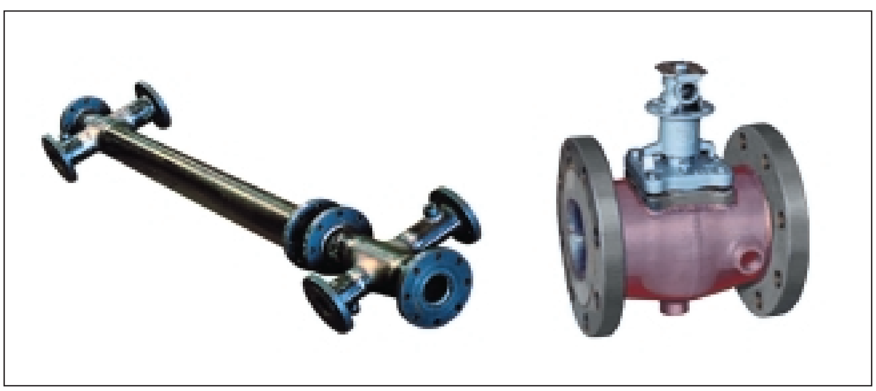


Fig. 5: Spools of jacketed sulphur piping. Note the multiple crosses for rodding out the lines.

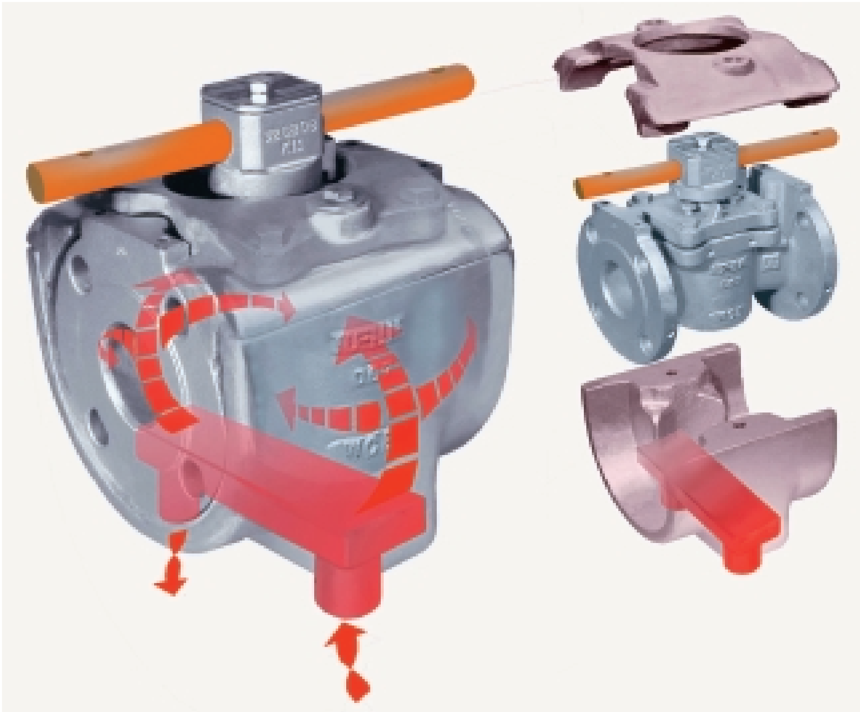


Fig. 6: These patented heating jackets are aluminum, cast-to-fit pieces that match the contours of the components to be heated.

Bolt-on systems for pipe

Bolt-on jackets for pipe are sophisticated design refinements of the trace concept. The heating element is made from carbon steel and contoured to exactly mate with the outside diameter of the process pipe. The highest quality is made from SA178 Grade A boiler tubing and pressure tested according to ASME Code. Heating elements and/or panels are strapped lengthwise onto the piping and exhibit excellent heat transfer.

Advantages of bolt-on jackets

There are two prime reasons for the emergence of the bolt-on alternative in the transport and transfer of molten sulphur: lower life cycle ownership costs and elimination of cross-contamination risks – both with equal thermal performance.

Equivalent thermal maintenance performance

The temperature window for effectively handling molten sulphur is a narrow one. Serious consequences result if sulphur temperatures drop below or exceed the operating window. Nevertheless, the fact is that a well designed and properly installed bolt-on system will operate as effectively as a fully fabricated system at maintaining process temperatures between 280 and 310°F.

Advocates for weld-on jackets sometimes argue that fabricated jackets transfer heat more efficiently than bolt-on jackets with their double barrier between the heating medium and the process. That is true. Fabricated weld-on jackets have a higher heat transfer coefficient. They further assert that the difference in heat transfer is important for start-ups and recovery. However, according to Controls Southeast's experience this is not often the case. The bottleneck to resuming production rarely lies in the pipe or individual piping components. Also, with respect to process components like valves, pumps and instruments, it has been observed that the higher rate of heat transfer is often being compromised by the amount of exposed or unheated areas. (Effective thermal maintenance is a function of the heat transfer coefficient, the surface area and temperature difference.) For example, if the flanges of the component or the mating flanges are left unheated or not adequately heated, they can act as a heat sink, or fin, counteracting the higher "rate of heat transfer". Or, if the packing area is left exposed, it can render the equipment inoperable. Bolt-on jackets for process components enable surface coverage of virtually all of the exposed areas making the higher rate of heat transfer unimportant.

In the case of bolt-on technology for pipe, because the heating elements are contoured to closely fit the outside diameter of the pipe, adequate surface area contact can be achieved to maintain specified operating temperatures. Proprietary software modeling capabilities are available which specify the number of heating elements (surface

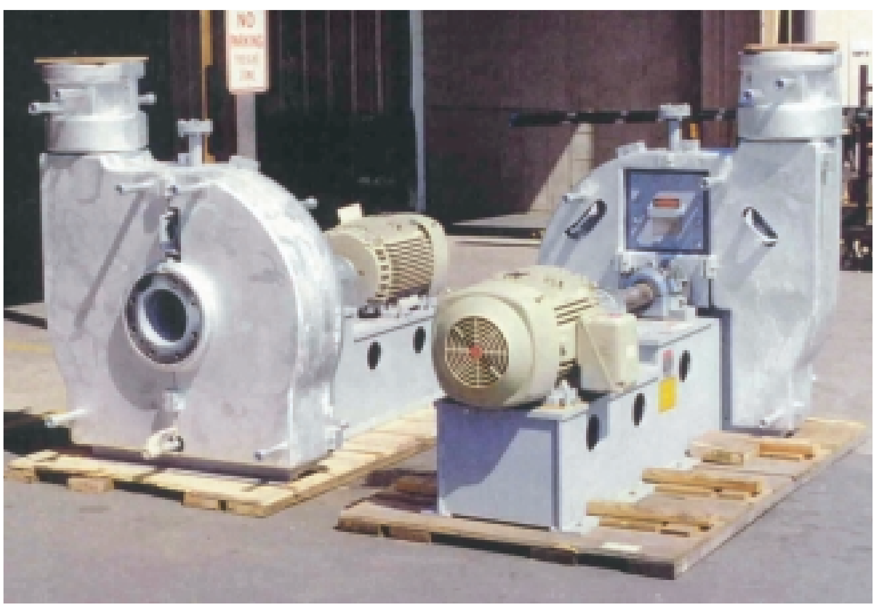


Fig. 7: Here Controls Southeast's ControHeat® type component jackets heat centrifugal blowers used in sulphur recovery at sulphur terminal.

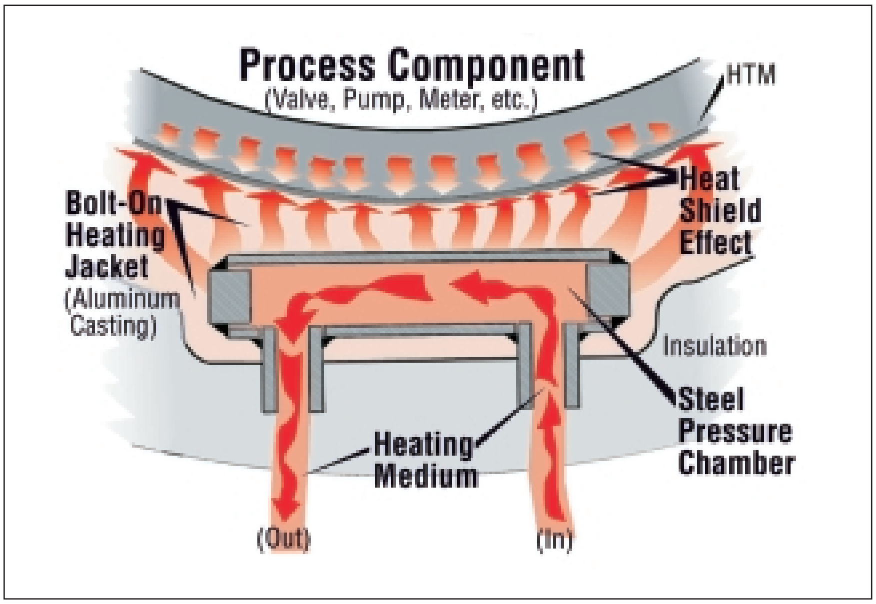


Fig. 8: The primary function of the bolt-on jacket is to act as a heat shield, compensating for process heat loss during normal operation.

area coverage) required to achieve temperature within a particular window and, if recovery time is a limiting factor, predict heat-up response.

To illustrate the effectiveness of ControTrace in achieving melt-out, *Figure 9* provides the results of a static heat test performed on a 4 inch schedule 40 carbon steel sulphur line heated with 2 ControTrace elements. It is important to note that using 297°F (147°C) steam, the exposed area of the pipe wall reached melt-out temperature within 20-30 minutes.

The equilibrium process temperature of 280°F was reached in 2 hours and 40 minutes. The limiting factor to achieving faster melt-out is the thermal conductivity of the process itself.

Elimination of cross-contamination risks

Mix a little sulphur with a little heating medium and there can be big problems. Sulphur and steam create sulphurous or sulphuric acid. Sulphur and hot oil result in quite a lot of mess.

Every maintenance engineer who has first hand experience with cross-contamination will do virtually anything to avoid it from happening again. Finding the problems may be more frustrating than cleaning it up and fixing it. Poor fabrication often leads to problems.

Losses can amount quickly – when offloading a sulphur ship or barge, losses can easily reach $20,000 per day. If the problem is a run down line in a refinery, they will be even higher. If sulphur is being transferred to a sulphuric acid plant, the decision whether to investigate bolt-on technology could be based on losing 1,000 tons of production per day at say $40/ton, i.e. a daily cost of $40,000.

With bolt-on technology there is no risk of cross-contamination.

Reduce life cycle ownership costs

Bolt on jackets can also be an advantage by lowering the cost of ownership. If an application requires thermal maintenance of a large number of pumps, valves, elbows, and instrumentation, fabricated jacketing will significantly raise component replacement costs and inventory in order to continue production if a problem arises with a component.

Bolt-on jackets, on the other hand, are custom made to fit standard "off the shelf" components. Consequently, an inventory of customized parts is not required. Chances are your local distributor will stock the base component on which you place the bolt-on jacket.

Further, the initial investment savings of ControTrace for pipe versus standard jacketed pipe is between 10% and 25%. The difference can be even greater on large diameter runs.

Quality performance depends on the source

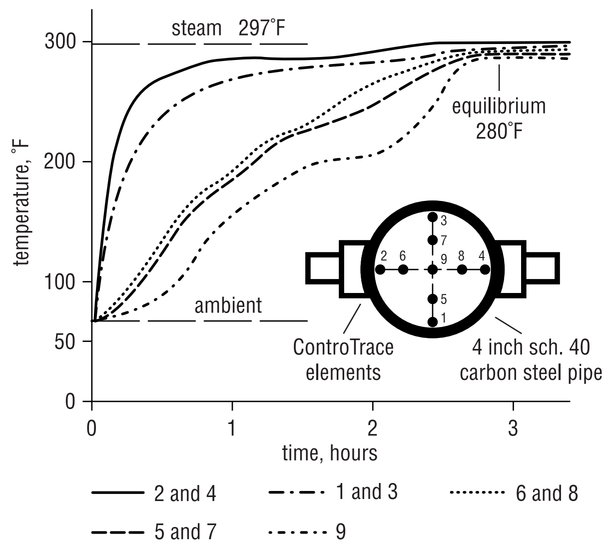
In the final analysis, bolt-on component jackets and trace jackets will only be as cost-efficient, reliable and effective as the designer and installer of the system. The following check list will help to identify the right vendor.

- What is the demonstrated expertise of the vendor? What is their installed base in bolt-on thermal maintenance systems for sulphur transport and handling? Only comprehensive experience will teach them the requirements and fine points they need to know to help you to address possible risks and special problems. Ask to see customer lists. Check references. Ask for details on bolt-on jobs that they have done which may be similar to yours. Ask about design advice and the heat transfer calculations used to determine whether adequate surface area is being covered. Ensure that the calculations are run for the worst case scenario (no flow or melt-out).
- Do they also manufacture fully fabricated systems? Experience with fully fabricated systems enhances the understanding and appreciation for the difference in capability and requirements of the bolt-on technology. In fact, sometimes a hybrid system may provide the best solution. For example, if a sulphur vent line requires the system to perform efficient heat exchange duty on the initial 50 ft off of the storage unit with the balance of the line operating as a true thermal maintenance system, the optimum solution is a fully fabricated system for the first 50 ft with ControTrace on the balance of the line.
- Does the vendor ask questions? Encourage them to ask questions because if you hire them, they are going to need the answers and sooner is always better than later. There are many process variables that help to define the thermal requirements of a particular application, for example insulation type and thickness, process temperature, heating medium tem-

perature, ambient design temperature and nominal pipe size.

- Does the vendor perform finite element modeling, design reviews, thermal profile analysis and transient analysis? Effective modeling will result in a temperature profile of the piping system at equilibrium and under no flow conditions. It will illustrate the heat lost to the atmosphere through the insulation and the net heat input to the process.
- Visit the facilities of the vendor you have in mind. It provides an excellent opportunity to determine the extent of their heat transfer and design sophistication. Take along drawings, schematics and flow plans. Will they review them upon receipt of the purchase order or do they simply build what they are asked? Do they make suggestions? Do they do the design work themselves, or do they subcontract?
- Finally, pay close attention to the production facilities and manufacturing operations. Are they an ASME Code shop? Is the fabrication and inspection process well documented? Do the craftsmen have long standing histories with the company? Is there daily interaction between production and engineering? Are rigorous safety policies and procedures adhered to?

Fig. 9: **Static heat test results**



Results of a static heat test performed on a 4 inch schedule 40 carbon steel sulphur line heated with two ControTrace type bolt-on elements. Note that using 297°F steam the exposed area of the pipe wall reached melt-out temperature within 20-30 minutes. Equilibrium process temperature was reached in 2 hours and 40 minutes.

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Reprinted from British Sulphur, Sept/Oct 1998.
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