Sulphur 2002
VIENNA • AUSTRIA
27–30 OCTOBER 2002

Using High Performance Heat Tracing Systems to Address Problem Areas in Sulfur Recovery Units

J. JONDLE

BP Texas City Business Unit.

H. P GAINES, JR

Controls Southeast, Inc.

10900 Brittmore Park Drive, Suite B, Houston, Texas 77041, USA

Sulfur recovery operations in refineries face many thermal maintenance challenges. Insufficient heat or piping failures in the transport of liquid sulfur or sulfur vapor compounds create safety hazards, environmental problems, and production chokes. This paper addresses these challenges in two specific areas of the sulfur plant: The vent line system from the storage pit to the eductor, and the liquid sulfur transfer and offload lines of the terminal. Pit venting—the expulsion of H2S gas from the liquid sulfur pit—occurs when air sweeps across the pit. Sweeping air entrains H2S, SOX and micro spheres of the molten sulfur mist. Pit vapors normally are sent to a thermal oxidizer or separator. The temperature in the pit is critical to the degassing of the molten sulfur. The temperature of the sweeping gas leaving the pit is critical in preventing the liquid sulfur mist in the gas stream from solidifying and plugging the flow of the air-H2S mixture flowing to the eductor. General practice in maintaining the vent lines at the optimum temperature has been to heat these lines either with tube tracing or enhanced tube tracing. Enhanced tube tracing is tube tracing encased in heat transfer mastic that creates a broad heat path between the two round surfaces of the tubing and the pipe wall. The contact area of the mastic is approximately two to three times the diameter of the tube tracer. Fully jacketed pipe is used infrequently on vent piping. For heating schemes on run-down and transfer piping for liquid sulfur, fully jacketed lines are usually preferred. However, both tube tracing and enhanced tube tracing are used frequently on various liquid-sulfur piping systems. A third method of temperature control, bolt-on thermal maintenance technology described in this presentation, has been used effectively on both vent piping and transfer piping. Operational and economic results of specific applications of this technology are topics of this discussion, including details on state-of-the-art analytical techniques that can be used to establish precisely a system's thermal requirements based on throughput and other process variables.

INTRODUCTION

Vent Lines. To keep H2S and SOX vapors from polluting the environment near sulfur run-down and storage pits, refiners and gas plants often use steam-powered eductors or large blowers to aspirate the headspaces in sulfur pits. In our instance, an eductor is located approximately 200 feet downstream from pit. The eductor sucks ambient air across the pit, entraining H2S, SOX, and sulfur mist, which it expels into the piping system feeding the oxidizer. The sweeping air from the pit to the eductor is conveyed through 6-inch piping (see Figure 1.).

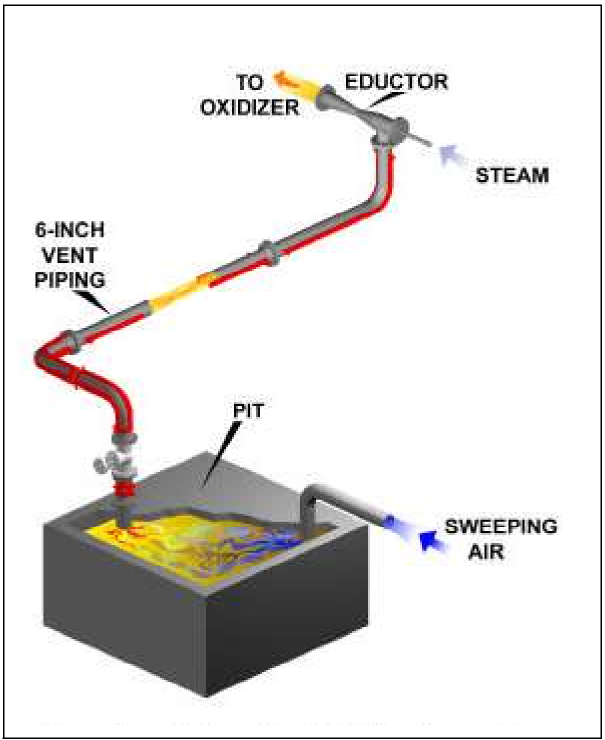

FIGURE 1 SULFUR PIT AND VENT PIPING LAYOUT

In steady-state operation, eductors are very cost effective. When process upsets occur, their effectiveness can decrease substantially. The challenge is to maintain uneventful processing while meeting environmental emission standards, all within constraints of targeted budgets. Too little heat in the vent piping system yields condensation and drop-out of sulfur. Plugging occurs. Emissions rise. Refinery production declines. Enhanced tube tracing, initially successful in the subject application, deteriorated in effectiveness over time and required maintenance expenditures well beyond a reasonable return on investment for a typical 1100 ton-per-day sulfur recovery plant.

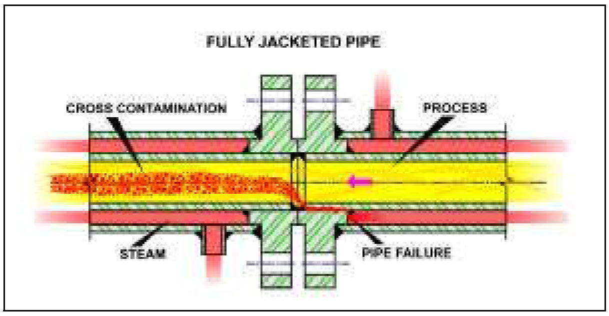

FIGURE 2 STEAM CONTAMINATION OF SULFUR PROCESS

Transfer and Offload Piping. In transfer and off-loading piping from the pit to the loading station, thermal stresses took a toll on our fully jacketed piping system. Cracks in the core piping allowed steam and condensate to breach the sulfur stream, creating a possible safety hazard. The fast-moving flow of liquid sulfur can pick up residual steam condensate (water). Even a small amount of condensate can again create a potential safety issue should it suddenly expand as it escapes from the loading nozzle inside the truck tank. Under these conditions liquid sulfur at 300 F could erupt from the loading opening in the truck creating a dangerous burn potential for personnel in the area. Finding a single core leak and remedying the problem often took several days. To determine which jacketed spool leaked, we sequentially turned off the steam to each spool during loading operations. When “sulfur-hammer” ceased, we knew we had identified the failed spool. Unfortunately, our trial-and-error method of turning off the steam allowed sulfur, in some instances, to contaminate and plug the condensate system.

ANALYSES

Vent Piping. The steam eductor used to aspirate the headspace of the sulfur pit pulls sweeping air across the pit. H2S, SOX, and S are entrained in the sweeping air and sucked into the vent piping. The air temperature entering the vent piping is critical. 260F is the preferred temperature. Minimal sulfur buildup occurs in vent piping when the temperature of the gas stream remains uniformly at 260For higher. Constrictions in the vent piping or sudden directional changes in flow patterns, as well as chill spots in the piping, are areas where sulfur mist tends to drop out and build up. Applying additional heat to the known critical areas, such as valves, instrument taps, and fittings can mitigate this build-up. On installed thermal maintenance systems, thermal imaging (heat guns) can be used to identify chill spots that develop when tube tracing systems pull away from the piping. The enhanced tube-tracing system formerly used on the vent piping frequently developed chill spots that became a constant source of concern. Sulfur build-up left unattended may become so severe that choke flow develops. Our analysis of the system showed that the solution to our problem was a thermal maintenance system that maintained a uniformly-high temperature profile of the gas stream from the pit to the eductor. Jacketed pipe, of course, provides this uniform temperature profile, but our negative experiences with jacketed pipe in the terminal loading facility gave us the incentive to investigate other options. Again, enhanced tube tracing was considered but waived on reviewing the long-term maintenance costs.

Eventually, we decided to use the bolt-on thermal maintenance technology of ControTrace heating elements. A major influence in our selection was the demonstrated accuracy of the thermal modeling techniques used in the design of these systems. Typical tube-trace sizing methods deal with only four criteria. These are: 1) ambient conditions, 2) insulation thickness, 3) pipe sizes, and 4) process temperatures. The number of tracers to be used is determined by the amount of bulk heat lost. How the heat transfers to all areas of the pipe is not considered. Therefore, simply adding more tracers to offset a calculated heat loss does not assure that all points on the pipe wall remain above the condensation temperature of the gas stream.

A thorough analysis looks at the conduction of heat in the pipe, determines how much of it conducts to and through the insulation, and how much of it enters the process through convection. To make this analysis, these variables must be known: 1) piping size, wall thickness and physical properties, 2) insulation thickness and physical properties, 3) ambient site design conditions including maximum wind velocities, and 4) process gas constituents, their properties and flow rates. Using these inputs, accurate heat transfer coefficients for convection can be developed. More significant, thermal profiles of the piping system for any combination of conditions at any location can be examined from printouts of the calculations (see Figure 3). Steam temperatures can be varied. The number of heating elements and their spacing can be varied. The effects of various insulation thicknesses can be inspected. Process flow conditions can be varied from an anticipated maximum to zero. Most importantly, this analysis tool allows the thermal system designer to select the optimum number of bolt-on ControTrace elements, and verify their position on the pipe to produce a wall temperature that inhibits condensation (see Figure 4).

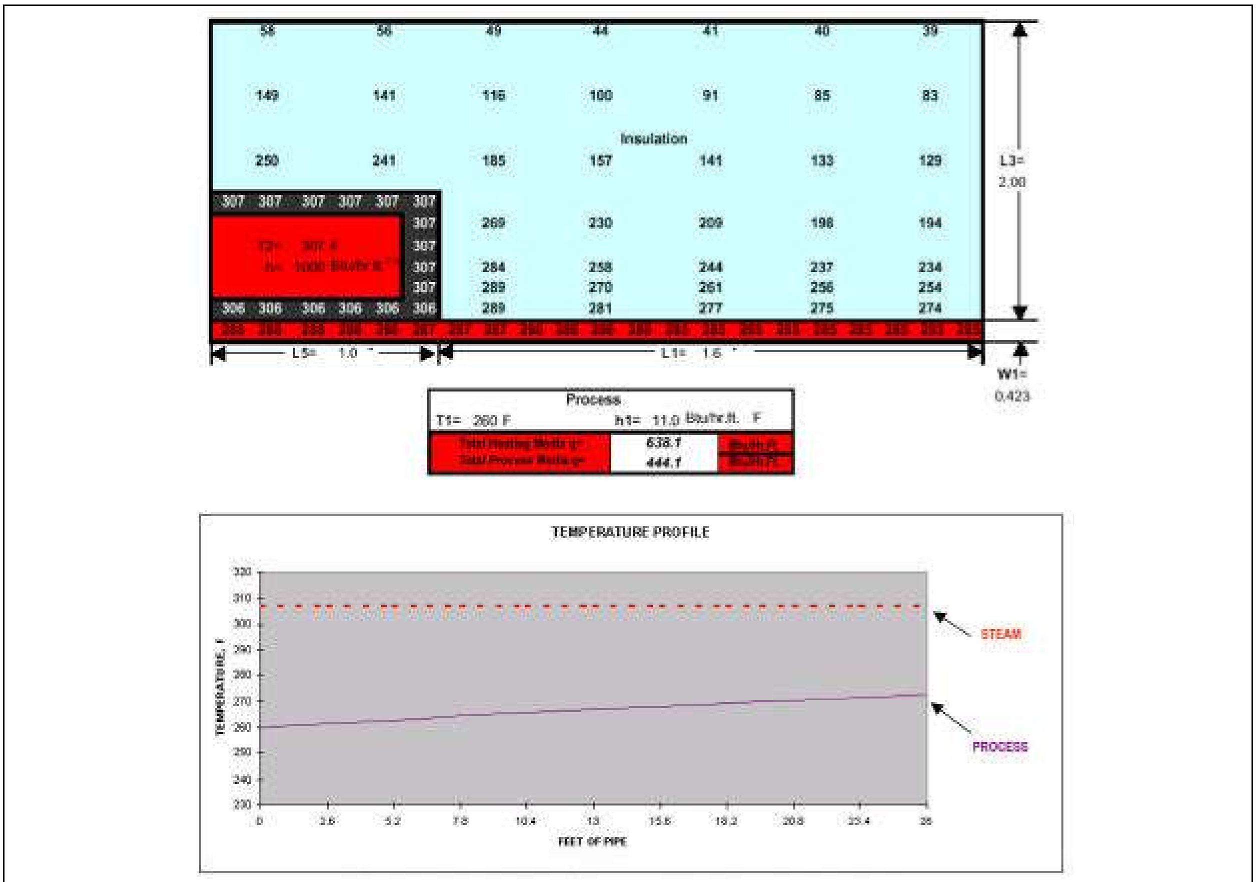

FIGURE 3A FIRST 26FT OF SWEEP AIR PIPING TO EDUCTOR

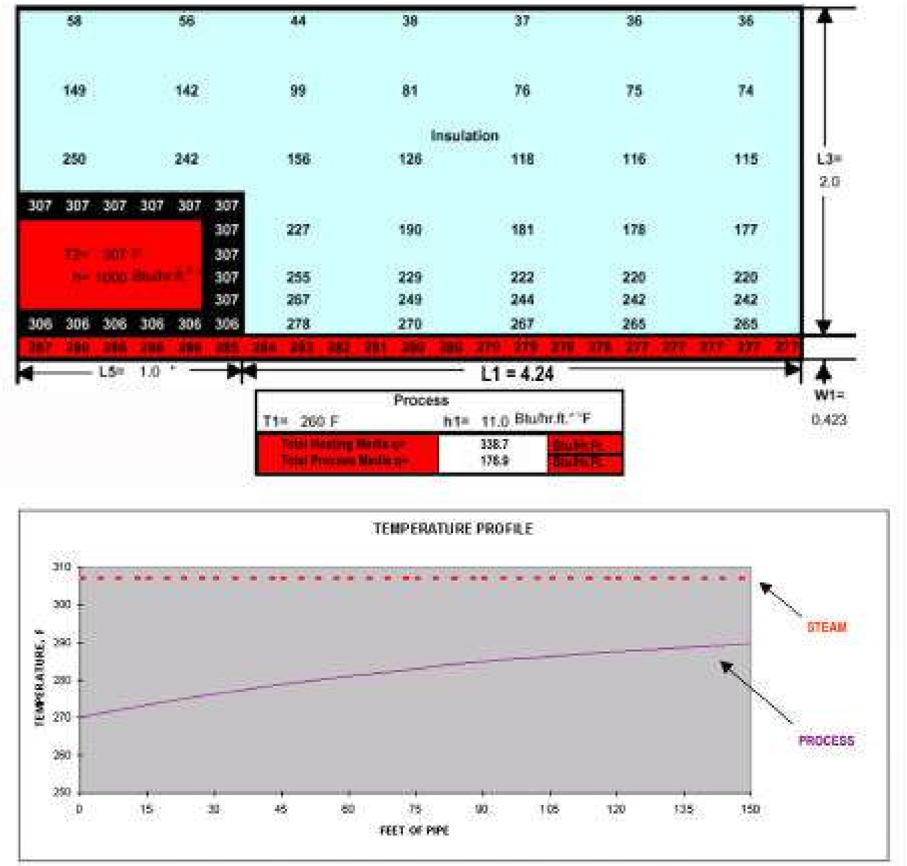

FIGURE 3B REMAINING SWEEP AIR PIPING TO EDUCTOR

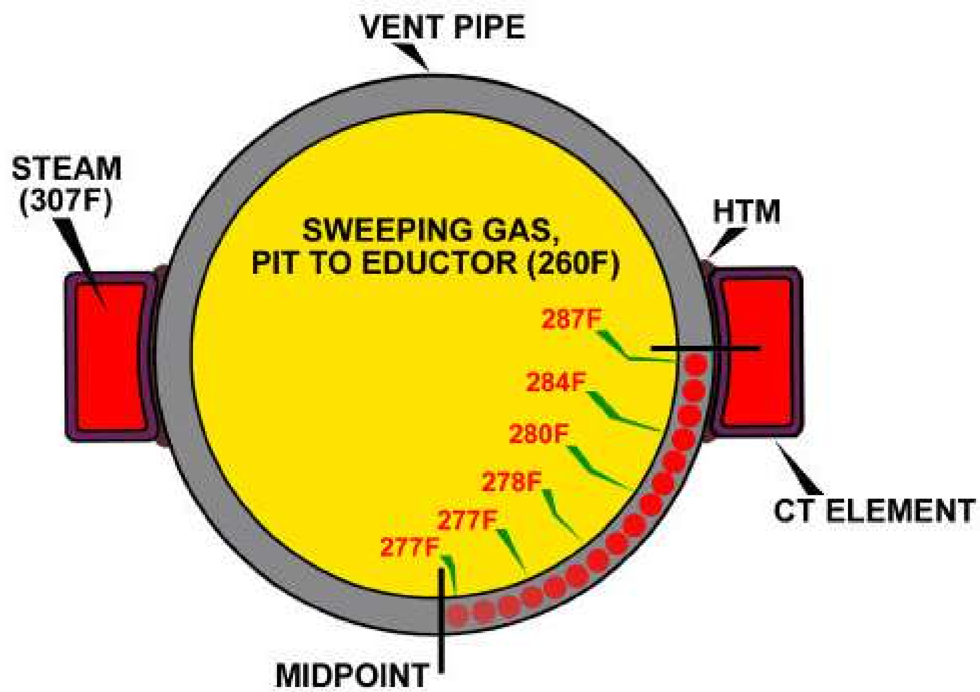

FIGURE 4 TEMPERATURE PROFILE OF 6-INCH VENT PIPING WALL

<u>Transfer and Offload Piping</u>. On investigating the causes of the cross contamination in the transfer and offloading system, we found that most of the piping failures occurred at the flange welds of the core piping (see Figure 2). Cyclic stresses were involved. Over the years, several modifications had been made to the

jacketed piping system. These modifications may have exacerbated to the problem; we suspect that they inhibited complete drainage of the core pipe after loading operations. When the steam was turned off, residual sulfur in the core solidified. On startup, unless the core pipe was fully drained, the jacket expanded more quickly than the core, creating high stress loads at flange welds. After many cycles of these high stresses, the core welds at the flanges failed and created the issues described previously.

The cross-contamination problems experienced with the jacketed transfer and offload piping system mandated that we consider adopting any thermal maintenance system that would yield safe, uneventful processing: fully jacketed pipe of heavy-wall constructions, multiple tube tracers in lieu of jacketed pipe, inductive heating, impedance heating, and the ControTrace system. A major safety consideration in our selection of the thermal maintenance system was accessibility to all piping welds for periodic inspection. Another safety consideration for the system was the elimination of any chance of cross contamination. We selected the ControTrace and ControHeat system over enhanced tube tracing and electrical heating methods (see Figure 5).

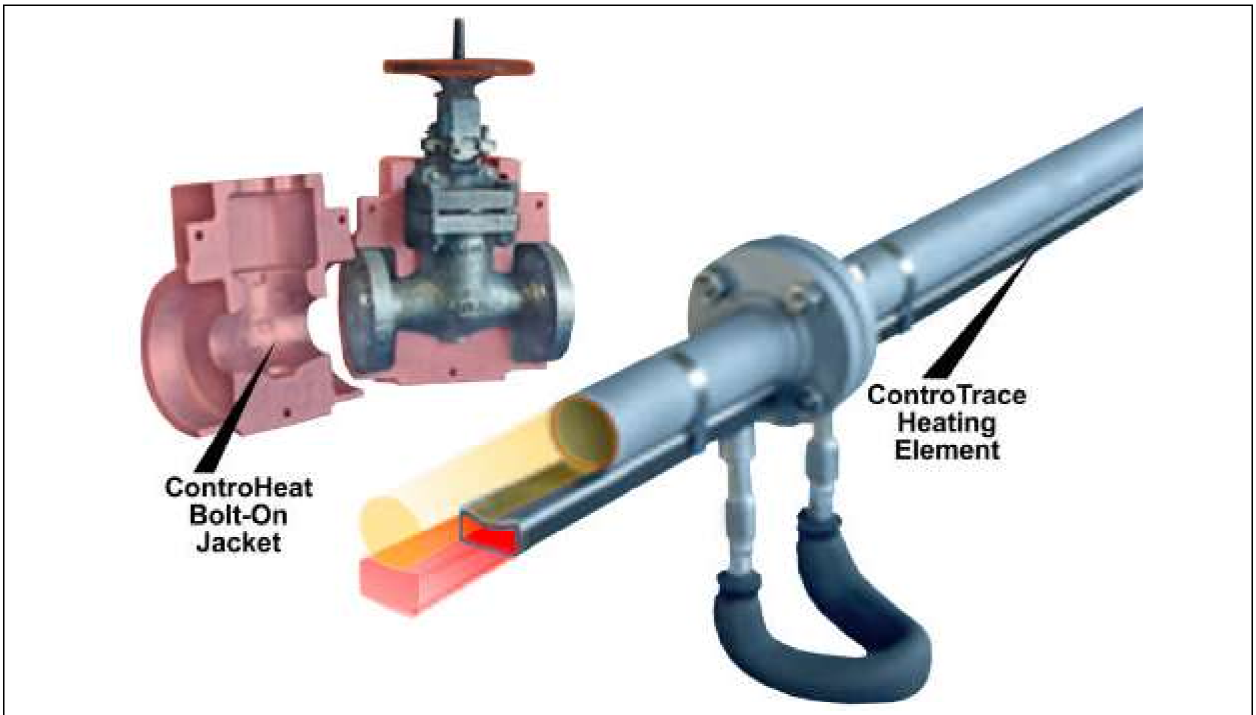

FIGURE 5 CONTROHEAT/CONTROTRACE THERMAL MAINTENANCE SYSTEM

We chose this thermal maintenance system for reasons very similar to those that led us to select it for the vent piping system, including accuracy of thermal modeling. In simplest terms, we saw a pretty good thermal image of the transfer system before we cut the purchase order. We were able to virtually scrutinize the thermal results of high, medium, low, and zero flow rates of liquid sulfur in the transport system.

The new thermal maintenance system included bolt-on heating jackets for the valves in the line. Analysis of this bolt-on technology, called ControHeat, pointed toward significant advances in our component maintenance program for the liquid sulfur transport system. On paper, ControHeat jackets showed us a reduction in inventory costs and maintenance response times while improving the plant's operating performance—they performed a prescribed heating function without the risk of cross-contamination. Supporting our decision to use the bolt-on jacket for piping components were several documented successes of their use in similar operations of other SRUs, as well as other areas of the sulfur industry, including gas plants, acid plants, maritime tankers and barges, storage facilities, and rail and road tankers.

EXECUTION

<u>Vent Piping</u>. Designers refined the configuration of the thermal maintenance system from the pit to the eductor to provide the highest level of thermal uniformity in the gas stream. Ambient air entered the pit and

became heated as it traversed the headspace to the vent. The pit cover was sealed and the air inlets to the pit were positioned to assure that there was a relatively uniform draft across the entire headspace of the pit. To assure that the sweeping gas leaving the pit was at least 260F, regardless of pit level, a very short section of the vent piping from the pit was fully jacketed, performing the function of a single-tube heat exchanger. We felt safe using jacketed pipe in this instance since only sweeping gas would flow in the core. The risk of cross contamination was minimal. Immediately following the short jacketed section, bolt-on ControTrace elements were applied to the pipe and maintained thermal contact throughout the entire run to the eductor. Four ControTrace elements were used on the first 26 feet of vent piping after the jacketed section. For the remainder of the run to the eductor, two ControTrace elements were used, as determined by thermal modeling. The locations of the2-element and 4-element tracers are shown in Figure 6. The use of four elements instead of the two on the initial piping section we considered inexpensive insurance against upsets that might inhibit the process gasses from maintaining 260F on their way to the eductor

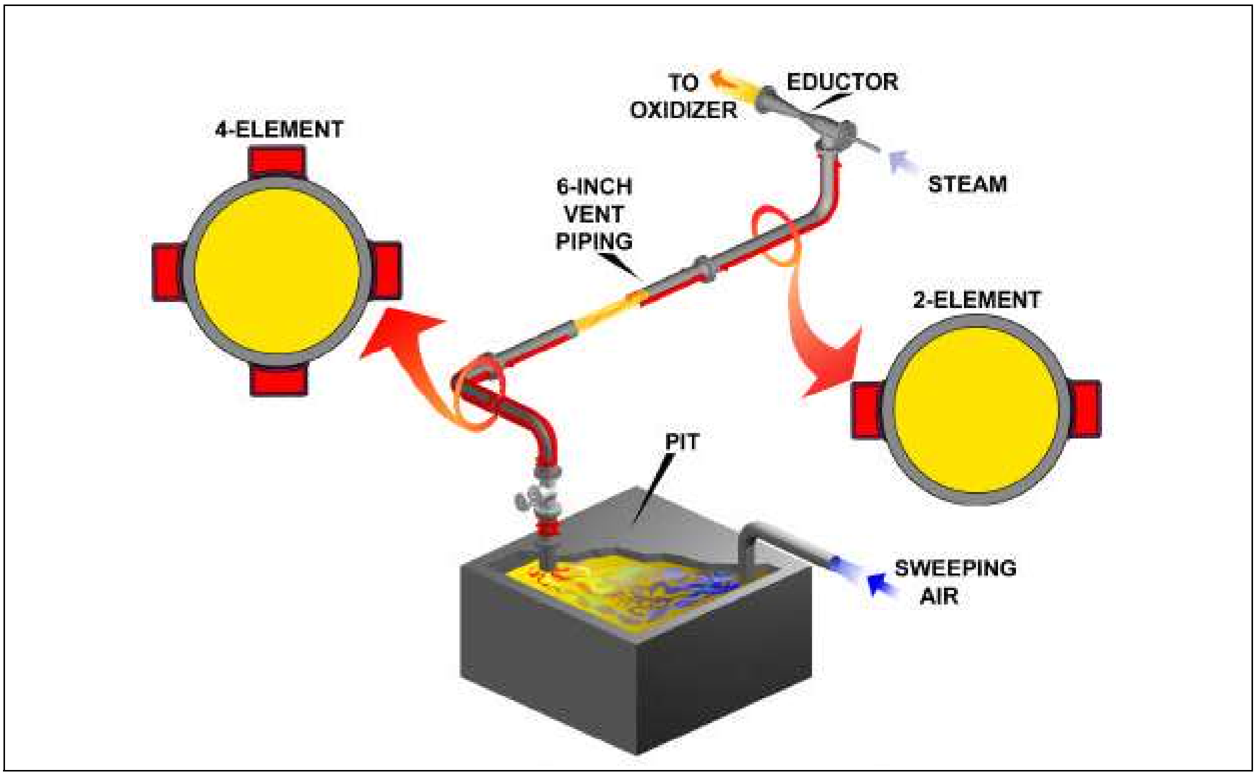

FIGURE 6 CONTROTRACE ELEMENTS ON VENT PIPING

Transfer and Offload Piping. The computerized thermal modeling techniques for the ControTrace heating elements used on the vent piping are easily applied to liquid sulfur lines. The entire transfer and offloading system was analyzed for high, medium, low and zero flow rates of liquid sulfur. Additionally, computerized stress analysis tools were used to look at flange welds under varying conditions from full to empty pipe with the ControTrace elements heated with 60-lb. steam (see Figure 7). The result was a ControTrace/ControHeat system designed to maintain the uniform temperatures necessary to prevent sulfur solidification at any point in the transfer line. A major bonus for the plant's safety inspection group was the fact that all welds in the piping system were available for scrutiny at any time.

For maintenance personnel and operators there was also a bonus: any possibility of cross contamination had been eliminated.

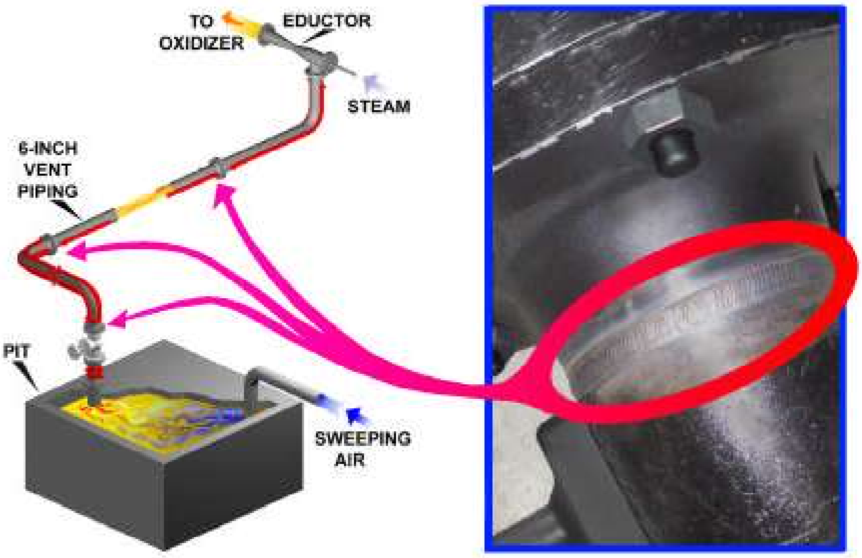

FIGURE 7 ALL PIPING WELDS CAN BE VISUALLY INSPECTED

CONCLUSIONS

Vent Piping. Bolt-on thermal maintenance systems, supported with computerized analytical tools, provide piping designers valuable, detailed thermal information that translates directly into operating benefits. The bolt-on ControTrace thermal maintenance system applied on the vent piping described herein has performed as predicted. No chill spots. No plugging problems. The ControTrace elements maintain thermal contact with the vent piping under all conditions. This uniform contact prevents chill spots from developing. All processing since the installation of the new thermal maintenance system has been notably uneventful. When a sulfur plant goes down unexpectedly, it threatens refinery production. All operating and maintenance personnel in the sulfur plant appreciate any technology that advances uneventful processing. It deserves a thumbs up.

Transfer and Offload Piping. The application of a bolt-on ControTrace and ControHeat thermal maintenance system to the transfer and offload piping system immediately solved a potential safety hazard. No longer was it remotely possible for steam condensate to enter the sulfur stream and explode sulfur from the loading nozzle. Every weld in the system was visible for inspection by plant safety and maintenance personnel at any time. One cautionary note: the heat-up time required for offload piping fitted with the bolt-on thermal maintenance system versus the heat-up time required for jacketed pipe is greater by about two to one (30 minutes versus 15 minutes). However, considering the benefits gained from safe, uneventful offloading, slower heat-up time is a minor inconvenience.