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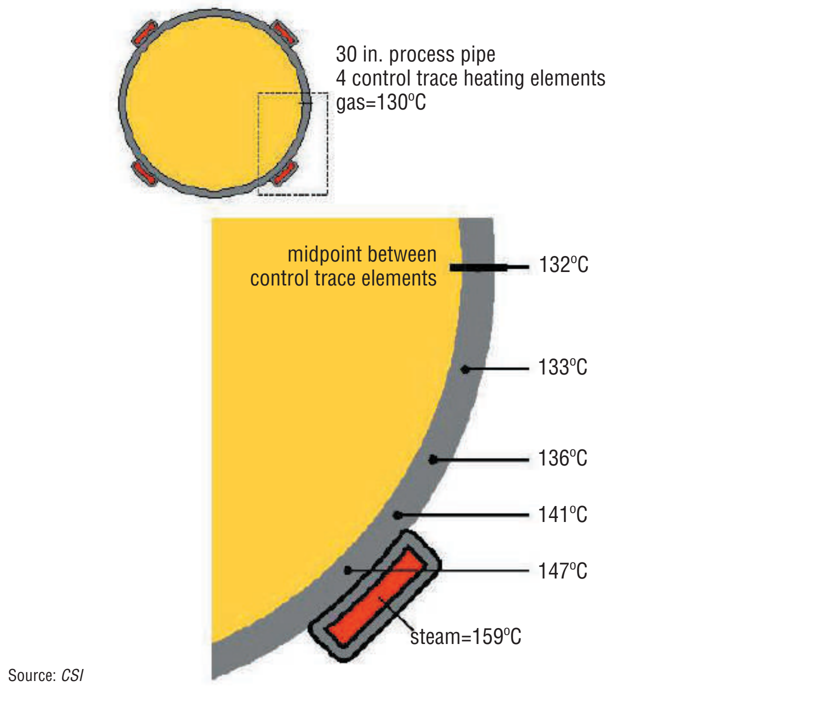
Ensuring uniform heat distribution in sulphur vapour lines

Uniform temperature distribution in sulphur pipeline walls can be achieved by applying heating elements which are strategically positioned using accurate thermodynamic process modelling software. A well-designed system protects the process from interruptions caused by corrosion or blockage of the pipeline. **David R. Hornbaker** of Controls Southeast, Inc. reports on a typical case in point.

Certain hot process piping services require thermal maintenance devices to keep stream temperatures within design limits. In such cases conventional pipe jacketing has been regarded as sufficient but often too expensive. An alternative to pipe jacketing, tube tracing, does not effectively prevent problems caused by temperature variations along the process pipe wall. Frequently, tube tracing is used as an economical way to try and compensate for heat loss. In low temperature applications with broad temperature envelopes, steam tracing can be effective. However, in those applications, the position of the tracers, and the temperature distribution in the pipe material are not considered important. A new system for process temperature maintenance or uniform pipe wall temperatures, comparable in price to tube tracing, consists of contoured, bolt-on trace elements. These elements are strategically positioned after modelling heat dynamics in the operating piping system. In dealing with the actual problems caused by unwanted heat variation, frequently the key principle is assuring uniform pipe wall temperature. To assure uniformity, it is necessary to manage the heat distribution in the pipe wall. Proper management of heat distribution depends on the number and placement of heating elements. This placement in turn depends on accurate modelling of process thermodynamics. Therefore, the heating element vendor should apply accurate process modelling software to assure uniform pipe wall temperature. An example of the result of this type of modelling is shown in *Figure 1*. Heat from steam at 159°C is applied from a contoured

Fig. 1: **Calculated pipe wall temperatures for an Alberta-based SRU**



Source: *CSI*

heating element to a pipe wall at defined intervals. Directly under the element, the wall temperature is 147°C. Note the decrease in wall temperature as the distance from the element increases, until a minimum of 132°C is reached.

At this point heat conducted through the wall from another heating element causes the wall temperature to rise again. The wall temperature varies within a defined range and the warmest and coolest points can also be readily identified.

Application of contoured pipe tracing after thermal analysis prevents problems of condensation and associated pipe corrosion caused by mixed vapours in sulphur processing.

Case history: sulphur recovery

Sulphur recovery units in refineries or gas plants usually include tail gas or degas vapour lines. These lines are commonly heated to prevent the condensation of either sulphur or water. In most cases, the gas in the line is at an elevated temperature and can be assumed to be at or above dew point temperatures. There are two dew points, one for water and one for sulphur. It has been common practice to employ conventional tube tracing (or in some cases electric tracing) to heat the line. Despite this practice, condensation and resulting corrosion are often still a problem. The cause is uneven or inadequate heating of the pipe.

A gas plant operator can achieve more uniform heating of the pipe. It is necessary to conduct a detailed thermal analysis of the pipe, gas, heating elements and insulation. Then the operator installs an innovative bolt-on temperature management system. Thermal analysis reveals that the flowing process gas may actually be cooling the pipe wall. Conventional steam or electric tracings are usually not heating the pipe uniformly, resulting in cold spots where condensation occurs.

Condensation can be prevented by using high-performance bolt-on steam tracing material, properly distributed around the pipe. This case describes an installation at a natural gas plant sulphur degassing unit in central Alberta, Canada.

Fig 2: ControTrace installation.

Steam tracing allows corrosion

The degas vent piping at the Alberta plant had been in place for about six years and had suffered serious corrosion, particularly in and around the low spots. The original steam tracing had been done with conventional $^5/_8$ in. tube tracing employing 500 kPag saturated steam. Vent line sizes were 20in., 24in., and 30in. diameter, running about 55 meters from the degas pit to the incinerator. They had been installed with 10 tracing tubes on the 20in. line and as many as 13 tubes on the 30in. line. The tracing was generally located around the bottom of the pipe in horizontal runs and on a convenient side on vertical runs. The analysis model showed that 13 tubes was the very minimum that could be used if they were spaced at equal intervals around the 30in. pipe.

Because they considered the six-year lifetime of the original pipe to be economically unsound, plant management sought to find a better way to maintain pipe temperature. They reviewed the experience of similar plants equipped with ControTrace systems. In some instances, these systems had been effective in comparable service for over ten years.

The gas plant operator analysed the various parameters involved in heating and cooling the pipe. They used a proprietary finite-difference computer model developed by Controls Southeast, Inc. (CSI), the manufacturer of the ControTrace system. They created a model for gas flow through the pipe and generated temperature profiles of the piping system under various operating conditions.

Conventional trace sizing programs simply deal with the pipe sizes, temperature, insulation and ambient conditions. These programs calculate total heat loss from the pipe and determine the number of heating tracers needed to replace that amount of heat. No consideration is given to how the heat gets distributed to all parts of the pipe. Adding more heat than is being lost does not assure that all points on the pipe will operate above the condensation temperature.

Better analytical tool

The more comprehensive analytical tool provided by CSI models shows how much heat is going into the pipe. It measures how that heat is distributed by conduction along the pipe wall, through the insulation, and by convection, to the process itself. The analysis uses the following data sets: pipe size; wall thickness and material properties; insulation thickness and properties; worst-case ambient temperature; wind conditions; process gas properties; and flow rates.

From all of these properties and flow conditions, CSI was able to calculate a heat transfer coefficient specific to the Alberta plant.

By applying the model, plant management and CSI determined detailed temperature profiles for various conditions. Variables included heating elements and their spacing, steam temperature, insulation thickness, and flow conditions (from maximum expected to zero flow). They deter-

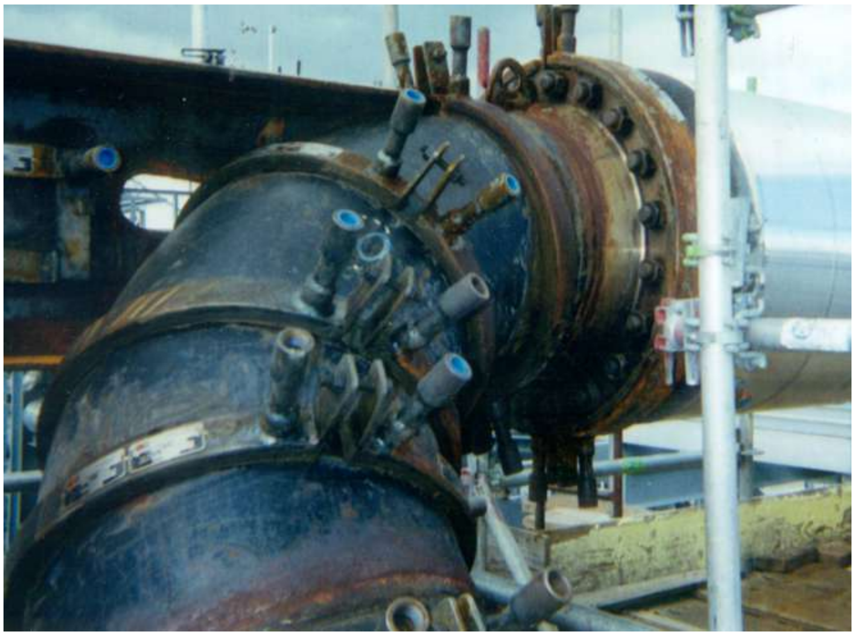


Fig 3: ControTrace on an elbow.

mined the optimum number of elements and their placement so that pipe wall temperatures would prevent process condensation.

Plant management then conducted a material cost and installation expense analysis specific to the Alberta plant. It revealed that even though the material cost for ControTrace was higher than for tube tracing, the installed cost was expected to be significantly less. Because the management of the Alberta plant expected longer pipe lifetime with the ControTrace system, both the performance and economic criteria were theoretically met. Management awarded a contract to CSI for the necessary thermal modelling/design and fabrication of the new bolt-on tracing system. Installation was done by the plant and plant contract personnel.

Effective heat transfer

ControTrace heating elements are drawn from SA178 carbon steel into a rectangular shape. One side is curved to fit the outside contour of the pipe. The ControTrace elements used on the sulphur pipeline are nominally 25 mm by 50 mm. They are registered in Canada with a pressure rating of 2380 kPag at 340°C. Heat exchange between the steam and the pipe is greatly enhanced by the use of a thin film of heat transfer mastic. This results in improved and more predictable performance. Not only does the ControTrace system use fewer elements (tubes) than the traditional round tubing, it is significantly more mechanically stable.

The sulphur pipeline continued to operate during the installation of the ControTrace system. In spite of this, the actual installation cost was less than originally predicted. Most of the installation was done from scaffolding, although some of the bolt-on tracing was shop mounted prior to pipe hanging. The ControTrace is supplied prefabricated into rings and headered panels. (*See figure 2*: photo for typical straight run.)

During installation, the non-hardening heat transfer mastic was applied to the trace surface. Then the individual panels and ring halves were bolted together. It was necessary that the panels and rings be pulled snugly against the pipe and flanges. Meeting this requirement was not difficult because the ControTrace is very rugged and can withstand large bolting pressures. The installation crew said that the ControTrace product was easier to install than tube tracing. (*See figures 3 and 4*: two photos show installations around an elbow and at a pipe support.)

Following installation the system was insulated. Insulating over the ControTrace was no more difficult than insulating pipe of similar size with tube tracing. Trapping of the steam system was based on plant standards and steam loads taken from the thermal modeling program. Interconnection of steam between individual components was done with hard piping in accordance with plant standards.

At startup, pipe wall temperatures were checked with a surface pyrometer. Temperatures quickly came to values in the expected range. Since then, periodic pipe wall temperature measurements have been made with all values falling in the expected range. S

Fig 4: ControTrace at a pipe support.