Texasgulf's
Heat Recovery System
Construction and Startup

by

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Texasgulf

Heat Recovery Systems Construction & Startup

Background

Texasgulf operates a phosphate complex in Eastern N.C. which was started when mining began in 1964. The mining and chemical complex now cover several square miles, and the capacity to produce finished phosphate products stands at about 1,270,000 tons of P_2O_5 per year. As a part of the chemical complex, Texasgulf operates four (4) sulfuric acid plants and a turbine generator. The sulfuric plants are the third, fourth, fifth, and sixth plants constructed at the site. The plants are permitted with the State of North Carolina to operate at rates as shown in Figure 1.

Plant #1, a single absorption plant, was shut down in 1985 when Plant #6 came on line. Plant #2 has reached the end of its economic life and was shut down in 1987.

Plants #3 and #4 produce 485 psig steam and plants #5 and #6 produce steam at 600 psig. By 1990 the plants were producing a combined total in excess of 1,000,000 pounds per hour of steam. About 334,000 pounds per hour of the total steam is used by the blower turbines to supply air to the plants and is exhausted from the blower turbines at 50 psig for other uses. The largest user of the 50 psig steam is for evaporation of phosphoric acid. Other uses include water treating, miscellaneous heating and losses bringing the total requirement for low pressure steam to 833,000 pounds per hour on average. Up to 430,000 pounds per hour had to be extracted from the turbine generator to meet the need for 50 psig steam. The demand for low pressure steam by the phosphoric

#3	1850	tpd	485	psig
#4	1850	tpd	485	psig
#5	3250	tpd	600	psig
#6	3600	tpd	600	psig

40 MW T/G w/50 psig extraction

Figure 1

acid evaporators is not constant. These variations in demand were reflected in changing extraction flow from the generator. At maximum extraction rates generator output can drop to around 26 MW while at minimum extraction the generator is producing at rates slightly in excess of 40 MW.

The desire to keep the generator producing at maximum capacity and minimum 50 psig extraction led management to investigate the installation of Monsanto Heat Recovery Systems on the Plant #5 and Plant #6. It turns out that the output of these two (2) units will almost exactly match the variation in demand for 50 psig extraction steam. The Heat Recovery System Steam Balance shown in Figure 2 shows the situation around the turbine generator with and without the Heat Recovery Systems. The Heat Recovery Systems were planned to contribute 273,000 pounds per hour of steam. Package boiler contribution would drop to zero except during plant downtime. Extraction flow from the turbine generator would be minimized for maximum power generation.

Another way to show how the HRS steam was expected to be used is shown on Figure 3 and indicates the variation in flow to condensers which was formerly reflected as variation in generator output. The Figure shows that all of the HRS steam is used to replace extraction steam for 40% of the time, varying to all of the HRS steam being condensed 5% of the time.

HEAT RECOVERY STEAM BALANCE

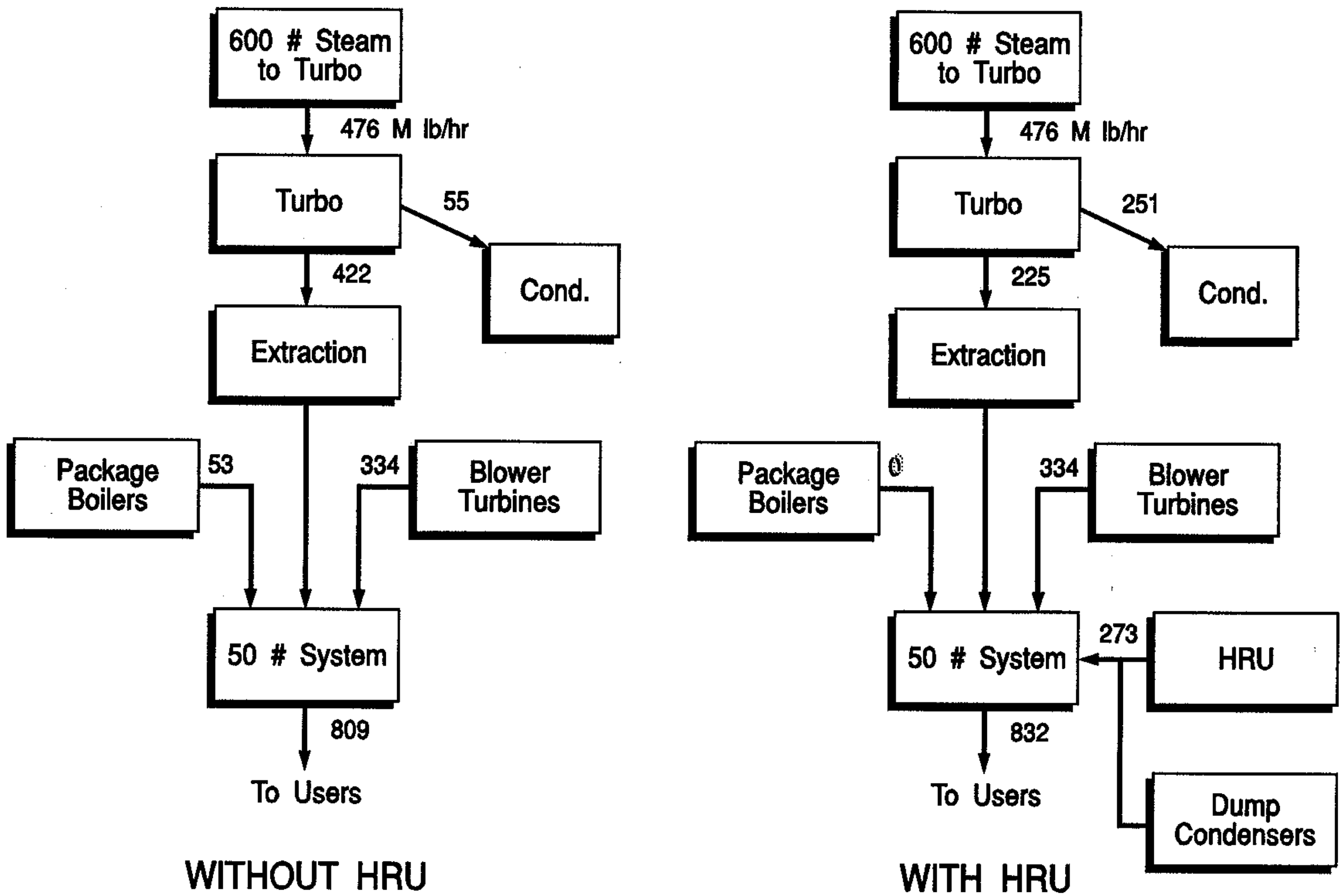
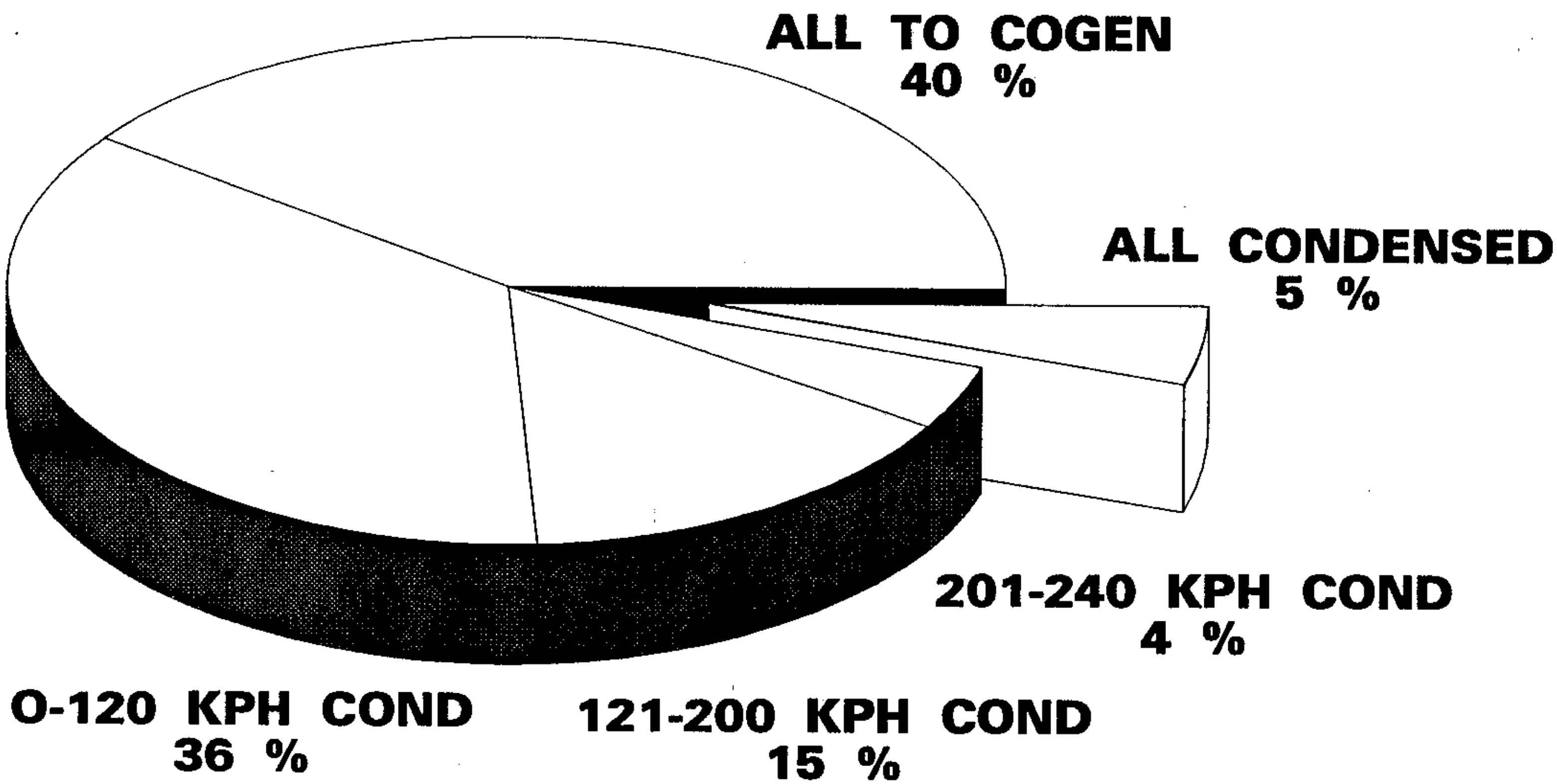


Figure 2

HRU STEAM FLOW
THEORETICAL JAN-JUN 1991



PERCENT OF HOURS IN PERIOD SHOWN

Figure 3

New Heat Recovery Systems

The features included in the new Heat Recovery Systems are shown in Figure 4 and are common to both plants.

These include:

- A heat recovery tower to replace the interpass absorption tower.
- An HRS boiler capable of operating at pressures up to 155 psig.
- A demineralized water pre-heater using exported HRS acid on the shell side to heat incoming demineralized water on the tube side.
- A deaerator.
- A boiler feed water heater using exported HRS acid on the shell side and boiler feed water on the tube side.

Other features of the project shown in Figure 5 include:

- A new demineralized water supply line which supplies water for the HRS steam as well as the HRS dilution water.

HRS tower

HRS boilers 155 psig design pressure

De-min water preheater

Deaerator & BFW pumps

Boiler feed water heater

Figure 4

Demin supply line

50 psig export steam line

sized for 50 psig rated 150 psig

Dump condenser for each plant

DCS for each plant

Figure 5

- A 50 psig export line to tie into the existing 50 psig header system. The line is sized for 50 psig flow and is rated for 150 psig operation.

- A dump condenser for each plant using cooling tower water on the tube side to condense steam on the shell side. In the case of Plant #6 the steam is condensed off the 50 psig header. In the case of Plant #5, steam is condensed off the exhaust of the blower turbine. This condenser operates first and keeps the back pressure on this blower turbine at a minimum when it is in operation, thus increasing the efficiency of this blower turbine and allowing more high pressure steam to flow to the turbine/generator.

- New distributed control system to control the HRS as well as the existing plant functions.

A very much simplified flow scheme is shown in Figure 6 which illustrates how the HRS system operates.

The heat recovery tower replaces the conventional interpass absorption tower. It is a packed tower constructed of 310 and 304 stainless steel which allow the recirculating acid to exit the tower at high temperature, up to 430°F vs. 250°F for a conventional tower. The hot acid is cooled in a kettle type boiler operating with water on the shell side and acid on the tube side. The cooled acid is then diluted and returned to the lower stage distributor and packing to absorb more SO_3. The gas

TEXASGULF
PLANTS 5 & 6
HEAT RECOVERY SYSTEM

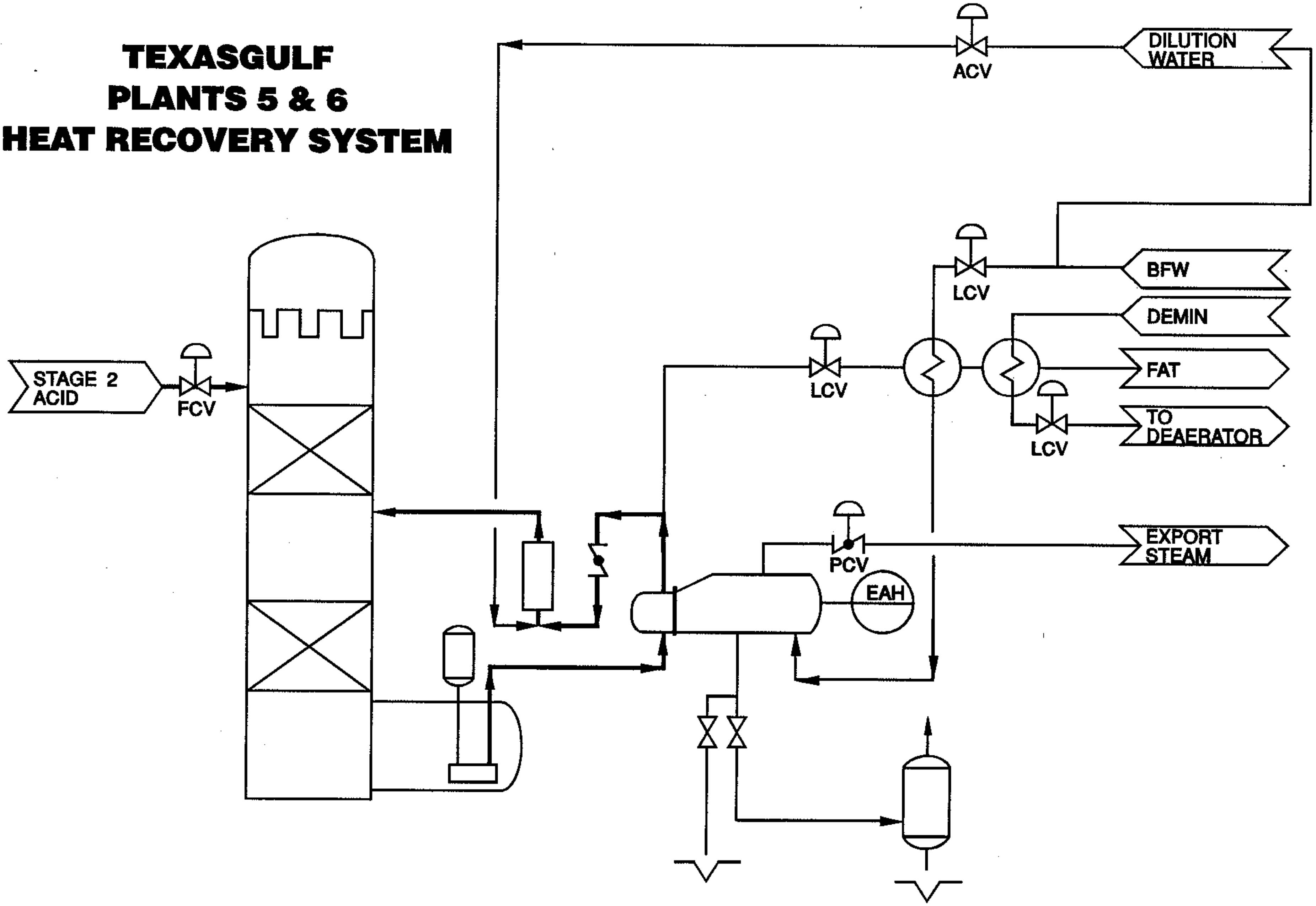


Figure 6

temperature leaving the lower stage is also hotter than in a conventional tower. It passes through an upper or second stage packed bed which is irrigated with acid imported from the existing pump tank and acid cooler system.

The combined flow of upper stage acid and product acid is exported in a line which branches off the main recirculating stream immediately after the boiler. This export stream passes through a heater which heats the boiler feed water coming from the deaerator. It then passes through a pre-heater which heats the incoming de-mineralized water on its way to the deaerator. Water for HRS acid dilution is supplied off the boiler feed water pumps and is mixed with the recirculating acid in a special teflon lined in line diluter.

Project Execution and Startup

The attached Figure 7 & 8 shows the project chronology and milestone dates for some of the major events in the project.

An important part of the project was a HAZOPS study which required seven days to complete. It involved personnel from Operations, Maintenance, Safety, Engineering and Monsanto Enviro-Chem process group. The study resulted in over 130 recommendations and/or questions. These included:

- Secondary acid level indication in the HRS tower pumboot.

- A very heavy wall 4" dip tube for acid level indication.

4-1-91 - MEC Estimate

7-25-91 - Management Approval

8-22-91 - Letter of Intent

11-22-91 - Contract

Figure 7

4-92	- Mobilize construction
9-92	- #5 DCS cut-over
10-9-92	- #5 tie-in & start-up
11-92	- #6 DCS cut-over
1-26-93	- #6 tie-in & start-up

Figure 8

HAZOPS MEETINGS

June 10 & 11, 1991	
July 8 & 9, 1991	
August 21 & 22, 1991	
December 13, 1991	
September 9, 1992	
September 28, 1992	#5 Walk Through
January 14, 1993	#6 Walk Through

Figure 9

HAZOPS RECOMMENDATIONS

- Secondary level in Tower
- Heavy wall dip pipe
- Expanded freeze protection
- 4 Manways for mist element removal
- Diluter design
- Gas damper interlocks

Figure 10

- Expansion of the scope for freeze protection in various parts of the system.

- Additional manways for mist element removal. Towers have 4-30" roof manways.
- Provision to check strength of acid from drain pumps.

- Damper interlocks to prevent blocking in the heat recovery tower on the gas side.

- Discussions and clarifications regarding diluter design.

In addition to the HAZOPS study a series of regular weekly update meetings was started in March of 1992. These meetings were attended by key personnel from Operations, Chemical Plant Maintenance and I&E Maintenance. A running list of open issues was updated each week. Copies of the weekly update meeting minutes were widely circulated, including a copy to the Monsanto project manager. In this way the lines of communication were kept open and many details were caught and resolved during the design stage instead of after the fact. The Sulfuric Operations Department assigned an experienced operator full time to the project. This expedited coordination with the Leonard Construction forces and again caught many details at a stage when they were easily resolved. Punchlisting of various systems was done on an almost daily basis starting as much as a month before tie-in and brought us to startup with very few last minute surprises.

Plant #5 was started up on October 9, 1992. The plant came on line smoothly and was up to full rate with no difficulty. However there was noticeable and excessive movement of the piping around the HRS diluter. This was corrected to some extent when the plant was stopped on October 15, 1992 to add more pipe supports and bracing and also to change out the drying tower pump (unrelated to HRS). Further discussions about diluter vibration led to installation of extra restraints on the diluter body itself which has reduced external pipe vibration to a very low level. The plant performance was demonstrated during the week of October 26, 1992. The plant met the requirement for mist carryover from the HRS tower of 1 mg/acf while making the guaranteed steam production of 123,900 pounds per hour and operating at 150 psig.

Because of concerns over the corrosion rates on lower stage distributors in Florida, Plant #5 was stopped after one month of operation and a quick inspection was made of the lower stage distributor on November 7, 1992. There was no visible corrosion and the plant was restarted. A second inspection was made after two months on December 5, 1992. At the same time the HRS circulating pump was changed out and replaced with the spare unit. A gas leak had developed at the mounting flange on the pump boot and an acid leak had developed at the outlet flange on the pump. New Gortex sealant was installed to correct the gas leak. The acid leak is believed to result from piping misalignment and has since recurred. Another purpose of the December shutdown was to switch the HRS boiler to 50 psig operation. The lower pressure allow a corresponding decrease in the recirculating acid temperature and a correspondingly lower corrosion rate as generally indicated by the corrosion curve shown in Figure 11.

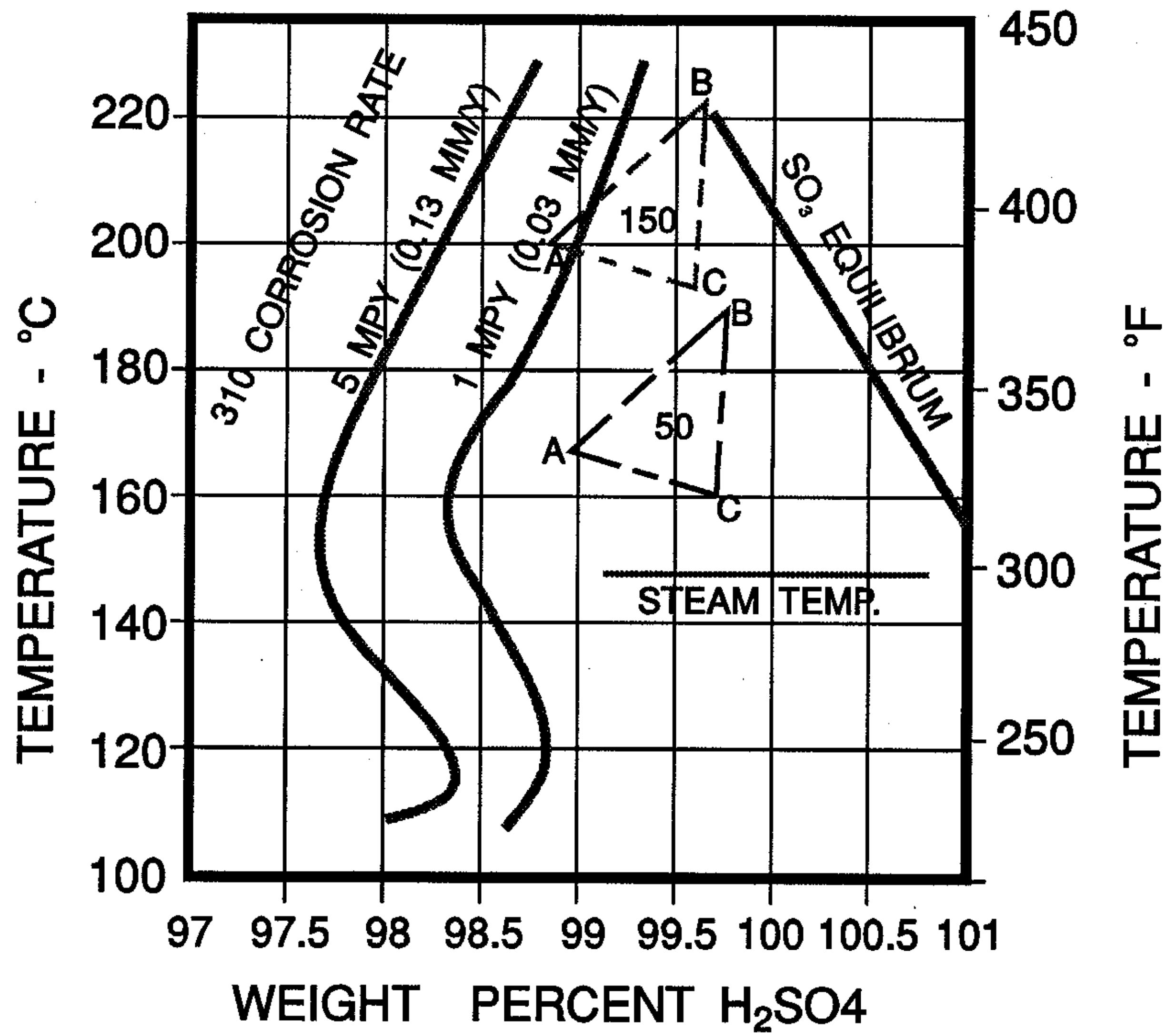
The December inspection showed some localized corrosion at the base of the weir slots on about 5-10% of the tubes. Photographs were taken and thickness readings taken on several components. Two of the trough drain tubes were removed and measured. The general corrosion rate on parts of the tubes in the acid was estimated at 3 mpy.

The steam piping was modified for 50 psig operation and the plant was restarted.

On March 11, 1993, after 5 months of operation, Plant #5 was taken down again, for gas leak repairs, and to inspect the HRS lower stage. Mist carryover from the HRS had increased as indicated by poor stick tests and increased knockout pot drainage ahead of the cold interpass heat exchanger.

The distributor showed essentially no deterioration since the switch to 50 psig HRS boiler operation in November.

The trough distributors are fed with acid by a pipe distribution system which uses teflon lined tees leading in to each trough section. One of the liners in these tees had collapsed and partly blocked the feed to that trough section. The tee was removed and replaced with an unlined tee. All of the teflon lining will be removed during the next shutdown now scheduled for July/August,



HRS OPERATING CYCLE

Figure 11

if not before. The original design tees will be replaced with a new design with larger passages which will lower the discharge velocity of the tees.

With all of the reports from the Florida plants about lower stage distributor problems, the decision was made to start Plant #6 up on with 50 psig operation on the HRS boiler. In addition Texasgulf and Monsanto had been discussing ways to extend the life of the lower stage distributors. We finally settled on a system using heavy wall teflon sleeves to cover and protect the tubes and weir slots which stand in the troughs. The downcomers and extensions below the troughs were covered with a thin wall heat shrunk teflon sleeve. Plant #6 was also retrofitted with the new diluter restraint system and additional pipe supports that had been installed on Plant #5.

Plant #6 was started initially on January 26, 1993. However there were problems with pressure drop in a catalyst bed, unrelated to HRS, and the plant did not get up to full rate until the first week in February. Plant #6 plant performance was demonstrated during the week of February 22, 1993. The plant met the requirement for mist carryover from the HRS tower of 1 mg/acf while making the guaranteed steam production of 153,745 pounds/hour at 50 psig.

During the shut down to correct the catalyst pressure drop problem the lower stage distributor was checked. The teflon sleeves appeared as installed with no problems. One result of the inspection was the discovery of spiral wound gaskets components in one of the troughs. This was traced to a set of 14" gaskets which had been installed in a 16" line. These were replaced before the startup. The gasket parts including the metal inner rings had passed through the teflon lined diluter and it was feared that this may have caused some damage to the lining. One of the heads was removed from the lower horizontal section of the diluter and the unit checked with a borescope. Visually it appeared to be undamaged. A leak developed in this unit in mid April, but the cause has not yet been exactly determined.

The series of photographs which follow show the construction, and also includes photographs of the Plant #5 and Plant #6 distributors and the diluter restraint systems.

References

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