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GLYCOL PRE-DEHYDRATION
OF GAS
BEFORE A CONTACTOR

By:

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ABSTRACT

A patent pending means of pre-dehydrating gas before entry into a contactor has been developed and field-tested that improves the performance of glycol dehydration equipment. The system consists of a means of extracting glycol from a contactor after it has already contacted gas and reintroducing it before the contactor to achieve an upstream contact with the gas stream. The overall flow scheme is one of both countercurrent flow and concurrent flow contact.

This results in a partial dehydration of gas occurring before it enters the contactor. The efficiency of the pre-contact averages about 91% of a theoretical stage. This enhances the overall efficiency of the contactor and moves any water based corrosion or scale build-up outside of the contactor. The pre-dehydration can be used for any glycol dehydration system but is particularly applicable for gas that contains hydrogen sulfide or high quantities of carbon dioxide.

This paper discusses how a glycol contactor in high CO2 and H2S service has been successfully installed and operated. The gas stream that is dehydrated contains about 85% CO2 and about 1.8% H2S. The equipment has been in operation for more than two years. During that time no maintenance has been required on the pre-dehydration equipment. Since operation commenced there has been no downtime associated with the pre-dehydrator or the contactor. After one and one half years of operation the contactor was opened and inspected. There was only minor scale build-up and no corrosion even though the contactor is made of standard carbon steel construction.

INTRODUCTION

The challenge of this project was to use glycol to dehydrate a corrosive gas and to do so in a carbon steel contactor. The corrosive gas consists of 2500-5000 MCFD of 85% CO2 and 1.8% H2S at 400 psig from 80°F to 120°F. In the presence of liquid water the CO2 would quickly corrode carbon steel and the H2S would create an iron sulfide scale that over time fouls a carbon steel contactor.

A common response to such process conditions in CO2 floods has been to change the metallurgy of the contactor from carbon steel to stainless steel construction. In some cases only part of a contactor would be of stainless construction and in others the construction would be entirely of stainless steel. Another metallurgical approach is to partially or completely clad the interior of the contactor with a suitable metal. Chemical inhibitors to limit corrosion or scale build-up are not generally practical because such inhibitors usually contaminate the glycol needed for dehydration.

If the dehydration point could be moved outside of the contactor the contactor could be made of carbon steel. It was also important to not add to the circulation rate of lean glycol and to avoid installing any additional pumps or controls. A further benefit of predehydration of gas would be that fewer trays would be required in the contactor to achieve dehydration.

DESIGN CONCEPTS

The design approach used to move the dehydration point to before the contactor is to remove the entire stream of glycol that has already contacted gas in the contactor and to reuse the glycol to partially dehydrate the raw gas. This glycol is referred to as semi-rich glycol. The overall flow scheme is shown in Figure “1”.

The design approach was to be implemented by relying on the following two assumptions:

- Dripping glycol into a high velocity stream of gas is an effective means of achieving intimate gas/glycol contact. Gas velocity would exceed 150 ft/sec at the point of contact.
- Dehydration using this technique is essentially instantaneous. For that reason the contact time before the gas/glycol mixture enters the integral scrubber is only about 0.15 seconds.

In order to effectively apply the above design assumptions the following design considerations were employed:

- The glycol to be used for the precontact would be semi-rich glycol; it would have already been used in the contactor on the gas stream.
- The entire stream of glycol is to be reused consequently no controls are required.
- The energy necessary to provide contact via mixing would come from the raw gas stream. The raw gas stream would act as the pump for this process.
- No pumps or other moving parts are required.
- Additional energy is supplied by the potential of glycol flowing downward from the hat tray to the inlet gas stream. This is not considered essential for operation.
- A standard glycol regeneration process would be used.
- A scrubber is to be installed upstream of the precontact section.
- The integral scrubber is to be converted from oil/water separation to rich glycol separation.

HOW THE PRECONTACT SECTION REPRESENTS NEW TECHNOLOGY

The concept of installing a precontact section to a glycol dehydration unit is not new. It has been envisioned since at least the 1950’s[1] and a number of patents have been issued relating to contacting glycol with gas before the gas enters a glycol contactor. Although the patent pending method presented in this paper makes a number of claims, one unique element is that precontact is accomplished without installing a pump for the semi-rich glycol. The raw gas stream supplies any energy required to accomplish the mixing of the glycol with the raw gas stream.

Below is a discussion of several other innovations to illustrate how prior methods of pre-contact are different from the one presented here. Please note that in the discussion that the use of the word “glycol” may actually refer to any of a number of liquid absorbents and that the use of the term “semi-rich glycol” may not actually appear in those patents. These terms are used in order to conform to the overall usage of these terms in this paper.

Schofield's[1] patent, for instance, includes a pump to move the semi-rich glycol into the raw gas stream. Interestingly, that patent is silent on details of how the mixing of the glycol with the raw gas is to be accomplished. In contrast, a patent by Turner et al.[2] clearly shows various configurations of nozzles used to achieve mixing but is silent on how the semi-rich glycol's pressure is to be increased. It is necessary to assume that a pump of some sort is employed to permit the nozzle to work effectively. These patents use a semi-rich glycol stream with a pump to introduce the glycol into the raw gas stream.

Other patents rely on splitting a lean glycol stream in order to dehydrate gas both before and within a contactor. Patents of this sort immediately differ from the method presented here because two or more lean glycol streams are needed rather than the use of a lean and semi-rich glycol stream to achieve dehydration. A patent by Mims[3] accomplishes dehydration by splitting a lean glycol stream into four separate streams. That patent fails to include details of how the lean glycol splitting is to occur. What is clear is that a pump supplies the energy to mix the glycol with the gas in four different locations. Patents of this sort are likely to have twice (or more than twice) the glycol circulation rates compared to techniques that reuse glycol such as presented in this paper.

A paper by Pyles and Rader[4] employs a single stage of contact using a nozzle and static mixer to provide contact of lean glycol. In this case the standard glycol contactor is omitted entirely and only a single contact occurs, so strictly speaking there is no pre-contact. However the technique of accomplishing mixing by the use of both a nozzle and a static mixer is similar to other approaches used with pre-contactors. Both of these devices provide good mixing but each device inherently imposes a pressure drop on the glycol and would require a pump to work.

In summary, other approaches to achieve the mixing of glycol in a pre-contact with raw gas involve additional pumps or controls. Additional pumps or controls are generally associated with additional investment, maintenance costs, and downtime. Where lean glycol streams are split there is an additional burden of higher glycol circulation rates. These added pumps and controls are not required by the method of this paper.

MECHANICAL DESIGN OF THE CONTACTOR AND PRECONTACT SECTION

For this particular application a used four-tray carbon steel contactor with an integral scrubber was available for a reasonable cost. The contactor is 30" x 17'. The contactor was modified by changing the nozzles, but not the internals of the vessel. A precontact section was then bolted to the front of the contactor.

The essential change to the contactor was to install a new 2" nozzle to drain glycol from the hat tray. This nozzle is located about two feet directly above the raw gas inlet to the integral scrubber portion of the contactor. This nozzle would be used to extract semi-rich glycol from the contactor that would then be introduced into the raw gas stream.

Other changes were made to the contactor which included installing five 6" flush mounted flanges for maintenance and clean out. Lastly, two nozzles were installed for a gauge glass to monitor whether the glycol would backup into the contactor. The purposes of these changes were to allow for online and offline inspection and maintenance of the contactor.

The precontact section includes the following elements:

- A 1" line for extracting semi-rich glycol from the contactor
- A 4" orifice flange with a 1" orifice plate to introduce the semi-rich glycol into the raw gas stream. The orifice flange and plate are the same type as are used for flow measurement.
- A 4" line carrying the glycol and gas to the inlet of the contactor located on the integral scrubber.
- A line to allow glycol to bypass the orifice flange. This has never been in service and is not shown on the flow schematic of Figure "1".

The pre-contact section was bolted to the contactor. The contactor could be returned to standard glycol operation without welding on the contactor.

Figures "2", "3" and "4" are photographs that show the mechanical configuration of the system as it has been installed and operated.

OPERATIONAL ISSUES

As may be evident from the design concepts and mechanical design, this system is intended to operate almost exactly as any other glycol dehydration system. The only difference is to have a pre-contact of the glycol with the gas before the contactor. In actual operation the system has worked as designed. In over two years of operation no added maintenance has occurred. No maintenance at all has been performed on the contactor or on the pre-contact section of the system. The regeneration of glycol appears to be unaffected by the pre-contact section. No unusual glycol degeneration has been noted.

There is no contract specification for a dewpoint or water requirement. However, it is important to keep the gas dewpoint below the ambient air temperature to avoid corrosion. Inspection of the pipeline and surface equipment has shown no significant corrosion downstream of this equipment. Therefore, it is apparent that this condition has been met. Regular dewpoint testing confirms that the dehydration system is regularly below ambient temperatures.

A glycol bypass line was installed to allow the glycol to bypass the orifice flange. The intent of the bypass was to allow the contactor to function as a standard contactor in the event of plugging of the semi-rich glycol line. The bypass has never been in service because no plugging has occurred.

A gauge glass was installed to determine if glycol would backup into the hat tray section of the contactor. No glycol level has been noted in the gauge glass.

The orifice plate has never been changed during operation of the dehydration system.

INSPECTION AND PERFORMANCE TESTS

The contactor was shut down after about one and half years of operation for inspection. The inside of the contactor was in good condition. There was no sign of corrosion. Minor amounts of scale buildup were found.

Performance testing took place from August through October 1999. A total of nine tests were performed on approximately a weekly basis during that time interval.

HIGHLIGHTS

- The pre-contact section removed an average of 81% of all water removed by the dehydration system. The maximum removal was 94% and the minimum removal was 67%.
- Calculations showed the pre-contact section achieved an average dewpoint reduction of 58°F.
- The overall dewpoint reduction of the system averaged 78°F.
- The outlet dewpoint at line pressure was 15°F on average.
- Maximum dewpoint reduction was 86 °F and minimum dewpoint reduction was 70 °F.
- The maximum outlet dewpoint was 21 °F; minimum dewpoint was 6.4 °F.
- The average lean glycol concentration was 99.34% pure.
- The water content of the outlet gas was calculated to average 4.8 #/MMSCF with the high at 7.4 #/MMSCF and a minimum of 1.1 #/MMSCF.

A simulation based on the experimental data showed further that an average of 91% of a theoretical stage of contact was achieved. The maximum theoretical efficiency was 100% and the minimum theoretical efficiency was 77%.

The average conditions, performance, and gas composition are attached as Table “1”.

CONCLUSIONS

1. Use of a pre-contact section is effective in dehydrating gas prior to a contactor and has allowed the use of a carbon steel contactor in corrosive service.
2. Both CO_2 corrosion and H_2S scale buildup is mitigated by installing the pre-contact section to the dehydration system.
3. The pre-contact section works reliably and does not require extra maintenance, no extra downtime and no extra operating expense.
4. The pre-contact section adds about 91% of a theoretical stage to the contactor system.
5. This arrangement easily retrofits on existing contactors
6. Use of a pre-contactor makes it easier to identify the “specification break” from wet service to dry service.

REFERENCES:

1. Robert E. Sattler and Joseph W. Davidson, Dehydration of Gases, Patent # 2,812,830, November 12, 1957, United States Patent Office.

2. Harry M. Turner, Jeffrey M. Bigger, and James P. Meyer, Gas Treatment Method, Patent # 5,693,297, December 2, 1997, United States Patent Office.

3. Charles M. Mim, Natural Gas Conditioning System and Method, Patent # 4,701,188, October 20, 1987, United States Patent Office.

4. Steve Pyles and Robert G. Rader, Single Stage Co-Current Contactor Replaces Trayed Column on Offshore Platform for Dehydration, Presented at the January, 1989 Production Technology Symposium Twelfth Annual Energy – Sources Technology Conference Exhibition, Houston, TX, copyright 1989 Koch Engineering Company, Inc.

TABLE 1
PERFORMANCE DATA FOR A DEHYDRATOR WITH A PRECONTACT SECTION

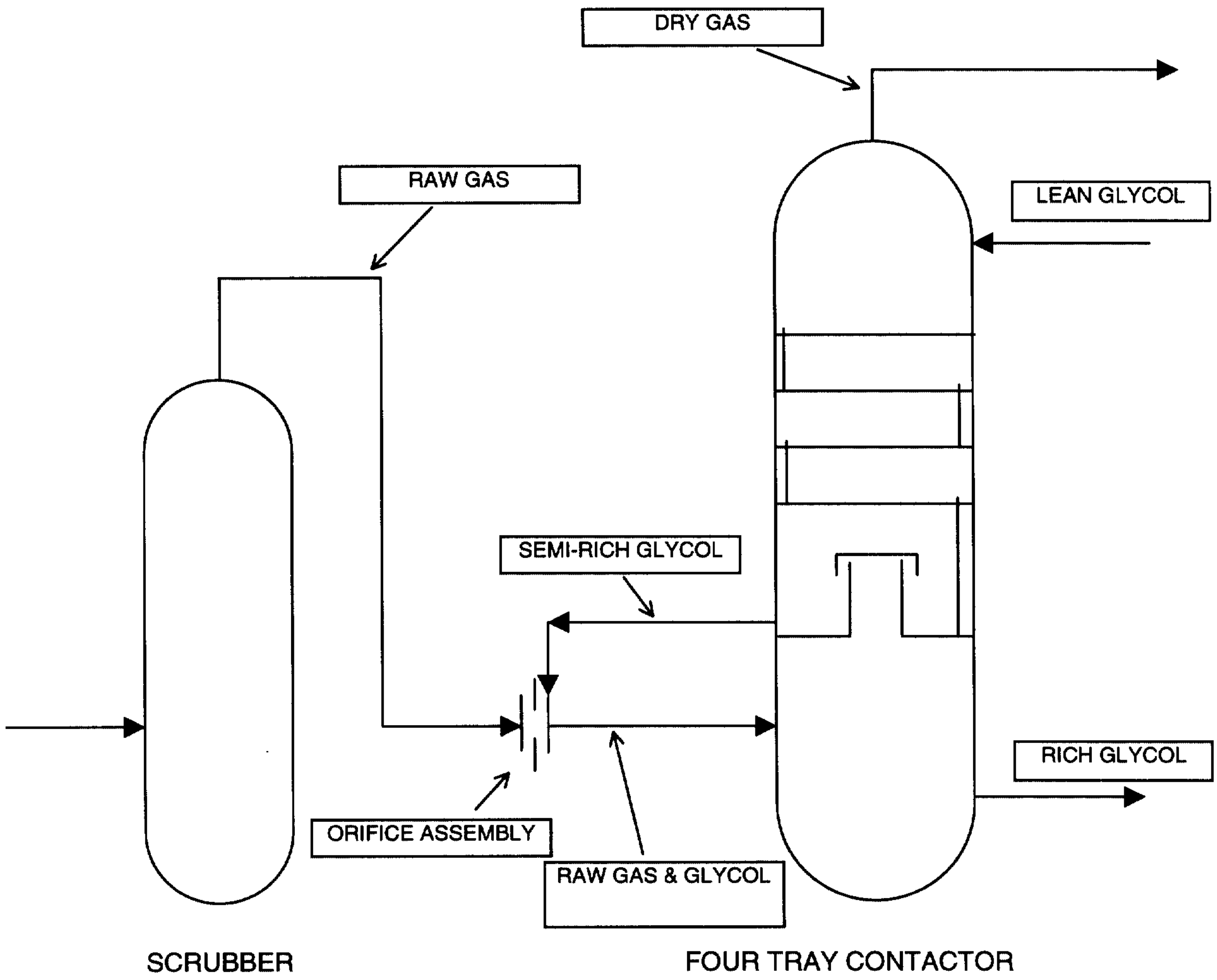
	AVERAGES	MAXIMUM	MINIMUM
Gas Data			
Flow (MSCFD)	2,855	3,777	2,254
Inlet Pressure (psig)	391	400	378
Inlet Temperature (deg F)	93.6	105.0	80.0
Glycol Data			
Circulation Rate (gpm)	0.97	1.03	0.92
Water Removal (gal Glycol/lb Water Removed)	3.66	4.98	2.68
Lean Glycol Percent Water	0.65%	0.73%	0.59%
Semi-rich Glycol Percent Water	1.06%	1.44%	0.70%
Rich Glycol Percent Water	2.82%	3.80%	2.08%
Water Content Data			
Inlet Gas Water Content (#/MMSCF)	101.1	140.2	66.4
Gas Water Content after Precontact (#/MMSCF)	14.2	26.0	6.9
Final Water Content (#/MMSCF)	4.9	7.4	1.1
Dewpoint Data at Operating Pressures			
Dewpoint After Precontact (deg F)	35.6	51.9	19.8
Precontact Dewpoint Depression (deg F)	58.0	61.9	51.6
Final Dewpoint (deg F)	15.3	20.9	6.4
Overall Dewpoint Depression (deg F)	78.3	85.9	70.2
Precontact Performance			
Precontact Percent of Total Water Removed	81%	94%	67%
Precontact Percent of Theoretical Stage	91%	100%	77%

GAS COMPOSITION	AVERAGE MOLE PERCENT
Nitrogen	0.528
Methane	5.169
Carbon Dioxide	85.268
Ethane	1.777
Hydrogen Sulfide	1.829
Propane	2.385
iso-Butane	0.500
n-Butane	1.187
iso-Pentane	0.419
n-Pentane	0.357
Hexanes	0.306
Heptanes +	0.276
TOTALS	100.000
Molecular Weight	42.79
Specific Gravity	1.4871
Gross BTU/CF (Dry)	273.7

FIGURE 1

FLOW SCHEMATIC

GLYCOL CONTACTOR WITH PRECONTACT SECTION



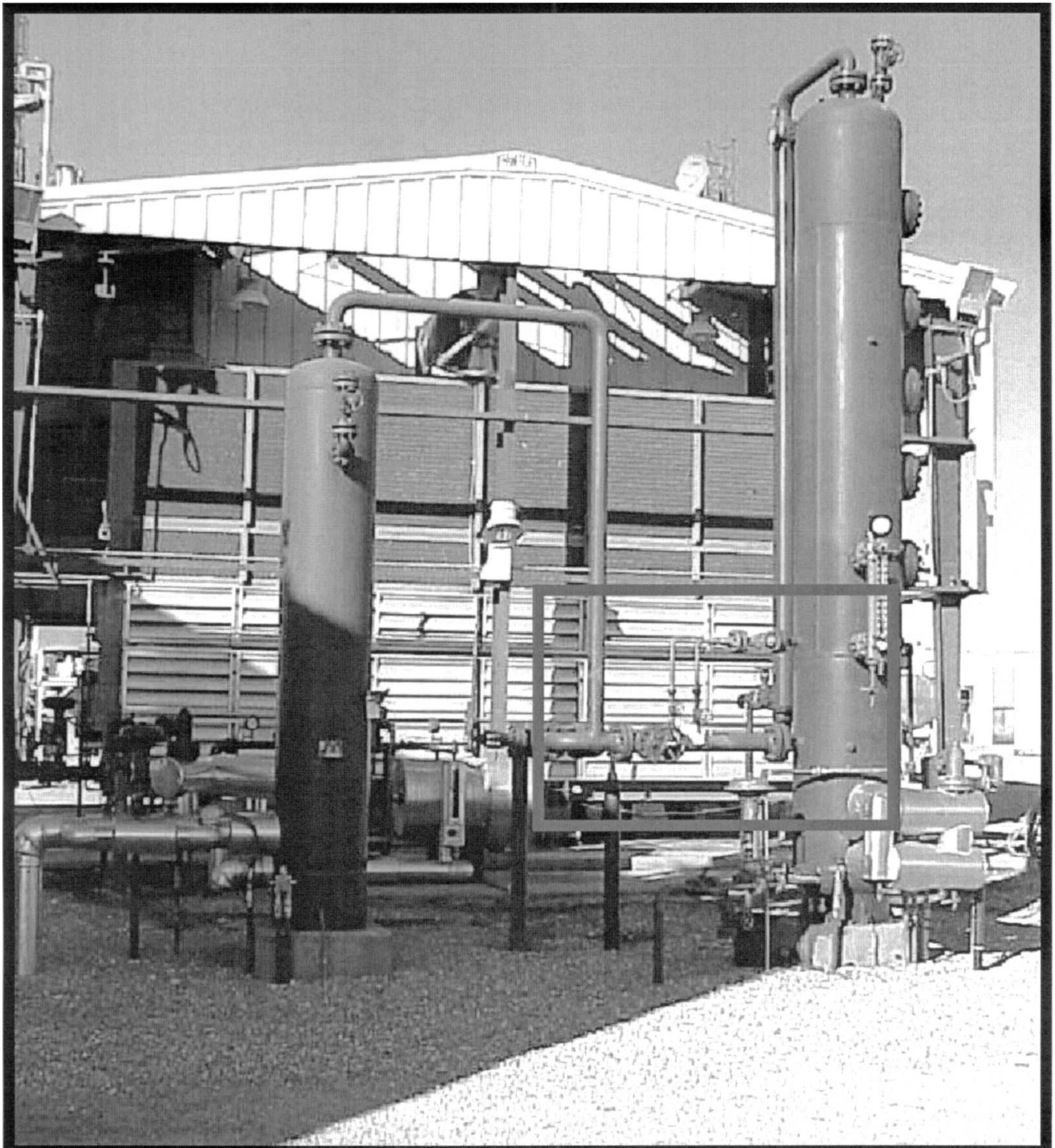


Figure 2

Overall photograph showing the scrubber and contactor with the precontact section shown within the highlighted rectangle.

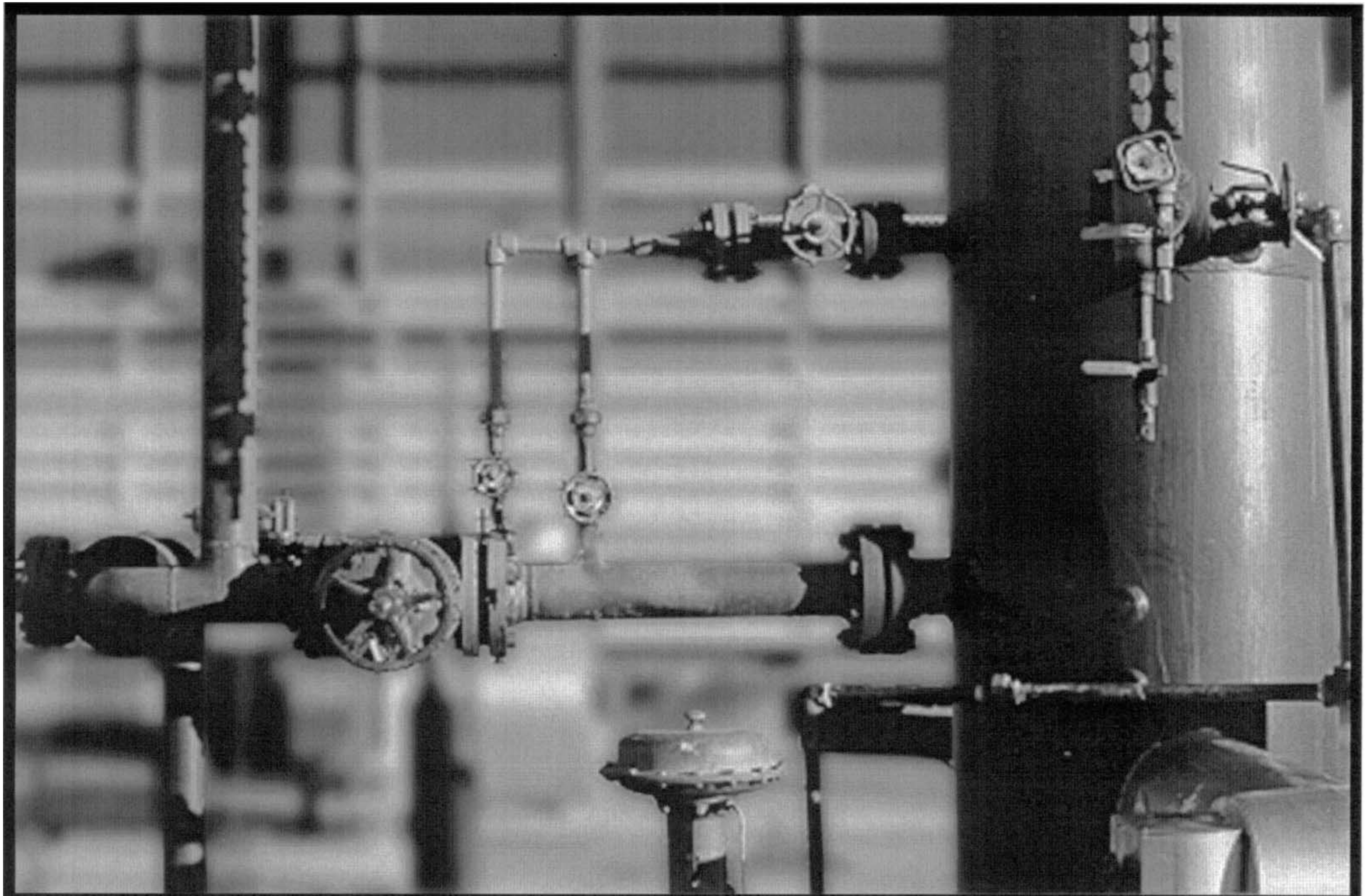


Figure 3

This photograph shows the precontact section of the dehydration system.

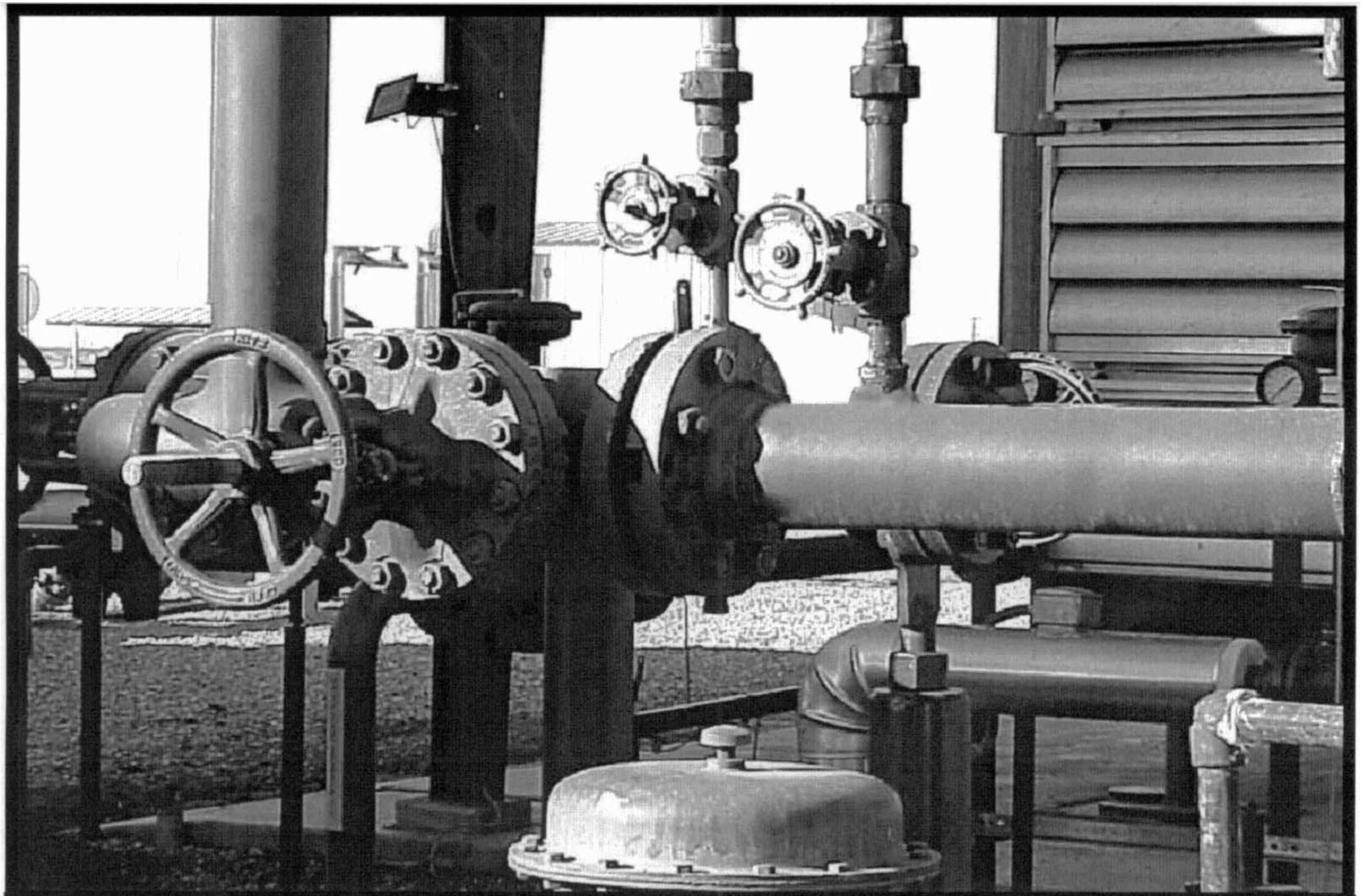


Figure 4

This photograph shows a closeup of the orifice of the precontact section.