3002

EVALUATION OF THE PERMA PURE DRYER FOR DRYING STACK GASES

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ABSTRACT

In the past, the sampling of stack gases containing hydrogen sulfide, sulfur dioxide, and water has always presented a problem because of the ease with which hydrogen sulfide and sulfur dioxide react in a wet stream. It is difficult to use an efficient solid absorbent without losing some of the sulfur compounds. Recently, Perma Pure, Inc., developed a dryer that operates on the principle of permeation distillation. The wet gas is passed through a bundle of semi-permeable plastic tubes encased in a stainless steel shell (Figure 1). The shell is purged with a counter current flow of dry gas.

In our study, analyzed synthetic stack gases were passed through the Perma Pure Dryer and the effluents analyzed. Results show that the only change in composition of the streams was the loss of water. Various solid dessicants were compared with the Perma Pure Dryer in efficiency and retention of sulfur gases.

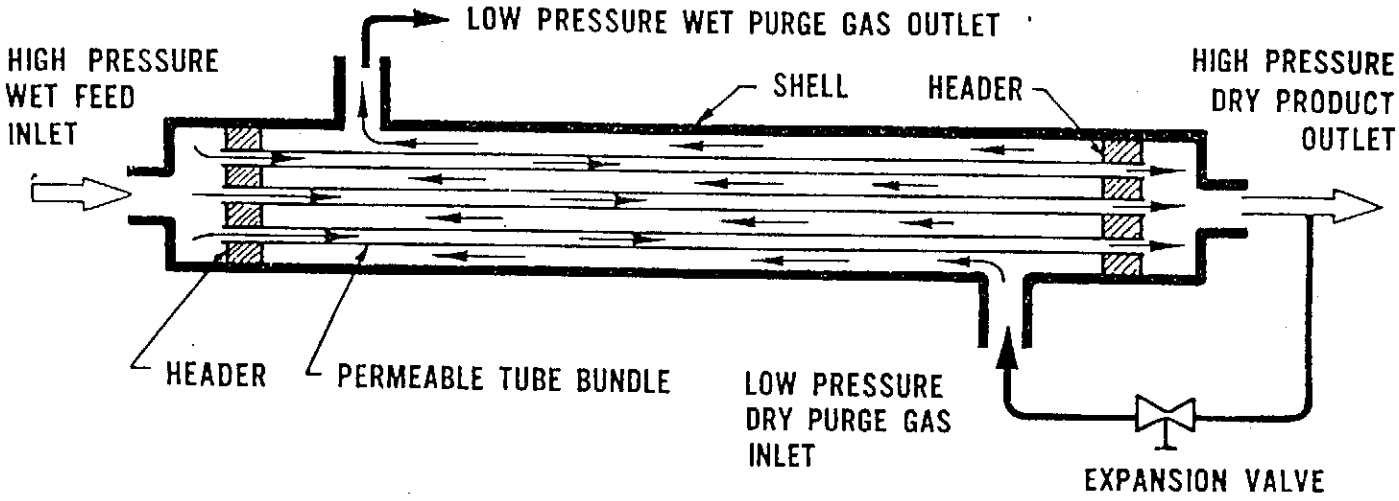
LOW PRESSURE WET PURGE GAS OUTLET
HIGH PRESSURE WET FEED INLET
SHELL
HEADER
HIGH PRESSURE DRY PRODUCT OUTLET
HEADER
PERMEABLE TUBE BUNDLE
LOW PRESSURE DRY PURGE GAS INLET
EXPANSION VALVE

FIG. 1

The sulfur compounds were analyzed by means of a gas chromatograph equipped with a flame photometric detector specific to sulfur. Flow measurements were made using a wet test meter rated at 0.6 liters per revolution. Gas blends were made by flow blending through a manifold and adjusting the flow of each gas using the wet test meter and stop watch. The original gas blends were 300 ppm each in nitrogen.

In order to obtain a valid analysis of the data from the experiments, the following gas blends were passed through the system:

APPROXIMATE CONCENTRATION IN PPM (v/v)

	H_2S	SO_2
1	50	--
2	--	50
3	150	--
4	--	150
5	50	150
6	150	150
7	50	150
8	150	50

In all cases the balance was air. Water was added to each of these blends at 4%, 8%, and 12% levels.

During one phase of the experiments, a glass tube was inserted between the saturator and the dryer. When the temperature of the tube was allowed to fall below the dew point and water droplets appeared, free sulfur was observed forming on the tube.

Tables Ia, b, and c summarize the data obtained in the course of these experiments. Qualitatively these data show:

- The determination of H_2S is more precise than SO_2.
- The determination of H_2S may be slightly more precise on dry gas than wet, but the opposite exists with SO_2.
- The overall relative precision is about 2% at high sulfur concentrations and 3% at low levels.

TABLE Ib

DRYING TUBE EVALUATION - SUMMARY
BINARY SYSTEM - EQUAL CONCENTRATIONS

v ppm, S

Component	Wt. % H_2O	Theory: 150				Theory: 50			
		Condition: Wet		Dry		Wet		Dry	
		Avg.	σ	Avg.	σ	Avg.	σ	Avg.	σ
H_2S	4	154	2.28	154	1.65	46	1.02	45	0.71
	8	154	2.54	153	1.38	46	1.31	46	0.76
	12	154	2.54	153	1.63	46	1.44	46	0.37
Overall Average(1)		154	2.28	153	1.41	46	2.25	46	0.71
SO_2	4	212	3.06	208	3.27	58	1.22	57	0.79
	8	212	4.45	208	6.10	59	1.74	56	1.12
	12	211	2.89	208	5.04	59	1.54	57	1.71
Overall Average(1)		212	3.36	208	4.57	59	2.85	57	2.28

(1) n = 15

- There is no great loss of either sulfur compound due to the drying process, regardless of initial water concentration

Table II summarizes the effectiveness of the drying tube. It can be seen that regardless of initial water concentration the H_2S loss is less than 1% at either high or low sulfur levels averaging about 0.03%. In the case of SO_2 although the loss is greater, averaging about 3%, it is still within the precision of measurement. "t" Tests of significance, an indication of the significance of differences show that the differences in average values before and after drying are not significant (i.e., not great enough that they cannot be explained by the measured variability).

Comparison of Drying Methods - Prior to the introduction of the Perma Pure Dryer, other means such as chemical dessicants had to be used for drying gases. Using standard blends of H_2S and SO_2, the efficiency of some of these dessicants was investigated. Table III presents a summary of our experimental data.

These data show that silica gel is the least satisfactory dessicant in this operation and Drierite dries to about the same degree as does the Perma Pure dryer. P_2O_5, of the three dessicants tested, shows the least loss of sulfur compounds with a satisfactory reduction of water concentration. For all runs involving dessicants, 200 g of drying agent was used and all were "cured" by passing dry H_2S and SO_2 ove than before using.

Alternative Operating Procedure - After the initial evaluations were completed, the manufacturer of the Perma Pure Dryer suggested the possibility of using the dryer without a purge stream, making it more convenient to use in the field. This was tried with the following results:

If the dryer has been purged overnight with no water input, and then wet gas is passed through at 100 cc/min, then there is no apparent loss of H_2S and SO_2 for 30 minutes. At the end of 60 minutes, the loss of each sulfur compound was about 20%. After 70 minutes, there was a breakthrough and the loss was almost total.

If the purge is turned off while the water input is maintained, there is a gradual rise in dew point. At -170°C (3000 ppm H_2O) achieved with no purge for 20 minutes and 300 ml/min throughput, (8% H_2O) the following data were obtained.

H_2S In	150 ppm	H_2S Out	<5 ppm
	148		<5
SO_2 In	140 ppm	SO_2 Out	<5 ppm
	145		<5

TABLE III

COMPARISON OF DRYING METHODS

Concentration in ppm (v/v)

	H_2O In	H_2O Out	H_2S In	H_2S Out	SO_2 In	SO_2 Out
Perma Pure Dryer	5%	8	250	248	242	240
Silica Gel (dried)		40	250	65	242	<5
Phosphorus Pentoxide		14	250	230	242	232
Drierite		9	250	<5	242	<5
Perma Pure Dryer	8%	9 ppm	250	246	242	240
Silica Gel (dried)		41	250	66	242	<5
Phosphorus Pentoxide		13	250	232	242	230
Drierite		10	250	<5	242	<5

NOTE: The water level of the purge gas used in the Perma Pure Dryer was 8 ppm.