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PUREX PULSE GENERATOR OPERATIONINTRODUCTION

A large (Size 2) Purex pulse generator was installed in the 321 Building Tank Farm to pulse solutions in the prototype Purex HA Column. Flow sheet considerations indicated a need for information on leakage rates with various size weep holes in the pulse generator piston. In addition to leakage tests, experiments were conducted to determine the air required under the piston to hold the column contents away from the pulse generator piston thereby preventing leakage during shut down and to determine the time required to bleed the air trapped in the pulse leg when the column is first filled.

SUMMARY

Leakage past the piston was not appreciably affected by pulse frequency. Average leakage rates were as follows:

	LEAKAGE RATE, Gal./Min.	
	Organic ⁽¹⁾	Water
Weep hole plugged-----	.03	.07
3/64 in. diam. weep hole--	.15	.19
3/32 in. diam. weep hole--	.57	---

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To maintain a static balance (no liquid leakage past piston) between the pulse leg and the pulse column with the column full, air at pressures from 8.0 to 13.5 lbs./sq. in. ga. was applied under the piston. At 9.5 lbs./sq. in. ga. and with a 3/64-inch-diameter weep hole, 1.6 std. cu. ft./min. of air was required to maintain a balance. With a 3/32-inch-diameter weep hole, 4.0 std. cu. ft./min. of air at 9.5 lbs./sq. in. ga. were required.

Bleeding the air out of the pulse leg under start-up conditions, even with the piston weep hole plugged, was rapid. The longest time required to bleed the pulse leg was 36 minutes, which included a column-filling time of 30 minutes.

DISCUSSION

A large (Size 2) Purex pulse generator (PG-G2-Op. Sp.) was installed in the tank farm of the 321 Building. This pulse generator was tested pulsing either water or an organic⁽¹⁾ solution in the prototype Purex HA Column. A schematic drawing of the installation is shown in Figure 1. The column was equipped with a prototype cartridge consisting of 23% free area nozzle plates and louver plates. Except for the head against the piston, which was two feet less (15.5 feet) than that in the Purex Plant, the installation was identical to the Purex Plant HA Column and pulse generator installation.

Results from previous studies⁽²⁾ on this pulse generator indicated that more information was required about: 1) leakage rates past the piston; 2) the possibility of using air pressure under the piston to hold the column in equilibrium during short shut-downs; and 3) time required to bleed the pulse leg when the column is initially filled.

Liquid Leakage Rates Past the Piston

The piston for the Size-2 pulse generator is 21.2 inches in diameter and has four rows of expanding piston rings and two guide rings (top and bottom of piston). The volume enclosed by the cylinder between the base of the piston and the overflow line in the cylinder is 17.8 gallons. The piston was designed with a 3/32-inch-diameter weep hole in the flat base so that no air would be trapped under the piston, and so that potentially "hot" liquids trapped above the piston would drain when the pulse generator was not in use.

Leakage rates past the piston with a 3/32-inch-diameter weep hole, a 3/64-inch-diameter weep hole, and no weep hole are given in Table I, and are plotted as a function of pulse frequency in Figures 2 and 3.

(1) 30 vol. % TBP in Shell Deodorized Spray Base.

(2) "Purex Pulse Generator Operation", From P. B. McCarthy to File, Feb. 4, 1955.

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By reducing the diameter of the weep hole by a factor of two, the leakage rate was reduced by about a factor of four. This is in close agreement with what would have been predicted by the orifice equation

$$\frac{Q}{A} = C \sqrt{2gh}$$

Calculated coefficients, shown in Table I, vary between 0.90 and 0.71. For these calculations, the leakage rate through the hole was found by subtracting leakage rates with the hole plugged from leakage rates with the hole open. At low leakage rates, small variations in flows cause large changes in the discharge coefficient, and this may be the cause of the variation in the discharge coefficient for the 3/64-inch-diameter weep hole.

Because of the greater pressure against the piston, leakage rates, as shown in Figures 2 and 3, were higher with water in the column than with organic.

Air Pressure Under the Piston

During crash shut-down of the Purex Plant entailing stopping all feed to columns, the weep hole in the pulse generators would allow the columns to drain to the pulse generator height. The equilibrium of the column would be destroyed and, in some cases, process solutions going through the weep hole would enter tanks in which its presence would be undesirable.

In tests made to stop the leakage past the piston, air was injected under the piston of the pulse generator. Air leakage rates past the piston at static conditions are given in Table II and are plotted against pressure under the piston (determined by liquid level in the pulse leg) in Figure 4. Since air flow rate changed very little over the pressure range involved, it was found desirable to control the liquid level with a pressure controller instead of a flow controller. With a pressure regulating valve, the liquid level in the pulse leg and column was held steady for five days during one period of shut-down.

A test was conducted in which the overflow line above the piston was closed and air applied above the piston through the overflow flange. With this installation, air flowed out of the cylinder head between the bushing and the piston drive shaft. Air leakage was about the same in this case (Table II) as it was with air under the piston and a 3/32-inch-diameter weep hole. In no case did air flow rates necessary to balance the column exceed 4.6 std. cu. ft./min.

Pulse Leg Bleed Time

Piston rings on all pulse generators are lubricated by the pulsed solution after it travels up the pulse leg to the piston. Table III gives the time required to bleed the pulse leg starting with an empty column. Pulse generator piston frequency did not appreciably affect the time to bleed air from the leg. At both 47 and 100 cycles/min. the pulse generator was

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TABLE III

PUREX PLANT PULSE GENERATOR TESTS

Time Required to Bleed Pulse Leg

Size 2 Pulse Generator, PG-G2-OP. SP., on 321 Bldg. Prototype HA Column

Head Against Piston: 15-1/2 Ft.

<u>Weep Hole Diam., Inch</u>	<u>Time Required to Fill Column, Min.</u>	<u>Solution in Column</u>	<u>Frequency, Cycles/Min.</u>	<u>Time to Bleed Pulse Leg, Min.⁽¹⁾</u>	<u>Time for Liquid To Reach 12'5", Min.⁽¹⁾⁽³⁾</u>
3/32	30 3/4	Water	0	-----	11
3/64	31	"	0	26	--
3/64	30	"	0	24 3/4	--
0	29 1/4	"	0	32	20
0	32 1/2	"	47	34(2)	20
0	30 1/2	"	100	32(2)	20
0	30 1/4	"	0	36	21

(1) Time from the start of column filling.

(2) Approximate time. With Pulse generator running leakage of air past rings could not be readily distinguished.

(3) Liquid level in pulse leg measured from the bottom of the column.

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PUREX PLANT PULSE GENERATOR TESTS

FIGURE 1

SCHEMATIC LAYOUT OF PUREX PLANT PROTOTYPE
HA COLUMN AND PUREX SIZE 2 PULSE GENERATOR

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FIGURE 2

PUREX PLANT PULSE GENERATOR TESTS

Size 2 Pulse Generator, 202A PG-G2-OP. SP.,
on the 321 Bldg. Prototype HA Column.
Head against piston: 15-1/2 Ft.
Solution in column: 30 vol. % TBP in Shell
Deodorized Spray Base.

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FIGURE 3

PUREX PLANT PULSE GENERATOR TESTS

Size 2 Pulse Generator, 202A PG-G2-OP. Sp.,
on the 321 Bldg. Prototype HA Column.
Head against piston: 15-1/2 Ft.
Solution in column: Water

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FIGURE 4

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PUREX PLANT PULSE GENERATOR TESTS

Size 2 Pulse Generator, 202A PG-G2-OP. SP.,
on the 321 Bldg. Prototype HA Column.
Head against piston: 15-1/2 Ft.
Solutions in column:

△ Organic, 30% vol. % TBP in Shell
Decolorized Spray Base
× Water

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