MASTER

DENSITY MONITOR FOR PUREX HA COLUMN

By

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DENSITY MONITOR FOR PUREX HA COLUMNINTRODUCTION

Prior to the use of Purex two-cycle flow sheets, uranium concentration in HA Column was obtained by static pressure measurements which were assumed proportional to uranium concentration (see Fig. 1). With the advent of Purex two-cycle flow sheets, including back cycle, a need became apparent to measure uranium concentration at the feed point. Back cycling of a column effluent stream plus scrub section dilution above the feed point necessitated this information which would be useful in determining optimum column operating conditions. The densimeter described herein was developed for this purpose.

STATEMENT OF THE PROBLEM

The problem consisted of developing an instrumentation system to satisfy the following conditions.

1. An accuracy of ± 0.0025 specific gravity units would be usable and ± 0.001 specific gravity units would be excellent.
2. Measurement range of 0.95 to 1.00 specific gravity units.
3. Maintain instrument accuracy for a column pulser frequency range of 50 to 104 cycles per minute.
4. Radiation resistance of the transducer sufficient to withstand the intense HA Column gamma radiation (approximately 10^4 Roentgens/hour at the outside diameter).
5. Transducer elements able to withstand nitric acid and organic solvents used in Purex.
6. Transducer elements suitable for remote installation on the column by a Purex canyon crane.
7. Transducer and cabling should have an estimated life of six months in HA Column.

SUMMARY

A densimeter system is described which was developed for use on HA column. Reproducibility of instrument readings is $\pm 1\frac{1}{2}\%$ of recorder span for pulser frequencies of 44 to 104 cycles per minute. The effects of column pulsations and column static pressure at the feed point are small. Simulated column feed point static pressure of 10 psig caused improved precision due to added damping of float oscillations.

All criteria listed in the preceding section were satisfied during 321 Building non-radioactive tests and in previous float-type column interface control installations. Following are the densimeter performance specifications.

Range = 0.95 to 1.00 specific gravity units

Precision = $\pm 1\frac{1}{2}\%$ of recorder span
= ± 0.00125 Specific gravity units
= $\pm 0.1\%$ of specific gravity reading

Sensitivity = 0.0005 specific gravity units (1% of span)

Accuracy maintained for Pulser frequencies of 44 to 104 cycles per minute.

RECOMMENDATIONS

Because of the favorable results obtained in 321 Building tests, it has been recommended to CPD Facilities Engineering Operation that a prototype densimeter, drawing SK-2-2951, be tested on the Purex HA Column.

DISCUSSION

In order to fully evaluate the instrumentation under dynamic but non-radioactive conditions a four-inch glass column was set up in the 300 Area, 321 Building. A variable frequency mechanical pulser was connected to the bottom of the column and lines were provided to feed an organic liquid in at the bottom and an aqueous phase in at the top. A side arm closely approximating the one on HA column was also installed (See Fig. 2).

Description of the Densimeter Mockup

Figure 2 is a photograph of the 321 Building glass column used to test the densimeter. As shown, the system consists of a two diameter (two stage) hydrometer type stainless steel float, float guide assembly, and a three-inch travel Fischer and Porter rotameter coil connected to a Type 9100 Foxboro Dynalog Recorder. Three one-fourth-inch diameter vertical air pipes are equally spaced around the float guide to provide circulation of organic through the column side arm, also see drawing SK-2-2951 included with this report.

An air-liquid interface exists at approximately the center of the vertical side arm (see Fig. 3) due to the entrapment of air. The float was designed to float at this air-liquid interface. A two-stage float was specified because it would have been impossible to place a one-diameter cylindrical float in the available space. Calculations indicated that a cylindrical one-diameter float would have had to be five feet long for the same float travel (three inches).

Interconnections of the rotameter coil with the Dynalog null-balance system are indicated in Fig. 4. Resistance values of resistors F, S and G are approximate only since they must be selected to match a particular rotameter coil and to obtain the desired recorder range. The system shown yielded full scale pen travel for three inches of coil armature travel, corresponding to a specific gravity change of 0.05 units (0.95 to 1.00 specific gravity units).

Results of Development Work

The first float tested was cylindrical in shape (3 inches in diameter by 16-1/2 inches long) and was designed for a float travel of one and a half inches for a specific gravity range of 0.9 to 1.0. This float was fairly stable and exhibited an over-all precision of $\pm 5.0\%$ of recorder span for column pulser frequencies of 32 to 114 cycles per minute. An immediate need was seen for a smaller diameter float in order to allow room for some reasonably sized air tubes around the float guide. The air tubes were needed to provide continuous

circulation of fresh feed point organic to the float. Testing of the three-inch diameter float was therefore discontinued because no room was available for air lift tubes around its outer diameter and a system with more precision was desired.

A two-stage float, consisting of a two-inch diameter submerged section 8-3/4 inches long and a one-inch diameter top section 4-1/2 inches long, was designed for one and one-half inches of travel for the specific gravity range of 0.94 to 0.98. In order to include three air bubbler tubes, the float guide assembly was redesigned at the same time.

On all tests up to this point, a 108 microfarad capacitor had been connected across the amplifier output in order to damp out recorder pen fluctuations caused by column pulsations. Because of unexplained drift in pen indications it was decided to replace the capacitor with a dashpot having a higher damping factor than the one already in the recorder. By using heavier dashpot oil and a closer fitting plunger and dashpot assembly, it was possible to raise the full scale pen speed from approximately five seconds to ninety seconds. This change caused the pen trace width to be reduced from 30% of full scale to a tolerable value of 2% and still provided an adequate response time of ninety seconds for full scale pen travel. Response time as used here is the time necessary for the pen to move through its full travel in response to a full scale step function input. Foxboro components used to make up the dashpot were silicone oil (30 second) part No. 48675, plunger (15 second) part No. E 100-KB, and dashpot (15, 60 or 100 second) part No. E 100-FF.

Tests of the two-stage float and new float guide were successful as regards the air lifting action of the air bubbler tubes and the damping action of the long time constant dashpot. Performance tests initially indicated a tendency for the light weight float to adhere to the inside surface of its guide and to cause reading errors of 25% in some cases. By roughening the

highly polished outside surface of the float and increasing the spacing between the smaller diameter of the float and the float guide, it was possible to reduce error due to float sticking to a negligible amount.

A total air flow through all three air tubes of between 0.5 and 1.0 scfh was determined to be satisfactory for proper air lifting action. The actual value in this range did not appear to be critical as long as it was maintained constant by means of pressure reducing valve (PRV) and a purge rotameter. A separate PRV and rotameter are required on each air pipe to maintain equal flows as well as a constant total flow in case of plugging in one or more tubes.

Tests of reading error vs column frequency for the two-stage float system indicated a precision of $\pm 8-1/2\%$ of recorder span for the pulser range of 30 to 100 cycles per minute. One way appeared to be available for increasing the precision; this was to cause the float to travel farther for a given specific gravity change. By increasing float sensitivity in this manner it would be possible to decrease even further the errors due to column pulsations and possible float sticking.

A third and final float was fabricated for the maximum (three inch) travel of the rotameter coil and for the specific gravity range of 0.95 to 1.00. This float, shown in Fig. 5, performed much better.

The effects of column pulsations were much less severe for the second two-stage float. Densimeter reading error plotted vs pulser frequency (Fig. 6) revealed a precision of $\pm 2-1/2\%$ of recorder span from 44 CPM to 104 CPM. This corresponded to ± 0.00125 specific gravity units for the span of 0.95 to 1.00 specific gravity units. In most cases column pulsations caused instrument readings to be higher than for static conditions, as indicated in Fig. 6. This was not considered serious because repeatability was excellent and pulsation error could be compensated for, if necessary, by calibrating the system to read slightly low with the pulser off. Starting the pulser would then cause instrument readings to

be more accurate under dynamic conditions. All tests on the final system were run with the glass column pressurized to 10 psig. This was done to determine the effects of HA Column static pressure at the feed point. No harmful effects were noted, instead, an improvement in precision actually occurred due to the additional damping introduced. Pressurization of entrapped air in the side arm probably contributed most to this effect.

Figure 7 is a typical recorder trace for the final system. The small pen fluctuations were caused by the pulser and probably could be completely damped out, however, a small oscillation is desirable to create operator confidence that the system is operating. In addition, any more damping would result in poor system response time. The effects of pulser frequency on precision are small, being always within $\pm 2-1/2\%$ of recorder span.

The final recommended transducer design is shown in reduced drawing, SK-2-2951 at the end of this report. It was designed to fit into a standard four-inch nozzle on a side arm just above the organic feed point.

C. E. Huck/jdm

CURVE OF ORGANIC PHASE SPECIFIC
GRAVITY VS. URANIUM CONCENTRATION

FIGURE 1

367 108

UNCLASSIFIED

FIGURE 2

UNCLASSIFIED

367 009

FIGURE 3

367 010

SKETCH OF H.A. COLUMN SIDE ARM
FOR DENSIMETER

FIGURE 4
SIMPLIFIED SCHEMATIC DIAGRAM
OF RECORDER BRIDGE CIRCUIT

FIGURE 5.

USE SCRIBE TO ~~_____~~
STRIATE FLOAT // TO FLOAT
AXIS, STRIATIONS TO BE
0.005" DP. - SPACED $\frac{1}{32}$ "
APART, ALL AROUND PT # ①.
REMOVE ALL BURRS W/ FINE
EMERY PAPER AFTER SCRIB-

TWO STAGE FLOAT FOR 3" TRAVEL (.95 TO 1.00 SFG. RANGE)
MTL: 304L STNLS. STL. WELDED, WATER-TIGHT CONSTRUCTION

TYPICAL DYNALOG RECORDER CHART
FOR THE FINAL DENSIMETER SYSTEM.

Recorder Span = 0.95 to 1.00 Specific Gravity Units
Float Travel = 3.0 ins.

QTY.	ITEM	DESCRIPTION	MATERIAL
1	ASSEMBLY		
1	FLOAT		
3	PIPE 1/2 DIA SCH 40 IPS		304L SST
1	TUBING, SEAMLESS 3/8 O.D. x .035 WALL		304L SST
1	PLUG 3/8 O.D. x 1/2 LG		304L SST
1	TUBING 2" O.D. x .0375 WALL		304L SST
1	SPRING 3/8 P.D. 1 1/2 TURNS 3/8 FREE LENGTH		1/8 (OAT) PHANO WIRE
3	FEMALE CONNECTOR 3/8 TUBE x 1/2 IPS		SWAGelok 600-7-4
6	FIN 10 1/2 x .688 x 1/8 THK		304L SST
1	TUBING 3/8 O.D. x .035 WALL x 1/2 LG		304L SST
1	ARMATURE FOR FISCHER & PORTER CO.		ROTAMETER COIL W/ 5" ARMATURE TRAVEL
1	ROD 1/2 O.D. x 2 1/2 LG.		304L SST
1	PIPE 2" SCH 40 IPS		304L SST
1	PLUG 3/8 DIA. x 1/2 THK		304L SST
1	WASHER FOR FISCHER & PORTER CO.		ROTAMETER COIL W/ 5" ARMATURE TRAVEL
2	SPOOL FOR FISCHER & PORTER CO.		"
2	COIL FOR FISCHER & PORTER CO.		"
1	PIPE 3/4 SCH 40 13 1/2 LG. TURN O.D. TO 3.750"		304L SST
1	PLATE 1/2 THK		304L SST
1	PLATE 1/2 THK		304L SST
2	PLATE 1/2 THK DRILL FOR PITS NO. 19		304L SST

APPROVED

- NOTES:**
- ALL PARTS TO BE MADE OF CORROSION TESTED 304L SST UNLESS OTHERWISE SPECIFIED.
 - TACK WELD THE (3) 1/2 SCH 40 AIR PIPES (PT 3) AT TOP, CENTER & BOTTOM OF THE ASSY. WELD PT 3 TO PT 13.
 - POT INSIDE OF CONNECTOR HEAD BODY WITH SCOTCHCAST EPOXY RESIN AFTER ASSY.
 - USE SCRIBE TO STRIKE FLOAT OF 1/4" TO FIDAT AXIS.
 - STRUTS TO BE .005" OF SPACED 1/4" APART ALL AROUND PT. 6. REMOVE ALL BURS WITH FINE EMERY PAPER AFTER SCRIBING.
 - PART NOS 4, 5, 6, 10, 13, 18 SHALL BE CONCENTRIC WITH EACH OTHER WITHIN ±.020 T.I.R.
 - PT. 6 TO BE ALL WELDED WATER TIGHT CONSTRUCTION OF 304L SST. CORR. TESTED. LEAK TEST AT 15 PSI MIN.
 - WIDE GROOVE 1/4" OF 1/8" LG. IN PT. 13 FOR PT. 9.
 - TACK WELD AFTER SHOP CALIBRATION OF SYSTEM.
 - ROUND OFF I.D. TO 1/8".
 - SEAL WELD AFTER SHOP CALIBRATION OF SYSTEM.
 - TURN DOWN O.D. OF PT. 18 TO 3.75".
 - BALLAST PITS NO. 19 (1) AFTER ASSY FOR 1.00" STEP SUBMERSION IN LIQUID OF SRG. 1.00. NOMINAL TOTAL WT. = 286.5 G.M.

ALL PARTS UNLESS OTHERWISE NOTED SHALL CONFORM TO THE FOLLOWING:

TOLERANCES: (FRACTIONAL & DECIMAL) ±.0005 INCHES
PARTS TO SHOW EDGE CONTOURS, FREE FROM BURRS
UNLESS SPECIFIED OTHERWISE, ALL SURFACES TO BE CLEAN
ALL MACHINED SURFACES √ MAX DIA. 1.000
ALL MATERIAL TO BE AS SPECIFIED ON SERIAL CERTIFICATE

NO.	DESCRIPTION	REV. BY	DATE	REV. BY	DATE
1	REVISIONS				
CLASSIFICATION					
NONE					
SK-2-2951					
SCALE: NONE					
DRAWN BY: J. J. DATE: 6/15/55					
CHECKED BY: J. J. DATE: 6/15/55					
APPROVED BY: J. J. DATE: 6/15/55					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
HA COLUMN LIQUID DENSITY MONITOR ASSEMBLY-FLOAT TYPE					
202A 5900					
SK-2-2951					

367-015