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TITLE

RESULTS OF AIR ENTRY CONTROL TEST #1
DR REACTOR

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RESULTS OF AIR ENTRY CONTROL TEST #1
DR REACTOR

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E. J. Filip, Manager
DR Processing Operation
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RESULTS OF AIR ENTRY CONTROL TEST #1
DR REACTOR

- Ref: 1. Baars, R.E., PITA IP-26-I, Transition to High CO₂ Concentrations and Revision of Gas Purity Limits and Controls, HW-79281, Secret, October 17, 1963.
2. Letter, D. K. George to E. J. Filip, Air Entry Control Tests - DR Reactor, November 8, 1963.

PURPOSE

PITA IP-26-I¹ specifies that testing be conducted to 1) establish an interim normal limit for nitrogen concentration in the reactor gas; 2) obtained information to be used in defining assuredly positive gas system pressure; and 3) obtain other useful information on the reactor gas system, such as total apparent system volume, accuracy of the gas activity meter at low nitrogen concentrations, etc.

TEST SUMMARY AND RESULTS

The test data are shown graphically in Figures 1 and 2. The test began January 20, 1963. The gas system unit pressure was first raised by 0.06 inches of water on January 21; the system pressure was raised a second time by 0.06 inches of water on January 27. The test ended January 28 by increasing the flow for a 45-minute period, then slowly reducing the unit pressure until the air entry rate increased, indicating that unit pressure dependent air was entering the reactor. Shortly after the start of the test, on January 22, the dewcell system was removed from service and valved out with no apparent effect on the air entry rate. Four dryer changes were made during the test with no apparent system air contamination. There was a small amount of air contamination when the unit pressure was lost momentarily. This air entry appears as a small "blip" on Figure 1.

Mass spectrometer samples of the CO₂ makeup taken during the test indicate a negligible (less than 0.01 per cent) amount of nitrogen in the makeup gas.

The apparent nonunit pressure dependent air entry rate was 45 cubic feet per day. The minimum pressure indicated on the circular recording chart that would exclude unit pressure sensitive air was + 0.08 inches of water. This pressure corresponded to a reading of 36 on the pressure recorder chart. The system makeup was controlled by the exit pressure differential. The inlet pressure differential varied from

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0.06 inches of water less than the exit differential to 0.15 inches of water greater than the exit differential during the test.

DISCUSSION

A. Air Entry Rate

The air entry rate to the reactor for any stable nitrogen concentration can be found from:

$$R_a = \frac{N_2\%}{100} \times \frac{1}{0.78} \times G_s$$

where: R_a = air entry rate, cfd.

G_s = daily total gas loss, cfd.

When the unit pressure is raised, the N_2 concentration will decline and stabilize at a new value. If the air entry rate does not change following a raise in unit pressure, this air entry rate must be nonunit pressure dependent.

The data obtained before the first unit pressure raise indicate an air entry rate of about 170 cubic feet per day. After the first pressure raise, the N_2 concentration stabilized at a value corresponding to an air entry rate of about 45 cubic feet per day. The second pressure raise also resulted in an apparent air entry rate of 45 cubic feet per day, which would indicate this air entry rate is nonunit pressure dependent.

B. Positive Pressure

The unit pressure was slowly reduced at the end of the test to determine what minimum unit pressure would exclude pressure dependent air. It was found that the first indication of increased air entry occurred following a drop from 36 (0.08") to 35.5 (0.065") on the pressure indicator chart. It was noted from the test data that the exit differential before the start of the test was also 36 (0.08") and this differential allowed an air entry of about 170 cfd; however, the inlet differential was about 35 (0.05") at the start of the test and 40 (0.20") at the time the first additional air entry was noted at the end of the test. Because of this variation in the inlet differential (or that differential which is not being controlled), the minimum positive pressure must be defined in terms of the lowest pressure differential on the indicator chart, which may or may not be the controlled pressure differential.

C. Evaluation of Gas Activity Meter

One of the purposes of the test was to evaluate the performance of the gas activity meter at low nitrogen concentrations. Figure 3, a plot of the exit

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gas activity meter readings against chromatograph N₂ concentrations, shows the activity meter was accurate at the lower N₂ concentrations. The gas flow was increased during the test to investigate the effect of flow on gas activity. No change in activity was observed as a result of this flow change.

D. Additional Information

1. Apparent System Volume

If no additional air enters the gas system following a pressure raise, the plot of N₂ per cent against total gas used (since the pressure raise) on semi-log paper, should be a straight line. The equation of this line is:

$$\log_e \frac{C_1}{C_0} = -\frac{G_1}{V_S}$$

where: C₁ = N₂ concentration at some time after the pressure raise.

C₀ = N₂ concentration at the time of the pressure raise.

G₁ = total gas used since the pressure raise.

V_S = total apparent system volume.

The plot of N₂ per cent against total gas used (Figure 1) followed a straight line in the early part of the test because the air entry rate was small relative to the initial air entry rate. The apparent system volume found from this plot is about 22,000 cubic feet.

2. The dewcells were valved out shortly after the start of the test with no resulting change in the apparent air entry rate. This implies that the dewcells are not a large source of air into the reactor gas system.
3. The first raise in unit pressure increased the total daily gas loss from about 4500 cubic feet to about 10,000 cubic feet. The second pressure raise increased the loss to about 12,000 cfd.

CONCLUSIONS

The test results lead to the following conclusions:

- A. The apparent nonunit pressure dependent air entry rate to the reactor is about 45 cubic feet per day.
- B. The minimum unit pressure differential that will exclude unit pressure

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dependent air entry is 0.08 inches of water, or 36 on the pressure indicator chart. Because of variations in the noncontrolled pressure differential, a minimum pressure controller setting cannot assure positive unit pressure.

- C. The gas activity meter is accurate at low nitrogen (N_2) concentrations and is not affected by gas flow changes.
- D. The apparent gas system volume, at equilibrium operating temperature, is about 22,000 cubic feet.
- E. The dewcell system is not a large source of air entry to the reactor gas system.
- F. A pressure increase of 0.06 inches of water increased the total gas loss from about 5000 cfd to about 10,000 cfd. A pressure increase of 0.12 inches of water increased the total gas loss to 12,000 cfd.

DK George

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FIGURE I. NITROGEN TRANSIENT

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FIGURE 2. AIR ENTRY CONTROL TEST # 1
DR REACTOR 1/21/64 — 1/28/64
GAS ACTIVITY TRANSIENT

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FIGURE 3. AIR ENTRY CONTROL TEST # 1
DR REACTOR 1/20/64 — 1/28/64
NITROGEN ACTIVITY CORRELATION

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