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DE92 019147

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PRODUCTION TEST IP-502-I

CALIBRATION OF GAS MONITORING INSTRUMENTATION
TO MEASURE THE AMOUNT OF OXYGEN IN A REACTOR

by

W. R. Smit

April 6, 1962

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-2-

HW-73304

PRODUCTION TEST IP-502-I
CALIBRATION OF GAS MONITORING INSTRUMENTATION
TO MEASURE THE AMOUNT OF OXYGEN IN A REACTOR

OBJECTIVE

This production test is designed to test the feasibility of controlling the amount of air entering a reactor, hence, the burnout of the graphite by monitoring the reactor gas activity. Gas activity comes from the induced activity on argon, which is one of the constituents of air.

BASIS AND JUSTIFICATION

The reactor gas system is built to keep the graphite stack from oxidizing by bathing it in a non-reacting atmosphere. However, there are various leaks in the skin of the reactor and, if the pressure is higher outside of this skin than inside, air will leak in. Because of variation in atmospheric pressure at various portions of the reactor, it is expensive to keep the gas pressure on the inside of the reactor higher than the atmospheric pressure on the outside. If the pressure on the inside is higher than the highest pressure on the outside, there will be large differences in pressure at other points where the atmospheric pressure is lower. This large pressure difference can allow considerable gas to leak out, thereby incurring large gas losses. On the other hand, if the pressure inside the reactor is reduced, air will be drawn in and some reaction with the graphite will take place.

Process standards limit the amount of oxygen that can be allowed in the piles in order to limit the burnout of the graphite stack. The oxygen monitoring equipment (O₂ analyzer, orsat, mass spectrometer, and gas chromatograph) samples the reactor gas in the pipe portion of the recirculating system. It is possible for oxygen to be drawn in at various locations around the graphite stack, react with the graphite to produce CO and CO₂, and never show directly on the oxygen monitoring equipment.

The mass spectrometer and gas chromatograph measure the nitrogen which is in the reactor gas. For reactors which do not use nitrogen as one of the primary gases in the gas system, controlling the nitrogen will control the amount of air leakage. KE reactor now uses nitrogen as one of the primary gases, and it may be used at the other reactors in the future. Mass spectrometer samples are limited to one or two per reactor per week because of the work load on the spectrometer. Only three reactors (KE, KW, and C) have gas chromatographs. Consequently, it is difficult to have confidence that there are not some leaks that may be unnoticed until the results of a mass spectrometer reading of the reactor gas is available.

Some previous work by M. L. Smith¹ has shown that the introduction of argon into a pile will cause the gas activity to increase due to the activation of argon-41. Air is 78 per cent nitrogen, 21 per cent oxygen, 1 per cent argon,

¹Smith, M.L., Test Results for Supplement A to Production Test IP-358-AC, HW-69583, May 19, 1961, Secret.

DECLASSIFIED

-3-

HW-73304

and trace quantities of miscellaneous gases. The argon is inert; consequently, the only way for the activity in the reactor gas, due to the argon, to decrease is for the argon to escape along with the reactor gas atmosphere through leaks in the pile skin. Conversely, if air is coming into the reactor, the argon activity will increase if the air intake supplies more than enough argon to equal the amount of argon escaping.

Mass spectrometer data have been compared to gas activity data for each reactor. Figures 1, 2, and 3 show the data for B, KE, and KW, respectively. KE and KW have many data points available over a wide range of gas activities. It is a curve of this type that this production test is designed to develop for each reactor. The data from B shows some of the best of the data which is available for the other reactors. Unfortunately, the range of values is not adequate to determine a very good curve, and the scatter in the data points is greater than one would prefer. The scatter in the data points is believed to be primarily due to faulty techniques of reactor gas sampling, which allowed contaminating air into the sample bottle. The other reactors have fewer data points and greater scatter due to various combinations of the following problems: 1) few mass spectrometer readings, 2) no gas activity recorder, 3) gas activity recorder scale not noted, and 4) small range of argon and nitrogen percentages. These figures represent a fit to the available data by the Method of Least Squares, after all activity data have been normalized to one power level, for that reactor. The purpose of this test is to determine the relationship of gas activity to air entry.

If a relationship can be obtained, a burnout chart can be developed, as shown in Figures 4 and 5 for KE and KW, respectively. Figures 4 and 5 allow a measurement of the burnout occurring as a function of the gas activity. The data for KE and KW show that this method of gas control will work if there is adequate information available, but the whole thesis revolves around accurate and reproducible gas activity data. One of the objectives of this test will be to determine if gas activity data are reproducible with a given amount of air in the reactor. Some concern has been expressed as to the reproducibility and long-range effects of instrumentation changes. Analysis of the data which was used in Figures 2 and 3 indicate that there were no drifts in these instruments over one year's time. The process engineer at each pile could make checks with the activity and mass spectrometer data against the calibrated activity line. If these indicated there was an instrument change, then a new activity vs. argon relationship could be determined. At reactors which have both inlet and outlet monitoring chambers, a comparison of previous outlet and inlet readings vs. new outlet and inlet readings will suffice if one of the chambers is changed. For instance, suppose the inlet chamber is replaced. Previously, an inlet chamber reading of 30 per cent equaled an outlet chamber reading of 40 per cent. If a new chamber reads 45 per cent when the old outlet chamber reads 40 per cent, then the new calibration would be based upon the new inlet chamber reading.

If the data taken during this production test are as good as expected, process standards specifications of permissible argon activity may be a desirable method for controlling air entry.

DECLASSIFIED

-4-

HW-73304

TEST DESCRIPTION

This production test is to be run independently at each reactor by the process engineer with the help of the test author. Each process engineer will arrange for the necessary fittings and flow regulators to allow the gas to enter the inlet reactor gas system without any extraneous air being added. Commercial grade argon and compressed air will be used as the contaminating gases, with commercial flow regulators for measurement.

Each reactor must have the gas activity instrument working. A continuous record of gas activity is of paramount importance to the successful completion of this test. The O_2 analyzer and orsat equipment should be in working order. For those reactors which have gas chromatographs (C, KE, and KW), the gas chromatograph should be continually running during this entire test.

This production test is basically a test to calibrate the gas activity instruments as a function of various amounts of argon in the reactor gas system. The first two parts of the test are calibration points with different amounts of argon. From these calibration points, extrapolation or interpolation can be used to determine expected activities for other amounts of argon.

The third test to be run is at double the normal flow rate (400 cfm at the old reactors, 700 cfm at the K's), to check upon the effect of flow rate on activity readings. The doubled flow rate should show the effects of the argon addition faster, but it is not expected to change the actual calibration of the equilibrium argon concentration.

Since the object of this test is to determine if the argon activity is proportional to the amount of air leakage, the fourth part of this test is to actually introduce air into the gas system. Two variations will be used; a burst of air, and a small leak rate for 24 hours. The burst will approximate the tests that are being made with argon. The 24-hour test will indicate the total system response to a slow leak. Less than one pound of graphite will be burned by the introduction of air. After this test is run at two piles, even this small amount of burnout may not be necessary. If the effect of adding air is the same as adding a proportional amount of argon, it will not be necessary to introduce the air at all piles. The tests at the first two reactors will be used to determine if further tests with air are necessary. Each process engineer, with the help of the test author, will determine if the air additions are necessary.

To minimize errors that could be introduced because of power level changes, gas concentration, or equipment changes, this series of tests should be run on consecutive days. It will probably take three days to do these tests.

After the complete series of tests is run, it seems advisable to have a re-check upon the reproducibility of these tests. Therefore, this production test further authorizes the introduction of up to 10 cubic feet of argon once a month for six months. The timing and amount will be determined by the process engineer to evaluate the reproducibility of this production test.

PROCEDURE

Some time after startup (at least three days) when the reactor gas is at equilibrium as shown by gas activity records, gas flow rates, and pressure, the following tests will be run to calibrate the gas activity charts to the amount of air coming into the graphite stack. The gas activity chart should be reading less than 25 per cent of full scale.

1. Take a gas sample for mass spectrometer analysis within one-half hour before the argon is introduced. After taking a gas sample, introduce 2.5 cubic feet of argon into the pile over a 10-minute period. Take a mass spectrometer gas sample when the activity comes to equilibrium.
2. After equilibrium, raise gas pressure enough to bring the gas activity down to its pre-test level. Take a mass spectrometer gas sample and then, at the same gas flow rate as for test, introduce 10 cubic feet of argon over a 10-minute period. Allow the gas activity to come to equilibrium and take a sample for mass spectrometer analysis.
3. Raise the gas pressure to bring the activity down to its pre-test level. Take a gas sample after the flow rate is doubled from its normal value. Introduce a quantity of argon (about 5 ft³) which will be determined from test 1 and 2. Allow the gas activity to come to equilibrium and again take a sample for mass spectrometer analysis.
4. Raise gas pressure to clear out the excess argon and return the gas flow to normal. Introduce 500 cubic feet of air into the pile over 10 minutes. Take mass spectrometer samples and readings on the gas chromatograph and gas activity recorders every hour for three hours, then every two hours for six more hours.
5. Raise the gas pressure to clear out the excess argon introduced into the pile and then introduce 1000 cubic feet of air over a 24-hour period. This will amount to 2/3 cubic foot per minute. Gas chromatograph and gas activity readings will be recorded continuously.

NOTE: Tests #4 and #5 may be modified to use 5 and 10 cubic feet of argon, respectively, based upon the results of this production test at other reactors. The reactor engineer at each area will decide which test will be of maximum value at his area.

6. Once a month for six months, test #1 or #2 will be rerun to test the reproducibility of this concept.

SCHEDULINGStart of Test

The test will be started during equilibrium operation when the reactor power level and gas conditions are as described under the procedure section of this production test.

DECLASSIFIED

-6-

HW-73304

Duration of Test

All portions of this production test will be completed within nine months of the issue date.

Reactivity Loss

None

Outage Time

None

Process Standards

Process Standard B-010 will be relaxed to allow the addition of argon and air as outlined in this production test. No other process standards will be relaxed by this test.

RESPONSIBILITY

Process Engineering

Obtain argon and air supplies and fittings. Analyze data and issue conclusions based upon the results of this data.

Reactor Operations

Obtain mass spectrographic samples.

W.R. Smit

Process Engineering Unit
Process Technology Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

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Issue Date July 5, 1962

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PAGE 7

HW-73309

FIGURE 1

B. REACTOR

GAS ACTIVITY VS ARGON AND NITROGEN PERCENTAGE

HW-7330A

PAGE-8
FIGURE 2
KE REACTOR

GAS ACTIVITY VS ARGON PERCENTAGE

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FIGURE 3

KW REACTOR

GAS ACTIVITY VS ARGON AND NITROGEN PERCENTAGE

X = NITROGEN
 * = ARGON

GAS ACTIVITY CORRECTED TO 4000 MW EQUIVALENT

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PAGE 10
FIGURE 4

HW-73304

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