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PRODUCTION TEST IP-524-AL
TESTING IN 1706-KE SINGLE-PASS TUBES OF
QUACHROM GLUCOSATE AS A REPLACEMENT FOR
DICHROMATE.

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by

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August 7, 1962

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-524-AL
TESTING IN 1706-KE SINGLE-PASS TUBES OF QUACHROM
GLUCOSATE AS A REPLACEMENT FOR DICHROMATE

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OBJECTIVE

The objective of this production test is to authorize testing in the 1706-KE single-pass facility to measure the corrosion of aluminum-clad fuel elements in process water containing 0.20 ppm of Quachrom Glucosate added in place of dichromate and to compare this corrosion to corrosion in normal process water.

SUMMARY

Tubes SP-5 and SP-6 will be run with 0.20 ppm of Quachrom Glucosate and no dichromate; tests will be made at both pH 6.6 and 7.0. Simultaneous comparison corrosion measurements will be made in two regular tubes, 4561-KE and 4660-KE, supplied with normal process water. The use of SP-1 and SP-2 as additional control tubes is authorized, but not planned. Effluent-activity samples will be taken. Premature discharge and special pick-up are authorized. The test program will last approximately one year.

BASIS AND JUSTIFICATION

Ex-reactor tests⁽¹⁾ conducted in the single-pass mock-up tubes at 1706-KE have shown that 0.17 ppm of Quachrom Glucosate is as effective as 1.8 ppm of sodium dichromate in inhibiting the corrosion of X-8001 and C-64 aluminum in flowing filtered Columbia River water. With both inhibitors corrosion rates of 19-23 mils/year were measured at 130 C, pH 7.0, with no pitting or other localized attack.

The substitution of Quachrom Glucosate for sodium dichromate in Hanford process water has the following potential advantages. With the use of 0.20 ppm of this inhibitor the total amount of chromium added to the Columbia River would be only 14% of that using 1.0 ppm of sodium dichromate. This would greatly reduce the concentration of hexavalent chromium in the river, which under certain conditions of river flow and reactor operation has reached the level of 0.02 ppm, which is considered an upper limit to avoid detrimental effects on fish.⁽¹⁾ The concentration in the river of Cr⁵¹ probably would also be reduced. However, since activation of Cr depends on adsorption on an in-flux surface, the rate of production of Cr⁵¹ will not be linearly proportional to the concentration of Cr in the water. The cost of 0.20 ppm of Quachrom Glucosate at present is about 86% of that for 1.0 ppm dichromate.⁽¹⁾

In-reactor tests on a limited scale are now required in order to assess the effectiveness of Quachrom Glucosate as an inhibitor under actual in-reactor conditions, to determine its stability under irradiation, and to determine the

(1) Larrick, A.P. and R.B. Richman, A Comparison of the Corrosion Inhibition of Sodium Dichromate and Quachrom Glucosate, HW-70533, July 25, 1961.
(SECRET).

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effect on effluent activity (particularly of Cr^{51}) when using it in place of dichromate. Since Hanford reactors are currently cooled with process water at both pH 6.6 and 7.0, it is desirable to test Quachrom Glucosate at both these pH levels. Previous in-reactor corrosion testing has indicated that there may be a seasonal variation in the severity of corrosion. Therefore, the testing will be continued for a period of one full year.

Quachrom Glucosate is a proprietary compound manufactured as a 53% aqueous solution by the D. W. Hearing Co. Its structural formula is

where R is a hydrocarbon chain with an average length of 26 carbon atoms.

TEST DETAILS

1. Test Facility

This test will be conducted in the single-pass tubes in KE Reactor which can be supplied with specially treated water from 1706-KE, specifically SP-5 (4557-KE) and SP-6 (4863-KE). Two regular reactor tubes, 4561-KE and 4660-KE, will be used as controls. These two tubes are to be used since they are currently being used as controls in tests of reduced dichromate, (2) and it is desirable to use the same control tubes consistently over a series of corrosion tests. (3) According to present plans SP-1 (2952-KE) and SP-2 (3050-KE) will be used for other tests during this period. However, if other tests are not being conducted in these tubes, they will be used as additional control tubes under this production test. Tubes SP-1, 2, 5, and 6 are ribless zirconium with ID of 1.681 inches; 4561-KE and 4660-KE are regular ribbed aluminum tubes.

2. Water Quality

SP-5 and SP-6 will be supplied with service water to which is added 0.20 ppm of Quachrom Glucosate. The pH will be either 6.6 or 7.0. Sodium hydroxide or sulfuric acid will be added if required to adjust the pH. (It is presently planned to run the first and third charges of fuel elements at

(2). Dickinson, D.R. and F.W. Van Wormer, Production Test IP-475-AL, Corrosion Testing in 1706-KE Single-Pass Tubes with Low pH and Reduced Dichromate, HW-72225, January 5, 1962 (Secret).

(3). Dickinson, D.R., Corrosion Testing in Support of Present Reactors. HW-73016, March 14, 1962. (Secret).

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pH 6.6 and the second and fourth at pH 7.0.) These tubes will be supplied from 1706-KE.

Tubes 4561-KE and 4660-KE, and SP-1 and SP-2 if used in this test, will be supplied with normal process water.

3. Fuel Elements

SP-5, and SP-6 (and SP-1 and SP-2 if used in this test) will each be charged with 38 K-IV-NS fuel elements.

Tubes 4561-KE and 4660-KE will be charged with normal charges of 38 K-IV-N elements.

All fuel charges will be numbered, and the downstream 19 elements in each charge will be weighed before charging.

4. Data Desired

- a. For the SP tubes with instrumentation at 1706: Orifice flow, inlet and outlet temperature, pressures at 1706 tunnel, crossheader, venturi, inlet nozzle, and outlet nozzle; all four times per shift.
- b. For 4561-KW and 4660-KW: Outlet temperature, venturi (Panellit) gage reading and front crossheader gage reading once per shift; Panellit and crossheader bases whenever changed.
- c. For all fuel elements: weaseling and visual examination. For the downstream 19 elements in each charge: weights before exposure, and after exposure and cleaning.

5. Effluent Samples

The effluent from SP-5, and SP-6 (and SP-1 and SP-2 if used in this test) will be sampled to obtain effluent activity data. A specific sampling schedule will be supplied prior to the start of the test by Radiological Engineering Unit. The sample lines will remain open and flowing during the tests as in previous effluent sampling.

6. Corrosion Coupons

In order to determine the effect of the use of Quachrom Glucosate on the corrosion of the process tubes and effluent piping, coupon holders containing samples of aluminum, carbon steel, stainless steel, and zirconium will be included in the rear spacer loading of all tubes under this test. The number, type, and location of these coupon holders will be selected by Coolant Systems Development Operation, HLO, with the concurrence of Coolant Testing Operation and KE Processing Operation, IPD.

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7. Thermal Hydraulics

Thermal hydraulic considerations give rise to the operating criteria discussed below.

a. General

In case of failure of the 1706-KE pumps, the safety of the tubes depends on the process water backup system. The system is simple and can be considered highly reliable. Process water is available to the system through inter-connecting lines, but it is excluded from the system by check valves. The check valves are held shut by maintaining the pressure in the 1706-KE supply system higher than the reactor process water pressures. When pump failure occurs, the pressure in the normal supply lines decays and the check valves open.

A second check valve is situated in the 1706-KE supply lines upstream from the point of process water intertie. This valve will prevent the flow of water from the back-up system to the 1706-KE pumps. It also protects the system from the remote chance that a line rupture occurs between the 1706-KE pumps and the process water intertie.

In order to insure protection, it is necessary to lock and tag open all stop valves on the process water lines upstream from the check valves.

b. Instability Limits

In order to ensure safe and stable operation of the tubes, the provisions of Process Standard A-050 will be met for both high and low venturi (tube) trip limits.

The use of crossheader pressure to detect upstream plugging is advantageous in that it is in excess of venturi throat pressure and is more sensitive to upstream flow stoppages. Therefore, the crossheader pressure low trip setting must be set at least 50 psi above the venturi high trip setting. Tube outlet temperature limits shall be calculated according to Process Standard A-020 but in no case shall exceed 130°C. These trip settings are valid for front crossheader pressures greater than 325 psig and a differential between high and low venturi pressure trips of less than 90 psi. All pressures are to be measured at a common elevation. To ensure back-up flow protection IT IS NECESSARY TO LOCK AND TAG OPEN ALL STOP VALVES ON THE INTER-CONNECTING LINES DURING REACTOR OPERATION.

c. BPA Outage Limits

In case of a BPA outage, the 1706-KE pumps trip out and the tubes are supplied with coolant from the process water system. In such an event, two critical periods exist. The first comes within a few seconds after the BPA outage. The flow to the tubes decays in two steps after the power decays. The supply pressure to the tubes drops immediately to that supplied by the process water system. Next, the pressure supplied by the process water system decays as the flywheel energy on the 190-KE pumps is used up.

In order to pass through the first critical period safely, it is necessary to insure that the total flow decay before the beginning of tube power decay is not excessive. Such protection is obtained by the limits shown in Figure 1 which are based on a flow reduction of not more than 20 per cent before tube power decay commences.

FIGURE 1
BPA FAILURE LIMIT

Maximum 1706-KE Tube Supply Pressure As Measured In The Pipe Tunnel - PSIG
Maximum 1706-KE Tube Supply Pressure As Measured In The Pipe Tunnel - PSIG

Bottom--of-Riser Process Water Pressure - PSIG

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The second critical period occurs about 100 - 150 seconds after the outage. At this time, the coolant flow has decayed about 85 per cent and the tube power has decayed about 88 per cent. Both the flow and power will remain relatively constant at these values for a considerable period of time. It is desirable that the tube exit temperature not exceed the rear crossheader saturation temperature. A maximum outlet temperature of 130 C has been specified under instability limits. Inasmuch as this is 9 C below rear crossheader saturation temperature, safe operation is assured.

8. Schedule

The tubes to be used in this test are currently being used for a test of reduced dichromate at pH 6.6.⁽²⁾ The testing of Quachrom Glucosate will start at the completion of this test, about October, 1962.

Fuel loadings under this production test will run to approximately normal goal exposure. However, all tubes must be charged and discharged at the same time. Up to six repeated sets of fuel charges are authorized; present plans call for four. Premature discharge is authorized if required for timely starting of the test or to charge all the tubes at the same time.

Unless earlier terminated, this test authorization expires August 1, 1964.

9. Special Pick-up

Special pick-up is required for the fuel elements discharged from all tubes.

COSTS

Cost Code: 5R23, XXX, 71

Elevator Time: For charge and discharge, 1/2 hour per tube or 2-3 hours per test.

Reactivity Loss: None.

HAZARDS

No significant new hazards are introduced. The probability of fuel element failure due to replacement of dichromate is slight.

RESPONSIBILITIES

Irradiation Processing Department

Manufacturing Section

KE Processing Operation will be responsible for:

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1. Operational safety of the reactor.
2. Production continuity, except where inconsistent with the provisions of this test.
3. Charge and discharge.
4. Obtaining effluent activity samples, when required.
5. Special pickup of test charges.

Research and Engineering Section

Process and Reactor Development Sub-Section will be responsible for:

1. Technical aspects of test, including effect on reactor safety.
2. Detailed effluent sampling instructions.
3. Termination of production test and issuing of final report.

Testing Sub-Section

Coolant Testing Unit will be responsible for:

1. Operation of 1706-KE equipment.
2. Recording operating data for all tubes.
3. Scheduling charge and discharge with concurrence of KE Processing Operation.
4. Reactor safety and production continuity as they are affected by the 1706-KE operation.

Component Testing Operation will be responsible for:

1. Weaseling, visual observation, cleaning, and weighing of discharged fuel.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Coolant Systems Development Operation will be responsible for:

1. Arranging for supply of appropriate weighed fuel elements.
2. Analyzing data and issuing technical reports.
3. Co-ordination of test details within HLO.

Chemical Research and Development Operation

Radiological Chemistry Operation will be responsible for:

1. Analyzing effluent activity samples and issuing technical reports.

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Coolant Systems Development Operation
Reactor and Fuels
Research and Development Operation
HANFORD LABORATORIES OPERATION

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