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EVALUATION OF N-REACTOR PIPING
DECONTAMINATION PROCEDURE FOR
EFFECTIVENESS AND MATERIALS

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EVALUATION OF N-REACTOR PIPING DECONTAMINATION

PROCEDURE FOR EFFECTIVENESS AND MATERIALS CORROSION

W. K. Kratzer

August 1, 1967

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EVALUATION OF N-REACTOR PIPING DECONTAMINATION

PROCEDURE FOR EFFECTIVENESS AND MATERIALS CORROSION

ABSTRACT

The effectiveness and corrosion characteristics of Turco 4512-A, an inhibited phosphoric acid, are being evaluated for N-Reactor primary system carbon steel decontamination by in-reactor decontamination tests, full scale component evaluations, and laboratory corrosion tests. To date these tests have showed that the decontamination procedure is effective for carbon steel decontamination and safe for all primary system materials that will be contacted by the solution. A few materials, namely, 17-4 pH SS, 416 SS, 420 SS, and Easy-Flo 45 braze alloy have not yet been completely tested. Results of their performance will be reported prior to full reactor decontamination.

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EVALUATION OF N-REACTOR PIPING DECONTAMINATION

PROCEDURE FOR EFFECTIVENESS AND MATERIALS CORROSION

INTRODUCTION

Personnel exposure levels on the N-Reactor front and rear elevators have increased to the point that decontamination of the front and rear connectors is required to reduce the system activity. A single pass procedure using inhibited phosphoric acid has been selected for the decontamination, primarily on the basis of its physical form, a concentrated liquid amenable to easy materials handling, and its previously demonstrated good decontamination of carbon steel.

The purpose of this document is to present the results to date of an evaluation of the effectiveness and materials corrosion of the inhibited phosphoric acid decontamination procedure. Although testing is continuing, more than 90 percent of the results are in, and it is timely to report them now.

SCOPE OF STUDY

Evaluation of the corrosion characteristics of the phosphoric acid piping decontamination procedure is necessary to assure no irreparable damage to the reactor system as a result of the decontamination. Consequently the major corrosion evaluation effort was directed toward determining the effects of the decontamination on carbon steel, stainless steel, and Zr-2, and on the different conditions and interfaces of these materials, such as welds, mechanical junctions, and crevices.

Certain components, either because of their nature or their number, are essentially irreplaceable. These include the Zr-2 process tubes, the nozzle-process tube rolled joints, V-11 valves, V-12 valves, the Grayloc connector fittings, and other principal valves in the decontamination flow stream, such as V-1, V-3, V-4, V-10, CV-1, and CV-2 valves. In addition to corrosion tests of the constituent materials, actual component decontamination, followed by disassembly and inspection, have been performed on the rolled joints, V-11 valves, V-12 valves, and the Grayloc fittings. Of the other valves, all of the critical materials in the valves have been tested in the decontaminating solution except for 17-4 pH steel, which is currently undergoing stress corrosion tests.

The effect of decontamination on process tubes was evaluated by through-reactor decontamination of sixteen tubes with visual examination of three. Destructive examination of a Zr-2 process tube from KER-1 after two decontaminations and two years subsequent operation provided an indication of the long term safety of the phosphoric acid process, even though the reagent used was Turco 4512 which has a less effective inhibitor system than the Turco 4512-A planned for the N-Reactor decontamination.

SUMMARY AND CONCLUSIONS

Materials and component evaluations are almost complete and so far have demonstrated the suitability of Turco 4512-A, used at or near a 10 percent solution of 160°F, for effectively decontaminating carbon steel with acceptable short term corrosion rates for carbon steel, stainless steel, Zr-2, and Stellite. The effect of stress, sensitization, and dissimilar metal coupling has been evaluated. Except for 17-4 pH steel, which is still being evaluated, the corrosion of the critical materials in the V-1, V-3, V-4, V-10, V-22, V-23, CV-1, and CV-2 valves has been tested in Turco 4512-A with satisfactory results. The corrosion of Easy-Flo 45, used to braze Expansion Joint 5, 416SS and 420 SS is also still being tested.

Small scale component tests have shown no damage to V-11 and V-12 valves, Grayloc couplings, nozzle-process tube rolled joints, fuel elements, and process tubes. A decontaminated rolled joint is being examined metallographically.

The materials and evaluation program has shown negligible risk of significant damage to any reactor components based on immediate evaluation after decontamination. However, it must be recognized that subtle, delayed, or cumulative effects of repeated decontaminations on reactor components can only be defined by component examination after considerable reactor operation after decontamination. The completely sound condition of the KER-1 system two years after a double decontamination is good evidence that there are no long term deleterious effects.

BASIC DECONTAMINATION PROCEDURE

The decontamination procedure consists of a single pass flush of the carbon steel piping with a 10 percent by volume solution of Turco 4512-A for 20 minutes at 160°F. Turco 4512-A is a proprietary material containing about 70 percent by weight H_3PO_4 with inhibitors and wetting agents added. A 10 percent by volume solution contains about 10 weight percent phosphoric acid.

The phosphoric acid procedure was chosen for evaluation for the N-Reactor piping decontamination because of its effectiveness in preliminary decontamination studies⁽¹⁾ and its physical form, which permits injection as a concentrated liquid with subsequent dilution in the system. None of the likely organic acids can be prepared in a solution much more concentrated than the use solution, and none are as effective for short contact times.

One of the limitations on the use of the phosphoric acid method is that it is effective for single pass application only. During recirculation the dissolved activated corrosion products tend to redeposit, giving a poor decontamination.⁽²⁾ This trouble is not encountered during single pass cleaning, however, because fresh solution is continually coming in contact with the surface being decontaminated. A second limitation is the need for complete rinsing since, unlike the organic acids, the phosphate ion does not break down during subsequent irradiation.

The advantages of the phosphoric acid procedure are its speed, as compared to a recirculation operation, and its applicability to the single pass decontamination of a restricted portion of the primary system. Basically the phosphoric acid

procedure is ideally suited to the limited scope, short downtime, decontamination currently planned for N-Reactor. It would not be satisfactory for a large scale complete primary system decontamination which would require extended (4 to 10 hour) contact time to add, recirculate, and remove the decontaminating solution while maintaining reactor cooling.

EVALUATION PROGRAM

Early in the history of N-Reactor a program was undertaken to evaluate the effectiveness and materials effects of decontamination procedures. By 1961 inhibited phosphoric acid (Turco 4512) was shown to be satisfactory for decontaminating the carbon steel piping. No further work on this reagent was done until it was realized in May, 1967 that decontamination of the front and rear connectors would soon be necessary. The early work was reviewed and it was decided to confirm and expand the early findings with a series of tests. These tests are described briefly in the remainder of this report along with the observed results.

I. Effectiveness Tests

A. Preliminary Work

From 1959 to 1961 the Hanford Laboratories evaluated a large variety of decontaminating materials for potential application to N-Reactor. This work showed that decontamination factors (DF=initial activity/final activity) of greater than 70⁽¹⁾ could be obtained with a single pass decontamination of carbon steel piping using the phosphoric acid procedure. It also showed that recirculation application gave poor results, a DF = 2, when used on the out-of-pile portion of KER-1, a recirculating in-reactor loop.⁽²⁾

B. Current Effectiveness Evaluation

The effectiveness of the single pass phosphoric acid procedure has been measured⁽⁴⁾ by two reactor tests - PT-86,⁽³⁾ involving two tubes, and PT-91,⁽⁴⁾ in which fourteen tubes were decontaminated. Because of the high background activity, attempts to measure the connector activity reduction as a result of the two tube test were not considered representative of what might be expected in a full reactor application. Values for DF of only 3 were measured on the rear connectors of the two tubes. On the other hand encouraging results were found when carbon steel dummies removed from the tubes before and after decontamination showed decontamination factors of 20 or greater.

Improvements in radiation measuring instrumentation shielding permitted better decontamination effectiveness measurements on the connectors in the fourteen tube test, PT-91. Reduction in connector activity to 10 percent or less of the original activity was observed on tubes decontaminated at the desired conditions -- 10 percent acid concentration at 160°F.⁽⁶⁾ Carbon steel dummy decontamination measurements were erratic, but generally verified the connector measurements.

Samples of solution taken during the decontamination and rinsing of tube 2542 were analyzed for radioisotopic concentration. Results of the analyses are given in Table I. Relating the isotopic concentrations in Table I to time and tube flow, and assuming (a) one-half of the activity came from the rear connector and one-half from the process tube, (b) the front connectors have the same amount and distribution of radioisotopes as the rear connectors and process tubes, and (c) all process tubes in the reactor behave the same as tube 2542, then a reactor piping decontamination should remove 180 curies of activity, including 85 curies of Co-60. All of the solution samples contained some particulate material. A not unexpected observation was that 95 to 99 percent of the activity was in solution in the acid samples, but only 10 to 30 percent in solution in the pH 10 rinse sample. This would suggest that neutralizing the acid solution in the Chemical Waste Storage Tank would precipitate out 70 to 90 percent of the contained activity as sludge. Even if this occurred it would not prevent transporting the waste material to 200 area storage.

II. Materials Corrosion Tests

A. Laboratory Evaluation of Turco 4512 and 4512-A

During the early evaluation of phosphoric acid decontaminants by the Hanford Laboratories, carbon steel, stainless steel, and Zr-2 were extensively tested for corrosion behavior. In general the corrosion behavior was good except for accelerated attack of carbon steel welded to stainless steel where galvanic corrosion caused pitting in the carbon steel at the weld junction. In 1959, the Turco Company changed the inhibitor in Turco 4512 to reduce this corrosion, calling the modified product Turco 4512-A, which will be used in the N-Reactor decontamination. Table II gives the results of past and recent corrosion measurements on carbon steel, stainless steel, Zr-2, Stellite, Monel, and Haynes alloy 41. The corrosion of bimetallic welds and mechanical couples are included.

B. Primary System Materials

A listing of the materials in the primary system valves and components contacted by the phosphoric acid during decontamination is given in Tables III and IV. Table III includes the components through which the phosphoric acid flows during decontamination; Table IV gives the closed valves contacted by the phosphoric acid on one side. Each material is referenced to the test in Table II or to the component evaluation test that describes its behavior in the decontaminating solution.

Tests are under way, but not completed, on the metallographic examination of a decontaminated nozzle-process tube rolled joint, stressed 17-4 pH steel used in many valve stems, and the Easy-Flo 45 braze material used on Expansion Joint 5. Two martensitic stainless steel, 416 and 420 are also being tested.

III. Effects on Actual Components

In addition to the corrosion testing of specific materials, the effect of a phosphoric acid decontamination on various reactor components has been evaluated. Results of the examination of V-11 valves, V-12 valves, Grayloc fittings, process tube nozzles, nozzle-process tube rolled joints, and process tubes before and after decontamination are reported in DUN-2917.⁽¹³⁾

A. Valves

One V-11 (front connector butterfly) valve and two V-12 (rear connector diversion) valves removed from the reactor and two V-11 and two V-12 valves from the 189-D loop Environmental Test Facility were decontaminated in 10 percent Turco 4512-A at 160°F for 20 minutes. Leak rates from three of the four ETF valves were measured before and after decontamination and are given in Table V. All valves were visually examined before and after decontamination, and then disassembled for a detailed examination to detect damage from the decontamination. No corrosion, packing damage, or component damage attributable to the decontamination were observed. Valve leakage shown in Table V appears to be more a function of the number of times the valve was actuated than of the decontamination.

The two V-12 valves decontaminated during PT-86⁽³⁾ and the fourteen decontaminated during PT-91⁽⁴⁾ functioned the same after decontamination as before. No leakage was observed on the two PT-86 valves after three weeks of reactor operation. Surveillance of the decontaminated valves will continue each reactor outage, and one valve will be removed for disassembly and examination in August, 1967.

B. Grayloc Fittings

Two Grayloc fittings were exposed on the Environmental Test Facility, decontaminated for 20 minutes in 10 percent Turco 4512-A at 160°F, re-exposed on the ETF at 550°F, 1600 psi, re-decontaminated, one in 10 percent acid at 200°F the other in 20 percent acid, 170°F, and then disassembled for examination. Examination before and after decontamination and after disassembly showed no attack on the fittings. No leaks occurred from the Grayloc fittings on the reactor piping before or after the reactor decontaminations.

C. Rolled Joints

Two rolled joints assembled as part of a training program were decontaminated in 10 percent Turco 4512-A for 20 minutes at 160°F and re-decontaminated, one in 10 percent Turco 4512-A at 200°F, the other in 20 percent Turco 4512-A at 170°F. The joints were examined before and after each decontamination and no attack at the carbon steel - Zr-2 junction was observed. One of the rolled joints has been sectioned for metallographic examination, which is not completed.

On the reactor, the rolled joints of tubes 2341 and 2442 were examined borescopically after decontamination. The front rolled joint of tube 2141 was examined after decontamination and three weeks subsequent reactor operation. No attack attributable to the decontamination was observed on any of the rolled joints.⁽¹³⁾

D. Process Tubes

1. KER Loop Experience

In August, 1960 and in May, 1961, the in-reactor portion of KER-1, including the Zr-2 process tube, was decontaminated using Turco 4512, which differs from Turco 4512-A by having a less effective inhibitor. The first decontamination used 10 percent phosphoric acid at 120 to 155°F for 20 minutes.

The second test involved 7 percent phosphoric acid at 100 to 120°F for 33 minutes followed by 20 minutes at 120 to 135°F. The first test used single pass flow; the second cleaning was with recirculating acid.⁽⁸⁾ The Zr-2 process tube was removed from KER-1 in July, 1963, for examination. No unusual corrosion, Zr-2 hydriding, or mechanical properties anomalies were found during the destructive examination of the tube.⁽¹⁴⁾

2. N-Reactor Process Tube Visual Examination

Process tube 2442 was examined with television equipment after decontamination, and tube 2141 after decontamination and three weeks subsequent high temperature operation. In neither case were any abnormalities observed attributable to the decontamination.⁽¹³⁾

3. Effect of Inhibitor on Process Tubes

A possibility of damage to the Zr-2 process tubes by the unknown corrosion inhibitor in Turco 4512-A remaining on the Zr-2 surface and impairing the corrosion resistance of the zirconium oxide film was suggested by S. B. Dalgaard, Sheppard T. Powell and Associates, consultants to the N-Reactor Project Section.⁽¹⁵⁾ Oral discussions with Eric Le Surf, of Chalk River, R. E. Westerman, BNW, and Bruce Griggs, BNW, tended to discount this possibility. All three felt that a single pass treatment with good rinsing would remove all significant quantities of inhibitor, and that any residual inhibitor, providing it contained no halides, would have at the most a very short term effect on the corrosion rate. Turco was requested to disclose the chemical composition of the inhibitor, which they did on a limited basis to a few members of the Decontamination Task Force. A review of available information by those individuals has convinced them that there is sufficient evidence to indicate that the effect suggested by Dalgaard will not occur.

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E. Fuel Elements

Fuel elements from tubes 2341 and 2442 were discharged and examined immediately after decontamination. The fuel elements from tube 2141 were discharged for examination after three weeks of high temperature operation subsequent to decontamination. Visual examination of all of the fuel elements revealed no damage or attack to the Zr-2 surfaces. The carbon steel shoes were changed to a dull grey color, but no visible damage had occurred. (16)

CONCLUSIONS

Experimental and analytical studies to support the safe and effective use of Turco 4512-A to decontaminate the front and rear piping of N-Reactor have been described here in a condensed form. Details are available in referenced documents. It is concluded that this reagent can be safely and effectively applied to N-Reactor. Sufficient leeway is available so that modest variation well within practical capability of the system is permissible. Detailed procedures and authorization documents to conduct a full reactor application are being circulated for review and approval.

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TABLE I

RADIOISOTOPES IN SOLUTION SAMPLES TAKEN DURING DECONTAMINATION OF TUBE 2542, PT-91*

Phase of Decontamination	Time After Start, min.	Radioisotopic Concentration, uc/l								Total uc/l
		Co-60	Mn-54	ZrNb-95	Cr-51	Ru-103	Fe-59	Zn-65	Sn-113	
ACID	2	61.08	9.43	8.45	29.54	5.81	38.85	0.01	0.01	163.17
	5	302.46	18.58	28.35	114.92	12.83	80.28	0.01	0.12	557.54
	8	43.63	3.01	4.51	21.63	1.60	13.08	0.03	0.04	87.53
	10	28.95	2.12	2.74	14.70	1.10	9.95	0.01	0.01	59.58
	16	12.13	1.51	1.47	8.31	0.63	7.72	0.01	0.01	31.78
	20	9.55	1.44	1.25	6.70	0.53	6.38	0.01	0.01	25.86
Rinse with pH 10 Process Water	25	8.27	1.91	3.97	12.13	0.50	6.98	0.01	0.22	34.59
	27	0.31	0.08	0.12	0.47	0.02	0.21	0.28	0.01	1.49
	33	0.09	0.03	0.03	0.13	0.01	0.06	0.01	0.01	0.34

*Tube was decontaminated with a 10 percent solution of Turco 4512-A at 160°F for 20 minutes at 10 gpm flow followed by 20 minutes of rinsing with process water at 15 gpm flow.

TABLE II

LABORATORY CORROSION TESTS IN PHOSPHORIC ACID

Test	Material	Corrosion Rate	Conditions	Reference
1	302 SS	0.009 mils/hr	A three-step process: 1 hour in film condition agent, 1 hour in 105 C alkaline permanagante, and 1 hour in 60 C 10% Turco 4512	(7) HW-62806 page 57
	302 SS sensitized	0.012		
	304 SS	0.011		
	304 SS sensitized	0.013		
	Carbon Steel	0.185		
2	302 SS	0.010 mils/hr	A two-step process: 2 hours in AP at 100 C and 1 hour in 10% phosphoric acid at 60 C	(1) HW-67937 page 133
	302 SS, sensitized	0.012		
	304 SS	0.005		
	304 SS, sensitized	0.007		
	304 L SS	0.010		
	321 SS	0.004		
	410 SS	0.019		
	A245 CS	0.128		
	Inconel X	0.005		
	Monel	0.025		
	Titanium, polished	0.01		
	Titanium, polished & etched	0.01		
	Zr-2, polished & etched	0.01		
3	A212 Carbon Steel	0.026 mils/hour	Cyclic AP-phosphoric acid two-step process; 2 hours AP at 105 C, 2 hours 20% phosphoric acid at 60 C	(1) HW-67937 pages 135-140
	304 SS, sensitized	0.004		
	304 SS	0.003		
	Stellite 6	0.173		
	Stellite 12	0.006		
	A212 CS-304SS weld	0.064 (1 mil/hr CS pitting)		
	Zr-2	0.011		
	A212 CS-304SS coupled	0.029		
	Zr-2-304SS coupled	0.012		
	Stressed Crevice, Sensitized 304SS to A212 CS	0.009 0.10		
	Stressed Crevice, Sensitized 304SS to Zr-2	0.009 0.010		
	Stressed Crevice, A212 CS to Zr-2	0.06 0.010		

TABLE II (continued)

Test	Material	Corrosion Rate	Conditions	Reference
4	304 SS A245 CS Zr-2	0.003 mils/test 0.17 0.03	August 1960, KER-1 Decon with 10% phosphoric acid, 55 C, 1.5 hours recirculation; 7.5 hours for draining acid and flush water	(1) HW-67937 pages 141-146
5	Carbon Steel	0.042 mils/hr	Single pass, 10% H ₃ PO ₄ , 70 C	(1) HW-67937 page 149
6	A245 CS, polished A245 CS, filmed A245 CS, previously decontaminated 304 SS 304 SS, sensitized Inconel X Zr-2	0.6 mils/hr 0.6 0.7 0.1 0.1 0.08 0.00	Cyclic test AP-phosphoric acid at 10%, 90 C.	
7	A212 CS A212 CS, normalized CS welded to SS CS coupled to Zr-2 CS coupled to SS Stellite 6 Stellite 12 Haynes alloy 41	0.13 mils/hr 0.14 0.16 (1 mil/hr pitting) 0.11 0.16 0.08 (pitting) 0.08 (pitting) 0.19 (pitting)	Cyclic test AP-phosphoric acid at 60 C, 10%, in aerated solution	(8) HW-71259 pages 86-87
8	A245 CS 304 SS Zr-2	0.13 mils/test 0.005 0.02	November 1960 KER-1 Decon with 10% phosphoric acid, 55 C, 1.5 hours recirculation	(8) HW-71259 page 100
9	A245 CS 304 SS Zr-2	0.10 mils/test 0.002 0.002	May 1961 KER-1 Decontamination, 7% phosphoric acid, 1 hour at 37 to 58 C followed by 48 minutes with 10% phosphoric acid at 50 to 57 C.	(8) HW-71259 page 105
10	A212 CS Welded to 304 SS A245 CS	Uniform: 0.040 mils/hr Pitting: 1 mil/hr Uniform: 0.014 mils/hr	10% Turco 4512-A at 95 C	(9)
11	A212 CS Welded to 304 SS A245 CS	Uniform: 0.011 mils/hr Pitting: 1 mil/hr Uniform: 0.004 mils/hr	10% Turco 4512-A at 71 C	(10)

TABLE II (continued)

<u>Test</u>	<u>Material</u>	<u>Corrosion Rate</u>	<u>Conditions</u>	<u>Reference</u>
12	CS, Crevice	0.02 mils/hr	10 minutes at 127 to 150 F	(11)
	CS, Plain	0.03	13% Turco 4512-A	
	A212-304 Welded	0.08	20 minutes at 158 F, 13%	
	AMS 5616	0.001	Turco 4512-A, Decontamination	
	Zr-2, Etched	0.001	of tube 2341, PT-86	
	Zr-2, Autoclaved	0.001		
13	CS Welded to 304 SS	0.10 mils/hr, no pitting	10% Turco 4512-A at 200 F	(12)
	CS-Zr-2 coupled	0.06		
14	CS Welded to 304 SS	0.07 mils/hr, no pitting	20% Turco 4512-A at 170 F	(12)
	CS-Zr-2 coupled	0.04		

TABLE III - COMPONENTS THROUGH WHICH PHOSPHORIC ACID WILL FLOW

Valve	Size	No.	Body	Stem	Seats	Packing	Disc or Plug	Other Materials
V-1	4"	16	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	Asbestos, Inconel ⁽⁷⁾		Cu sheet gasket ⁽⁵⁾
V-3	8"	8	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	Mica, JM-397 ⁽⁸⁾		
V-4	10"	8	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	JM-397 ⁽⁸⁾		
V-10	4"	16	CS ⁽¹⁾	304 SS ⁽¹⁾	Stellite 6 ⁽⁶⁾	JM-397 ⁽⁸⁾		
V-11	2"	1003	CS ⁽²⁾	Greek Ascoloy ⁽²⁾		Asbestos, Inconel ⁽²⁾		
V-12	2"	1003	CS ⁽²⁾	410 SS ⁽²⁾	AMS5616 ⁽²⁾	Mica, Inconel ⁽²⁾ .430 SS mesh		
V-22	24"	1	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	JM-397 ⁽⁸⁾		
V-23	16"	2	CS ⁽¹⁾				CS, Stellite face ⁽⁶⁾	17-4 pH ⁽⁴⁾
CV-1	8"	8	CS ⁽¹⁾	304SS ⁽¹⁾		JM-397 ⁽⁸⁾	A216 ⁽¹⁰⁾	
CV-2	4"	16	CS ⁽¹⁾	304SS ⁽¹⁾		JM-397 ⁽⁸⁾	A216 ⁽¹⁰⁾	Stellite 6 ⁽⁶⁾
CV-4	24"	1	CS ⁽¹⁾	416SS ⁽⁴⁾		Ankorite 425 ⁽⁹⁾		Monel bushing ⁽¹¹⁾
EJ-5	24"	1	347SS ⁽³⁾					347SS brazed to pipe with Easy Flo 45 (45% Ag, 15 Cu, 16 Zn, 23 Cd) ⁽⁴⁾

1. Table II, tests 1-14
2. Entire valve tested as one component.
3. Assumed behavior same as other austenitic stainless steels, Table II, tests 1-3, 8-11
4. Behavior being tested.
5. Edge only sees acid. Corrosion rate less than 1 mil/day.
6. Table II, test 2 and 7
7. Not tested, assumed behavior same as V-11 packing.
8. Not tested, assumed behavior same as V-12 packing
9. Not tested

10. Assumed same as other carbon steel, Table II, tests 2, 3, 6, 11
11. Table II, test 2

TABLE IV - CLOSED VALVES WITH PHOSPHORIC ACID ON ONE SIDE

Valve	Size	No.	Body	Stem	Seats	Disc or Plug	Packing	Other
V-5	16"	2	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾		JM-397 ⁽⁸⁾	
V-7	8"	1	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾	JM-397 ⁽⁸⁾	
V-8	1-1/2"	16	CS ⁽¹⁾	17-4 pH ⁽⁴⁾		420 SS ⁽⁴⁾	JM-397 ⁽⁸⁾	
V-9	1-1/2"	16	CS ⁽¹⁾	17-4 pH ⁽⁴⁾		420 SS ⁽⁴⁾	JM-397 ⁽⁸⁾	
V-16	2"	16	CS ⁽¹⁾	316 SS ⁽³⁾	Stellite 6 ⁽⁶⁾	316 SS ⁽³⁾ Stellite 6 ⁽⁶⁾	JM-397 ⁽⁸⁾	
V-18	6"	2	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾		
V-19	16"	1	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾		JM-397 ⁽⁸⁾	
V-21	3"	6	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾	JM-397 ⁽⁸⁾	
V-24	24"	1	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾	JM-397 ⁽⁸⁾	Cu Asbestos gasket ⁽¹³⁾
V-33	3/8"	2	CS ⁽¹⁾	316 SS ⁽³⁾	Stellite 6 ⁽⁶⁾		JM-397 ⁽⁸⁾	440 C SS Bushing ⁽¹³⁾
V-38	1"	16	CS ⁽¹⁾ Stellite 6 ⁽⁶⁾	316 SS ⁽³⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾ Stellite 6 ⁽⁶⁾	Asbestos ⁽⁷⁾	
V-43	4"	2	CS ⁽¹⁾	17-4 pH ⁽⁴⁾	Stellite 6 ⁽⁶⁾		JM-397 ⁽⁸⁾	
V-46	4"	2	CS ⁽¹⁾		Stellite 6 ⁽⁶⁾		JM-397 ⁽⁸⁾	Mn Bronze Split Gland ⁽¹³⁾
CV-3	18"	16	CS ⁽¹⁾	Haynes 25 ⁽¹²⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾		
CV-5	18"	16	CS ⁽¹⁾	Haynes 25 ⁽¹²⁾	Stellite 6 ⁽⁶⁾	CS ⁽¹⁾		

1. Table II, tests 1-14

2. Entire valve tested as one component.

3. Assumed behavior same as other austenitic stainless steels, Table II, tests 1-3, 8-11

4. Behavior being tested.

5. Edge only sees acid. Corrosion rate less than 1 mil/day.

6. Table II, tests 2 and 7.

7. Not tested, assumed behavior same as V-11 packing

8. Not tested, assumed behavior same as V-12 packing

9. Not tested

10. Assumed same as other carbon steel, Table II, tests 2, 3, 6, 11.

11. Table II, test 2.

12. Corrosion rate less than 1 mil/yr in boiling 10% H₃PO₄: Union Carbide literature

13. Should not see acid.

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TABLE V

VALVE LEAKAGE AT THE ENVIRONMENTAL TEST FACILITY

Valve	Leakage, mls/min, at 1600 psi, 100 F			
	<u>Operation*</u> <u>Before</u> <u>Exercising</u>	<u>After</u> <u>Three Days</u> <u>Operation**</u>	<u>After</u> <u>Decontamination</u>	<u>After Three</u> <u>Days Additional</u> <u>Operation**</u>
#2 V-11	0	835	460	1485
#7 V-12	0	27.5	120	8
#8 V-12	0	.1	0	0

* Operation was at 550 F, 1600 psi

** The valve opened and closed 10 times per day during operation.