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COMPONENTS CONTAINING SILVER IN THE PRIMARY AND GRAPHITE COOLING SYSTEMS - "N" REACTOR

AUTHOR
B. S. Kosut
Chemistry and Metallurgy
Research and Engineering
N-Reactor Department

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December 13, 1963

M. C. Leverett, Manager
Research and Engineering Section
N-REACTOR DEPARTMENT

COMPONENTS CONTAINING SILVER IN THE PRIMARY AND GRAPHITE COOLING SYSTEMS - "N" REACTOR

INTRODUCTION

In response to your request[1] dated November 23, 1963, a survey has been made of the graphite and primary coolant systems to locate those components containing silver and to determine the corrosion problems associated with the silver as a result of its reaction with the ammonia in the coolant. These components are listed in the Appendix.

This study was initiated as a result of the change from a lithiated to an ammoniated coolant for the primary system and the discovery that ammoniated water will dissolve the silver.[2]

SUMMARY

The components containing silver in the primary and graphite cooling systems have been segregated into three categories.

Category I involves components containing silver plated parts through which the coolant will be recirculated and then pass through the reactor causing activation of the silver.

A total of 38 grams of silver will be recirculated and activated. This should not present a serious radiological problem because most of it will eventually bleed off through the normal feed and bleed procedure.[3]

It appears that corrosion of the silver plated components after removal of the plating should not present a problem but will be confirmed with valve tests in ex-reactor loops. It is expected that the general corrosion will not be severe. However, the hardened 416 S.S. part that is silver plated may stress corrode as the valve packing contains 28 ppm of chloride.

Valve leakage should not increase as a result of the loss of silver plating but will also be confirmed with valve tests.

Category II involves almost identical components to that mentioned in Category I except that the water in these devices normally will not be recirculated through the reactor.

Corrosion and valve leakage as a result of the removal of the protective silver plating on the component parts is described under Category I, above. The valve tests described above will provide needed information on coolant effects on these devices.

Category III involves devices that are in vent and drain systems and from which the coolant is discharged without being recirculated in the loops.

The corrosion and leakage problems as a result of the plating removal on the valves will be the same as in Categories I and II. The removal of the silver braze on six expansion joints will require periodic inspection to detect possible performations that may occur at the seal welds as a result of crevice and galvanic corrosion.

DISCUSSION

The components containing silver in the primary and graphite cooling systems has been segregated into three categories. Each category explores the effect of the corrosion on the plated part as a result of the loss of the silver plating.

The radiological problems with the activated silver and coolant leakage from the component also as a result of the silver dissolution is considered.

Category I - Components containing silver are located in the system such that the coolant will be recirculated through the reactor after passing through a component. A total of 30 valves varying in size from 1 inch through 2 inches in the primary and graphite cooling system are in this group.

The total amount of silver that these valves contain amounts to about 38 grams.

a) Silver Activation - The preliminary startup tests will dissolve about 6 grams of this silver which will be dumped into the radioactive drains as a result of normal feed and bleed and once through operation. The remaining 32 grams will dissolve slowly over a period of months and should also be bled off into the radioactive drain systems.

However, some of this silver will settle into crevices and cracks and will increase the radiological level of the crud to a minor degree.

b) Corrosion - The silver plating covers the retaining rings in all of these valves to inhibit corrosion of the 416 stainless steel base material, provide a lubricant to the retaining ring threads and valve stem, and to help seal the mating surfaces and decrease coolant leakage into the valve packing area.

It is expected that with the removal of the silver from the retaining rings there will be some additional corrosion of the base material. However, the silver will be replaced with magnetite as a natural by-product of the iron, oxygen reaction between the coolant and the retaining ring. This magnetite may cause some difficulty when the valve requires maintenance and the threaded ring has to be removed as the magnetite is abrasive and will be in the threaded area of the ring.

In addition, the 416 S.S. is subject to stress corrosion when hardened above Rockwell C 35. The hardness of these rings is a minimum of 35 R_c according to the vendor's drawings. Tests will be required with identical valves under "N" conditions to completely assess these corrosion problems.

Tests are now in progress to determine whether the silver will deposit on Zircaloy. A Zircaloy clad heating element in a KE loop will closely simulate the internal heat generation of a fuel element and the silver samples in the same area should provide an indication of whether the silver will deposit on a hot surface either in a hydroxide or nitrate form.

An analysis of the Teflon impregnated asbestos packing adjacent to the retaining rings in the majority of valves containing silver plated parts has found to contain 28 ppm of chlorides. Samples of hardened 416 S.S. along with the Teflon impregnated asbestos are also in test now to determine if stress corrosion will occur.

c) Valve Leakage - The dissolution of the silver should not create a serious coolant leakage problem as the retaining ring is backed up with the valve packing. The latter's prime purpose is to allow freedom of movement of the valve stem and prevent coolant leakage at the same time.

Nevertheless, an inspection of these valves in the loops has shown a potentially high leakage of coolant due to the excess weight and leverage action on the valve stems by the large and heavy motor and gear unit on the remotely operated valves. Corrective measures should be undertaken to eliminate bending loads on the valve body and valve stems.

Category II - These consist entirely of valves that perform functions such as shut-off devices for coolant sampling stations, stop valves on risers, root valves for pressure, temperature transducers, helium injection valves and similar devices.

Normally the effluent from these valves does not circulate through the reactor except as noted below:

Included in this group are 16, four inch valves on the front face of the reactor that will be activated during an emergency dump of a loop on a once through operation so that the effluent will not be recirculated.

There are also 16, six inch valves on the rear face of the reactor that are always open except during maintenance on the risers, at which time these valves are closed. Effluent from these valves will go into the crib.

The total number of valves in Category II is 140 valves varying in size from 1/2 inch through 6 inches.

a) Silver Activation - Normally, the dissolved silver will not be recirculated through the reactor after passing through root valves for transducers unless the piping upstream of the valve is depressurized and the instrument is removed. Neither should the valves being used at helium injection points cause silver injection into the loops as the valves should not contain coolant. These valves are closed except when the helium is being forced into the system.

The valves being used as stop valves on the coolant sampling lines will allow the dissolved silver to be drawn off with the sample. This is not felt to be a greater problem than already exists as a result of radioactive crud and fission debris that may normally be found in coolant samples.

b) Corrosion - The same problems mentioned above for the corrosion problems under Category I are present in the valves classed under Category II except that the pressure seals in the 4 inch and 6 inch valves are made from soft iron which may lock into place and be difficult to remove for valve maintenance.

c) Valve Leakage - The valve leakage conditions as a result of removal of the silver plating on the 1/2 inch through 1-1/2 inch valves is identical to those described in Category I valves where the valve packing will prevent excessive leakage. On the 4 inch and 6 inch valves the pressure seals are backed up with a steel gasket that should prevent valve leakage.

Category III - Components in this class include valves, strainers and expansion joints.

The coolant passing through these components will go into the radioactive vent and drain systems.

There are 338 valves varying in size from 3/4 inch to 2 inch in this class. There are also six expansion joints varying in size from 12 inches through 24 inches and one six inch strainer containing silver in this group.

a) Silver Activation - There should not be any problem regarding circulation of the silver in the loops from these components as all effluent from these devices will be drained or vented into the radioactive drain system.

b) Corrosion - The corrosion of the silver plated component parts on these devices is the same as in Categories I and II except for the expansion joints (EJ-1 through 6).

A silver braze was made on the inside lip of the bellows expansion joint connection to the carbon steel nipple. The purpose of this braze was to eliminate the crevice and crud pocket that existed between the bellows lip and the carbon steel nipple when the top surface of the bellows was seal welded with a lap weld.

This braze will be dissolved by the coolant allowing corrosion products to settle in the pocket which will then result in crevice and galvanic corrosion. The large expanse of carbon steel in the piping compared to the small surface area of the stainless steel expansion joint will provide a galvanic potential that will cause some corrosion. The corrosion will take place from the inside out so it may be difficult to observe until after penetration has occurred but periodic inspection should be made at the seal welds for penetration.

c) Coolant Leakage - It is expected that removal of the silver from the plated retaining rings and on the pressure seals will create a corrosion problem and possible leakage as mentioned under Categories I and II, above. The corrosion aspects of the silver braze on the expansion joints has been mentioned above under item (b) Corrosion.

CONCLUSION

A survey has been made of the components in the primary and graphite coolant systems that contain silver. Silver will be dissolved by the ammonium hydroxide in the coolant and be circulated through the reactor causing its activation and attendant radiological problems.

It was found that about 38 grams of silver will eventually be in the coolant. However, the content of silver in the coolant will only be about 6 grams at the beginning of loop operation and the remaining 32 grams will slowly enter the water during reactor operation.

Neither the initial 6 grams or final 32 grams should present any problem from a radiological standpoint unless the silver deposits preferentially in cracks or crevices.

The effect of loss of the silver plating from the component parts will cause accelerated general corrosion and stress corrosion of the part that the silver was protecting. The effect of accelerated corrosion on these parts will be investigated by the installation of typical valves containing the silver plating in test loops.

Valve leakage as a result of the silver plating removal is also an unknown but does not appear to be a problem. The valves to be tested and mentioned above should help furnish us with this information.

Maintenance difficulties as a result of the part formerly protected by the silver may also prove to be a problem if the part locks in place due to the corrosion. This again will be determined by the valve tests.

Future Work

The study of the problem of silver in the primary and graphite cooling systems will be followed by a report on the location of the copper and Teflon bearing components and their possible effects on the materials in these same loops.

It is known that copper based alloys are damaged by ammonia. It is also known that tetrafluoroethylene (Teflon) consists almost completely of fluorine and carbon. The fluoride ion is also damaging to zircaloy and it is also believed to cause an increase of pH of the coolant with which it is in contact. The coolant sampling lines contain valves with valve packings made from Teflon impregnated asbestos. The reaction of the Teflon to temperatures from 100°F to 535°F is now being studied in laboratory tests.

Bert S. Kosut

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Research and Engineering
N-REACTOR DEPARTMENT

BSK:gb

REFERENCES

1. Desirability of Removing Silver Gaskets from Valves in Primary Loop - Private Correspondence, M. L. Leverett to D. H. Curtiss, November 23, 1963.

2. Corrosion of Silver and Copper in High Temperature Water Environments - Private Correspondence, A. P. Larrick to B. S. Kosut, November 18, 1963.

3. Radiological Aspects of Silver Plated Velan Valves - Private Correspondence, J. W. Vanderbeek to B. S. Kosut, December 12, 1963.

APPENDIX

The components that are listed below contain silver either as a plating or in the form of silver braze.

A search of the system diagrams vendors drawings, and purchase records was made to compile this record. As far as may be determined the list is complete. However, recent changes to the system by either adding additional valves or deletion of valves or components may affect the total number of components in the various categories.

Category I Valves containing silver through which the coolant will circulate and be activated by the reactor flux are as follows:

Valve Number	Size	No. of Valves	Function
PCRV-201 (No.'s 11-15)	1½"	5	By-pass valves around large valves
PCRV-212 (No.'s 11-15-6-10)	1½"	10	By-pass valves around large valves
PRV-206	2"	2	pressurizer strong back valves
PRV-208	2"	1	pressurizer spray line valve
PCSV-211 (Valves 1,2,3,4,5)	1½	5	by-pass valves around motor operated gate valves
1WV-271 (No' 3,4,5)	1"	3	ammonium or lithium hydroxide injection valves
GCRV-312	1½"	2	root valves for liquid flow transmitters
GCRV-308	2"	2	surge tank strong back shut-offs

Category II These are valves in which the coolant ordinarily will not normally be circulated through the reactor after passing through this valve.

Valve Number	Size	No. of Valves	Function
PCRV-201	1½"	12	Helium injection stop valves, vents

Valve Number	Size	No. of Valves	Function
PCRV-207 (PT-valve No.'s 1-5 Sampling lines), Valve No.'s 6-10) (Crud probe)	1"	11	pressure trans. valves, sampling lines crud probe
PRV-213 (Valves No.'s 1-4)	1"	4	pressurizer vent helium injection valves
PSCV-207 (Valves No.'s 18-22)	1½"	4	helium injection valves
PCSV-212	1"	34	valves for press. transmitters, flow transmitters
PCRV-207 (PT-211-215) (Sampling lines root valves 43,47)	1"	12	root valves for press. transmitters and sampling lines
V-1	4"	16	Valves on front face that will be actuated during an emergency dump.
V-2	6"	16	Outlet end of reactor maintenance valve. Valve always open except during flush after reactor shutdown. Valves are closed when maintenance is required on risers.
IWV-272	1"	2	root valves for sampling lines
IWV-278 (PT valve No.'s 211-215) (PS valve No.'s 388-397 219 etc.)	3/4"	10	root valves for press. trans. and press. switches
IWV-289	1"	2	root valves for flow transmitters
IWV-257	1½"	1	root valves for radiation element

Valve Number	Size	No. of Valves	Function
GCSV-313	1"	2	root valves for flow transmitters
GCRV-314 (Valve for CE 251 DOA 345, PHE 256)	3/4"	2	root valves for conductivity element dissolved oxygen analyzer, pH monitor
GCRV-306 (PT 204)	½"	1	root valve for press. transmitter
GCSV-312	½"	10	root valves for press. trans.
GCRV-315	1"	1	helium supply valve

Category III The list of components below include those that the coolant will pass through and then go to the radioactive vent and drain systems.

Valve or Component No.	Size	Number Involved	Function
PCRV-201	$1\frac{1}{2}$"	40	Vents and drains
PCRV-208	2"	5	drains from pump seals
PCRV-209	2"	27	drain valves from heat exchangers, primary coolant suction lines
PCRV-211	1"	21	drain valves
PCRV-212	$1\frac{1}{2}$"	5	vents
PRV-201	1"	13	root valves for press. flow transmitters and press. switches
PRV-204	1"	2	drains
PRV-210	2"	2	pressurizer vent valves
PRV-211	2"	1	relief drain valve
PRV-212	$1\frac{1}{2}$	1	drains
PRV-214	1"	2	drain valves
PCSV-205	2"	18	drains
PCSV-207	$1\frac{1}{2}$"	7	vents
PCSV-209	1"	10	drains
PCSV-211	$1\frac{1}{2}$"	10	vents
PCSV-214	1"	14	drains
PCSV-215	$1\frac{1}{2}$"	5	vents
RDRV-204	2"	2	drains
RDRV-206	$1\frac{1}{2}$"	2	drains
RDRV-208	2"	1	drains
RDRV-211	$\frac{1}{2}$"	1	drains

Valve or Component No.	Size	Number Involved	Function
RDRV-215	1"	1	drains
RDRV-217	2"	1	drains
RDRV-218	2"	2	drains
IWV-261	1½"	15	vents, drains
IWV-261S	1½"	5	vents, drains
IWV-266	1½"	5	drains
IWV-270	1½"	25	vents, drains
IWV-271	1"	2	drains
IWV-275S	1"	5	drains
IWV-276	1"	6	drains
IWV-277	1"	6	drains
IWV-280	1"	2	drains
IWV-281	1½"	3	vents, drains
GCSV-304	1½"	10	drains, vents
GCSV-305	1"	9	drains
GCSV-306	3/4"	6	vents, drains
GCSV-310	1½"	5	drains, vents
GCSV-314	1½"	1	drains
GCSV-315	1½"	1	drains
GCSV-319	1½"	2	drains
GCRV-304	1½"	10	vents, drains
GCRV-309	1"	9	graphite coolant return line drains
FLV-202	1½"	7	drains
BDV-202	3/4"	2	drains
BDV-204	1"	1	drains
BDV-207	1½"	4	drains