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SUMMARY

The Homogeneous Reactor Test is designed for maintenance to be performed while the parts of the reactor are partially or completely submerged in water to reduce radiation levels. Tools with long handles permit the operator, standing above the equipment, to disconnect flanged joints, air lines, electrical and instrument leads, etc., in a minimum time. In this paper are described the techniques and tools employed to accomplish these various operations and to minimize intermixing of the contaminated process fluids with the shielding water. Estimates of shutdown times and costs of tools and spare parts are presented also.

*This paper was prepared for presentation at the Nuclear Engineering and Science Conference of the 1958 Nuclear Congress, which was held in Chicago, Illinois, March 1958.

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DIRECT MAINTENANCE PRACTICES FOR THE HOMOGENEOUS REACTOR TEST

S. E. Beall¹ and R. W. Jurgensen²

Before any nuclear reactor type can gain wide acceptance by the utility industry as a heat source for the production of electricity, reliability of operation must be demonstrated. Closely allied with reliability, if not actually a part thereof, is the reactor's maintenance character, which must be such that components can be repaired or replaced with a minimum of outage time and with a maximum of personnel safety. Perhaps the most important purpose of the Homogeneous Reactor Test (HRE-2) is to demonstrate the reliability of operation and ease of maintenance of a typical aqueous homogeneous reactor system.

Unlike a heterogeneous system where practically all radioactivity can be limited to a single vessel, the fission product contamination and activation in a homogeneous reactor are distributed throughout the reactor and cooling system components. Because of the high level of radioactivity in the pumps, heat exchangers, valves, and connecting piping, the problems of maintenance are considerably more difficult than in a solid-fuel system. It is therefore essential that special attention be given to methods of maintenance, to the layout of the reactor equipment, and to the protection of personnel performing repairs in a liquid-fuel system.

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MAINTENANCE DESIGN BASIS

In designing the HRT (HRE-2), one of the early decisions was that the maintenance be direct rather than remote, and that it be done completely under water, where possible. If complete submergence appeared impractical for some jobs, at least partial flooding was to be utilized to shield the radioactivity emanating from components at lower elevations. The choice of direct, underwater maintenance was the outgrowth of the Oak Ridge National Laboratory's experience with underwater development work for the MTR, and with dry, direct maintenance of the HRE-1.

Certainly the pro's and con's of submerged maintenance will be debated for a long time to come. It is conceivable that rapid decontamination procedures might be developed for homogeneous reactors so that dry, direct maintenance can be performed with very little shielding. Furthermore, it is very likely that manipulators, remote cutters, and automatic remote welders will be developed to make dry, remote maintenance feasible for future homogeneous reactors.

However, even after these devices have been satisfactorily demonstrated, underwater maintenance with long-handled tools manipulated from above will continue to be attractive for many applications. Water is the least expensive and most flexible shielding material. It greatly simplifies the viewing problem, and it permits the use of inexpensive, comparatively simple tools.

The major disadvantage of underwater maintenance is the difficulty of preventing the leakage of shielding water into the reactor piping; however, inleakage is not disastrous in any sense. The penalty of inleakage is the time (approximately 24 hours) required to remove the "light" water and dry, or rinse, the system before operation can be resumed. (There is little

danger of leaking light water into the fuel because the fuel is isolated in storage tanks during repair periods, sealed off by a freeze plug and two valves.) Another unpleasant possibility is that of contaminating the shielding water with fission product activity from the inside walls of the reactor piping. In most instances, intermixing of the two systems can be easily prevented by freeze jackets, placed around the piping at flange disconnects to form and maintain plugs of "heavy" ice in the pipe. In the few instances where freeze plugs are impractical, the flanges are located so that partial flooding provides sufficient shielding.

The wetting of thermal insulation and electrical components are not difficult problems. Several layers of freezer-wrap aluminum foil satisfactorily solved the insulation problem. Electrical components are kept dry by means of glass-metal Kovar joints and compression-type Conax seals, with air-pressurized conduit.

In selecting the wet approach to maintenance, it was hoped that a plant availability of 80% could be achieved, even if the failure rates experienced in HRE-1 could not be reduced. The importance of minimizing outage time led to the decision to maintain the plant by replacing whole components instead of attempting repairs in place. The replacement concept is logical where the component costs are not a large fraction of the total reactor cost, but may not be the best plan for large homogeneous power reactors of the future unless a hot repair facility is provided to reclaim the more expensive parts. The failed HRT components will be stored until a dismantling facility is available at the Oak Ridge National Laboratory.

In order for replacement to be practical, a satisfactory, disconnectable high-pressure joint is extremely important. The joint chosen

for the HRT was the ring-joint flange with an oval, stainless-steel gasket ring. Over 125 pairs of flanges were required in the HRT to permit sufficient flexibility in equipment removal. An important adjunct to the ring-joint flange is the leak detector which indicates whether the joint is leak-free after the bolting is completed. With the technique of pressurizing the groove under the gasket, the leak test can be performed before the reactor is restarted.

In addition to these general design features, several minor concepts were adopted for over-all convenience. An attempt was made throughout to locate components and flanges so that they can be reached directly from above. Where possible, the flanges are located in vertical pipe runs so that the bolts are vertical and therefore easily handled. A freeze coil was provided for each flange which might have to be opened under water. Space around the equipment pieces was allowed for the manipulation of tools. Piping raceways were designated to prevent the random routing of lines. The plan view of the reactor equipment is shown in Fig. 1.

TOOLING REQUIREMENTS

Following the practice of maintenance engineers in many power companies, the initial step in the HRT maintenance program was to compile a list of all equipment which might require replacement during the course of operation. Each replacement job was then studied sufficiently to determine the devices which would have to be designed and procured in each of the following categories:

1. Jigs.--Required for the fabrication of equipment components to desired dimensions to insure replaceability.
2. Fixtures.--Required for holding component assemblies in a fixed relation to the flanged connections.

Fig. 1. Reactor Component Arrangement, Plan.

TOOLING REQUIREMENTS (Continued)

3. Lifting Bails.--Required to lessen difficulties encountered in the remote handling of equipment.
4. Disconnects.--Easily manipulated disconnects are required for the various service lines: water, air, leak-detector, thermocouple, and electrical power. Snap-Tite connectors were chosen for air lines, Unibolt flanges for some water lines, Autoclave Engineers' fittings for leak-detector lines, Thermo-electric bayonet plugs for thermocouples, and Airesearch connectors for electric lines.
5. Wrenches and Tools.--Required to tighten, loosen, and remove the many sizes of bolts in both horizontal and vertical positions, remove and apply insulation, separate flanges, remove ring gaskets, etc. Approximately 71 tools were designed and constructed. Several are shown in Figs. 2 and 3.
6. Auxiliary Devices.--Many additional items are required to successfully perform remote-maintenance jobs. This category includes such items as glass-bottom viewing boxes, shielded working platform, portable refrigeration equipment, underwater TV and periscopes, underwater lights, vacuum cleaner, etc. Several of these devices are pictured on the tool cart in Fig. 4. The underwater TV camera by Dage is in Fig. 5.

JOB ANALYSES

The next step in the over-all program was the study of each repair assignment, the goal being to keep shutdown time to a minimum. Detailed analyses, organized in the following categories, were performed on 71 jobs.

1. Component Information.--All information pertaining to the particular equipment involved was organized into a workable filing

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Fig. 2. Long-Handled Tools for HRT Maintenance.

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Fig. 3. Long Handled Tools for HRT Maintenance.

Fig. 4. Tool Cart with Tools and Accessories.

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Fig. 5. TV Camera and Container for Use Underwater.

JOB ANALYSES (Continued)

1. Component Information. (Continuation)

system. This includes nameplate data, drawings, specifications, correspondence, and history of the equipment. With this information, it is relatively easy to prepare a replacement part for installation.

2. Materials.--All materials required to perform the work were identified and their availability determined. The required spare parts assemblies are included in this category.

3. Tools.--The tools required to perform the work were listed in the order in which they would be needed.

4. Special Equipment.--A list of special aids, such as glass-bottom boxes, remote television equipment, periscopes, lights, etc., was prepared.

5. Health and Safety.--Special consideration is given to the possible health hazards arising from radioactivity, the shielding and protective clothing required to minimize the hazards, and the available health-physics services to help protect personnel.

6. Job Procedure.--This entailed the detailing of each phase of the work to successfully perform the over-all job in a minimum of time with the least possible expenditure of manpower. Included in the procedure is the necessary preparatory work before the outage begins. Each step in the Job Procedure is fully described, with the proper tools indicated at each.

An examination of the Job Procedure (see Appendix) prepared for the replacement of the fuel circulating pump will serve to illustrate the various points discussed in this paper.

The procedure lists 96 steps for completion of the job. The more important steps are briefly described here. After the reactor is shut down, the fuel solution is drained to the outer storage tanks and the piping flushed with heavy water which had been evaporated from the fuel solution earlier. Automatic weighing devices on the dump tanks aid in raising the condensate level in the piping to a predetermined height to allow formation of freeze plugs at the pump flanges. The reactor cell is then flooded with light water. The required upper layer roof shield plugs are removed to gain access to the gastight steel membrane underneath, so that the shallow steel pans which are welded to form the seal, can be cut away at the desired access area. The required lower roof plugs (usually one or two) can then be lifted out to provide access to the reactor cell, and the work platform placed in position, as shown in Fig. 6, with the required tools. As soon as the working platform is located, freezer lines are connected and the heavy water frozen at the flanges. Figure 7 is a photograph taken from above the submerged pump.

Gas pressure is applied to be certain the lines are frozen, and then the remaining heavy water is transferred to the outer storage tanks. Next, the storage tanks are isolated from the reactor piping by valves and freeze plugs, so that light water cannot enter the storage tanks even if a flange freeze plug should thaw while submerged. When the lines are frozen, the scavenger line (a sort of wet vacuum cleaner) is positioned to remove the radioactive condensate trapped between freeze plugs, and thus to prevent contamination of the shield water when the flanges are opened. Next, wrenches are lowered to unbolt the flanges. In Fig. 8 a hydraulic torque wrench is shown in position on the 3-1/2-in. IPS flange at the pump discharge. The smaller flanges are unbolted with a

Fig. 6. Work Platform in Position.

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Fig. 7. Looking Down on Submerged Pump.

Fig. 8. Hydraulic Torque Wrench in Working Position on Flange.

simple socket wrench. The bolts are removed one by one and placed in a storage rack with a retriever tool (Fig. 9). Next, the electrical wires are disconnected, using the tool shown in Fig. 10. Only $1/8$ of a turn is required to loosen or tighten this type of disconnect. The thermocouple connections are unplugged with an upward motion of the tool shown in Fig. 11.

With this work completed, the pump is ready for removal to the storage pool where it is kept under water for future repair or dissection.

Installation of a new component follows these steps in reverse with a spare pump, previously fabricated on the pump jig (Fig. 12) to insure its dimensional integrity. The light water trapped between the flanges must be removed to prevent dilution of the heavy water. Removal is accomplished with the aid of auxiliary thin-walled copper gaskets fitted with two hypodermic tubing connections and attached snugly to the O.D. of the stainless-steel ring gasket (see Fig. 13). The length of the copper gasket is sufficient to seat on the raised faces of the flanges before the stainless-steel gasket starts to seat. With only the copper gasket sealing, compressed air is introduced through the hypodermic tubing.

The trapped light water is displaced by the air and forced out the second hypodermic tubing section. The flanged joint can be flushed by flowing heavy water through the tubing also. By this means, dilution of the heavy water can be kept to a minimum. The flange bolts can then be tightened until the stainless-steel gasket seats. The copper readily crushes and does not interfere with making up a leak-tight joint.

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RETRIEVER TOOL

RACK FOR BOLTS

Fig. 9. Retriever Tool Moving Bolt To Storage Rack.

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Fig. 10. Disconnecting Electrical Leads to Pump.

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THERMOCOUPLE
DISCONNECT TOOL

BAYONET PLUG
STORAGE RACK

Fig. 11. One Thermocouple Connector is Placed on Storage Rack.

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Fig.12. Main Circulating Pump Being Fitted to Jig.

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Fig. 13. Ring Joint Flange with Auxiliary Copper Gasket to Permit Removal of Light Water.

The removal and replacement of a circulating pump is one of the most difficult of the 104 jobs studied, requiring a shutdown of approximately 125 hours. It would be surprising if a pump failure occurred more often than once per year. No other replacement job, except the steam generators and the main core vessel would require so long a shutdown.

In several instances, shorter shutdowns have been made possible by special designs, as illustrated by the following examples.

SPECIAL DESIGNS

Valves

Approximately 60 valves are required to control the flow of liquid and gases in the Homogeneous Reactor Test. With such a large number of units, numerous replacements can be expected. Spare assemblies have been prepared for each type, using the "universal" assembly jig shown in Fig. 14 to guarantee the fit of the high-pressure process piping flanges. In the low-pressure system, the flange grooves were machined into the valve body, thus making it possible to use one set of bolts for both inlet and outlet flanges.

Typical high- and low-pressure valve installations are shown in Fig. 15. Note the quick-disconnect stations on the supply and discharge air lines. The disconnects are located at the top of the cell where they can be operated easiest. Freeze coils of copper tubing are wrapped around the pipes at the entrance and exit flanges to seal off the process pipes before the flanges are unbolted. Replacement of some valves can be accomplished in a 60-hour shutdown.

Feed Pumps

In the HRE-1, the fuel and blanket high-pressure feed pumps required frequent replacement and, although the present pumps are much more

Fig. 14. Universal Jig for High Pressure Valves.

Fig. 15. Typical Valve Installations

reliable, provision for rapid replacement was specified. The resultant design is shown in Fig. 16. By locating the pumps adjacent to the shield wall, it was possible to extend all the flange bolts completely through the wall. Thus, the pump flanges can be unbolted quickly from the control-room side. The pump can then be lifted from the cell and a new one installed. It is estimated that the replacement of a feed pump can be made in no more than 60 hours.

Instrument Elements

Instrument sensing elements, such as pneumatic pressure and differential pressure cells often require adjustment. Electrical devices usually must be shielded for proper performance. Availability and radiation protection were provided in the HRT by designing instrument blisters on the face of the reactor shielding wall. The blisters, shown in Fig. 17, are equipped with quick-opening hatches.

They are well shielded and are unlikely to become seriously contaminated because the instruments are attached to the reactor through long condensate-filled lines. Thus, direct maintenance can be accomplished in a few hours without flooding and without having to contend with the radioactivity of the main reactor cell.

Rupture Disks

The rupture disks, which separate the fuel and blanket high-pressure systems and protect the core tank against excessive pressures, are located at the highest point in the reactor. The vessel containing the disks is difficult to isolate with freeze plugs. Since, in this case, the shield water level could be raised high enough to cover all other radioactive equipment, it was feasible to provide a special shielded plug through which tools can be manipulated to open the flange, discard

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Fig. 16. Feed Pump Installation for Dry Maintenance.

Fig. 17. Instrument Blister.

the old disks and install the new ones. Fig. 18 shows the arrangement of plug and tools over the rupture-disk pot. The shield is designed with an eccentric lead plug, so that the tool openings can be maneuvered to any position by rotating the parts of the eccentric plug. With this shield and a TV camera inside the work area, dry maintenance can be accomplished without great difficulty. Core and blanket corrosion sample assemblies and the hydroclone assembly of the attached chemical plant are also removed by this technique.

COST OF TOOLS AND SPARE PARTS

One of the arguments in favor of direct underwater maintenance is the lower cost of the tools required, as compared to cost of equipment for remote work. For the HRT, the total cost of tools was \$196,000, broken down as follows:

Design	\$ 91,000
Fabrication	64,000
Development	<u>41,000</u>
	\$196,000

This amounted to 5.1% of the total design and construction cost of the reactor.

The spare parts estimated to be required for a 3-year operating period are listed in Table 1. On an annual basis, this would amount to 3.9% of the original investment for the entire reactor.

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Fig. 18. Shield for use in Direct Dry or Partially-Wet Maintenance.

Table 1. HRT Spare Parts Requirements

Item	No. on Hand	% of Original Equipment	No. Required (3-yr Period)	Total Cost (3-yr Period)
Valves	38	60	30	\$ 22,500
Circulating Pumps	2	100	3	87,000
Steam Generator	1	50	1	60,000
Feed Pumps	6	150	12	111,200
Purge Pumps	4	100	15	68,125
Letdown Heat Exch.	1	50	2	4,000
Sampling Station	1	50	1	19,800
Pressurizer Heaters	4		8	4,950
Instruments				20,000
Miscellaneous				50,000
				<u>\$447,575</u>

EXPERIENCE

The experience to-date with direct maintenance in the HRT has been accumulated in three full-scale practice periods in which over 30 equipment pieces were removed. The procedures previously prepared were checked out and improved. It is believed that the times required for these first attempts can be substantially reduced in future work. However, the actual times are the basis for the tabulation of total shutdown times for the replacement jobs in Table 2.

On the basis of the experience of thousands of hours of loop and mockup operation at the Oak Ridge National Laboratory, it is also possible to make a tabulation of expected equipment performance.

Combining these expected performances with the shutdown times, it can be seen that a total of approximately 1,388 hours of shutdown time will be required if the equipment performs in the reactor as well as it has in non-radioactive service. This would leave 400 hours for miscellaneous other work and still realize the ~~interim~~ goal of a plant availability of 80% per annum. There is much reason to believe that the expected lives can be lengthened and the outage times shortened as more experience is gained. Furthermore, it is very unlikely that all of the outage times in Table 2 would be additive. In fact, the difficulties which would require immediate shutdown are limited to circulating pump failure, steam generator tube leakage, and excessive seat leakage past four of the 60-odd valves. In all other situations, it should be possible to continue operation at full power until a convenient shutdown, combining other repairs, can be scheduled.

Table 2. Estimate of HRT Outage Periods

Item	Expected Life Years	No. of Items in Reactor	Expected Replacements Per Year	Outage Time Per Replacement- Hours	Total Outage Per Year Hours
Circulating Pumps	2	2	1	122	122
Feed Pumps	1	4	4	60	240
Purge Pumps	1/2	4*	6	60	360
Valves	1/2 to 10	60	10	60	600
Steam Generators	6	2	1/3	198	66
					<u>1,388</u>

* Only 3 are in use presently.

APPENDIX

JOB PROCEDURE FOR FUEL CIRCULATING PUMP

Remote replacement of the fuel circulating pump, Item 5. Underwater Replacement. Assume fuel solution has been drained from the high-pressure system.

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
1.	Fill the high-pressure system with D ₂ O.	
2.	Flush the high-pressure system with D ₂ O. Leave the high-pressure system full.	
3.	Operate fuel circulating pump purge pump. Pump and pressurize fuel system to approximately 20 psig pressure to fill the fuel circulating pump.	
4.	Procure all tools and facilities, and check their condition for operability and safety.	
5.	Obtain new 400A pump assembly from spare parts.	
6.	Flood cell to 823.0-ft elevation. (Job Procedure No. 88)	
7.	With the water level near 823 ft, remove upper roof plugs 5S, 6S, and 7S. Place these plugs on blotter paper in the southwest section of the high-bay area.	
8.	Cut all seal welds on seal pans 6S and 7S with oxygen-acetylene torch. Weld U-shaped lifting lugs formed from 3/16-in. welding rod to each corner of the two pans. Remove the pans and place on blotter paper in the west end of the high-bay area. Prepare pans for rewelding by hand-grinding if permissible from the health-physics standpoint.	
9.	Shut off the exhaust fan and close the 16-in. evacuation valve.	
10.	Reopen valve 386A in cell A and raise the flood water to the top of the lower plugs.	
11.	Remove lower plug 14S and place it on blotter paper in the southwest corner of the crane bay.	
12.	Attach a clamp-on freezer to line 125 on the circulating pump side of flange 125B.	
13.	Freeze line 797 at the purge pump, using plant refrigeration system, item 108, and freeze pump side of flange 125B, using the portable refrigeration system.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
14.	When the ΔT on the freeze plug refrigerant becomes constant, open flange 125B and remove bolts from the cell.	
15.	Attach gas pressurization flange to the pump side of flange 125B.	
16.	Place a rubber stopper in the opening in line 125B. Stopper size O.	
17.	Thaw freeze plug in line 125 on the pump side of the flange.	
18.	Drain contents of the high-pressure system to the dump tanks.	
19.	Attach temporary refrigerant lines, 5/8-in. soft copper refrigerant tubing properly insulated, from the portable refrigerant system supply to the freezer connections for lines 102 and 103. Open the refrigeration valves at the supply station.	
	Note: Before attaching the temporary refrigerant lines to the supply station, attach the lines to the cell freeze coils. Blow out the entire temporary line with air to remove water.	
20.	When the thermocouples attached to the supply and return lines indicate a constant ΔT , pump D ₂ O condensate into the high-pressure system with PCV-152 closed until ΔT on the refrigerant thermocouples increases. Check the fuel inventory to determine if liquid level is at the freeze coils, as indicated by the thermocouples.	
21.	When the ΔT again becomes constant, it can be assumed that ice plugs have been formed.	
22.	Check the freeze plug by pressurizing through line 125 with helium.	
23.	Remove lower plug 138. Place on blotter paper in the west end of the high-bay area.	
24.	Shut off cooling water circulating pump, Item 62.	
25.	Close valve 421A, cooling water to the circulating pump, and discharge line valve FCV-934.	
26.	Close leak-detector valves.	
27.	Remove the west roof plug from the hot storage cell and place on blotter paper in the southeast section of the high-bay area.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
28.	Check the water level in the hot storage cell and wash basin. A minimum 15-ft depth required (one ft below plug ledge).	
29.	Cover floor around work area and path between the work area and hot storage cell with plastic-backed blotter paper.	
30.	Place working platform over roof plug opening above pump.	
31.	Lower the underwater light. Caution: The light must not be turned on unless submerged in water.	
32.	Disconnect electrical power leads. (Tool No. 26 and 16)	
33.	Disconnect thermocouple leads. (Tool No. 13)	
34.	Loosen bolts in cooling water flanges. (Use 3/4-in. socket wrench - 10-ft handle. (Tool No. 38)	
35.	Lower bolt rack (No. 8) and mechanical retriever tool (No. 30) with 10-ft handle and place cooling water and purge line flange bolts in the rack (Tool No. 35).	
36.	Remove the bolt rack and the retriever tool from the cell and place on blotter paper. Check activity.	
37.	Lower the cutoff tool and cut pump casing leak-detector line near the pump.	
38.	Remove the cutoff tool from the cell and lay on blotter paper. Check activity.	
39.	Loosen the leak-detector disconnect. (Use 7/8-in. socket on 10-ft handle, No. 26.)	
40.	Remove the disconnect wrench from the cell and place on blotter paper. Check the activity.	
41.	Remove the cutoff leak-detector line from its disconnect with mechanical retriever tool, and slowly raise from water while checking activity. If activity level permits, slip plastic bag over the end of line and transport it to the hot storage cell.	
42.	Remove flange insulation from the cell and place it in hot trash can. (Tool Nos. 3 and 4)	
43.	Lower bolt wrench to 4-in.-2500-lb flange. Use hydraulic torque (No. 38) or torque multiplier wrench (No. 31d). Loosen all bolts. Note torque required.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
44.	Remove the wrench from the cell and lay on blotter paper. Check activity.	
45.	Lower spinner wrench and spin bolts until threads of all bolts are disengaged.	
46.	Lower torque multiplier wrench (No. 31b) to 3-1/2-in.-2500-lb flange. Loosen all bolts. Note torque required.	
47.	Remove torque multiplier wrench from the cell and place on blotter paper. Check the activity.	
48.	Spin all bolts free with spinner wrench.	
49.	Lower bolt rack for 1-1/2-in. bolts and mechanical retriever tool. Transfer bolts and ferrules from the flanges to the rack. Leave the bolt rack under water, but place it clear of pump assembly.	
50.	Remove the spinner wrench and retriever tool from the cell and place on blotter paper.	
51.	Assemble lifting bail (No. 33) and hang from the overhead crane hook with come-along. If the necessary facilities have been provided, attach the TV camera to the lifting bail. Place TV monitor behind the temporary shield for crane operator.	
52.	Attach lifting bail to lugs provided on the pump support plate and pull snug with the come-along.	
53.	Lower 1-3/4-in. socket wrench with 17-ft handle and loosen pump base hold-down bolts. Spin bolts free.	
54.	Remove base hold-down bolt wrench from the cell and place on blotter paper. Check the activity.	
55.	Lift pump approximately one foot with come-along. Adjust bail to get an even hang.	
56.	Remove the working platform and get pump assembly in the clear for straight vertical lift.	
57.	Close area gate and remove all personnel to the 7500 area shop building except for the crane operator, health-physics man, and maintenance supervisor.	
58.	Shift supervisor to give "all clear" by PA when all the personnel are in the shop.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
59.	Crane operator, health-physics man, and the maintenance supervisor position themselves behind temporary shield at the west end of the building.	
60.	Lift pump assembly from the cell; let it drain and transport it to the wash basin in the hot storage cell. Marks on the crane rail and crane girder will aid in centering the pump assembly over the wash basin. If TV is not available, large mirrors should be located at the cell working area and at the wash basin to give necessary visual aid to the crane operator. Extreme caution should be exercised during the vertical movements.	
61.	If it is desired to remove corrosion specimen holder in line 103, the special carrier should be lowered and the holder handled into the carrier with the special tool provided.	
62.	Blotter paper contaminated by pump drainage should be removed and the personnel allowed to return to the reactor building.	
63.	Disengage overhead crane from the hot pump bail and engage the second lifting bail.	
64.	If desired, new corrosion specimen holder should be reinserted in line 103.	
65.	Attach second lifting bail the the new pump assembly. New rings are to be attached to the pump assembly flanges. Fill the pump casing leak-detector line with D ₂ O.	
66.	Attach air pressurization flange to the purge line flange of the pump assembly. Air line to be fitted with regulating valve and pressure gauge.	
67.	Lower the new pump assembly into place, maintaining just enough air pressure to keep the air bubbling out at the main pump piping flanges.	
68.	Reinsert the flange bolts and ferrules, spin down the bolts and start torquing the bolts with the tools and facilities used during removal.	
69.	When torquing flange bolts, follow the procedure stated in Robinson's memo to Beall, dated 9/10/56. It is recommended that the first round of torque be limited to approximately 10% of the last final torque recorded in the flange log book. After the first torque round has been applied, open the leak-detector valve to flush out the cell light water trapped in the flange grooves. After flushing, continue torquing in at least three additional steps until the last recorded torque value has been reached. Leak test all newly-made flange joints.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
70.	Upon satisfactory seal test of the flanges in lines 102 and 103, and the making up of the cooling-water line flanges, turn off the refrigeration valves.	
71.	Disconnect refrigerant lines from the freezer station and cap the nipples. Blow helium through the refrigerant lines to remove the refrigerant. Catch refrigerant in a container and discard.	
72.	When the freeze plugs have thawed (approximately 1-1/2 hours required), pump D ₂ O into the high-pressure system until line 125 is full. Check water level in the system with a radiation instrument by monitoring air-addition line; care should be taken to insure that no spill of the liquid from the reactor occurs.	
73.	Freeze a plug in line 125 attached to the pump.	
74.	Connect the pump casing leak-detector disconnect.	
75.	Remove air addition, flange from line 125.	
76.	Remake Fig. 125B, and check seal with leak detector; also, check the pump casing leak detector.	
77.	Remake thermocouple disconnects and attach microphone.	
78.	Reconnect the electrical power leads. Be certain of proper orientation to insure proper pump rotation.	
79.	If used, replace flange insulation.	
80.	Begin draining the flood water from the cell. (Job Procedure No. 88a)	
81.	When the flood water level is down to 823 ft-6 in., open the 16-in. evacuation valve and allow water trapped in the evacuation duct to drain out through the 2-in. overflow line into the east valve pit and then start the stack fan. Disconnect and remove the refrigeration lines and cap the nipples in the cell.	
82.	Open the cooling-water valves 421A and FCV-934, start the cooling-water circulating pump (Item 62) and make visual inspection of the flanges in the cooling-water lines for leaks.	
83.	Remove all tools and facilities from the work area.	
84.	Replace lower plugs 13S and 14S. Replace seal pans 6S and 7S and seal-weld in place.	

<u>Step</u>	<u>Description of Work</u>	<u>Man-Hours</u>
85.	Replace the upper roof plugs 5S, 6S, and 7S, and the locking steel keys. Shut off the stack fan, but leave the 16-in. evacuation valve open.	
86.	Release equipment to operations.	
87.	Make a radiation survey of all the tools, facilities and the work area. Insert contaminated tools in plastic bags and place them on decontamination slab on the south side of the 7500 area.	
88.	When the dewatering pump is shut off by the low water protective device, close valves 386C, 528A, and 529A in cell A.	
89.	Jet the remaining water out of the reactor cell by opening the jet discharge valves 520A and 521A, and the jet steam supply valves 600A, 602A, and 603A.	
90.	When all the water has been removed from the cell as determined by observation of the discharge line at the waste pond, close the jet steam supply and discharge line valves.	
91.	Close the cell evacuation valve 532A.	
92.	Clean up the work area.	
93.	Make proper disposition of the pump assembly in the wash basin. This will probably involve some decontamination flushing of the pump assembly, and then transfer of the assembly to the hot storage cell from the basin.	
94.	Make proper disposition of all the tools and facilities. Clean and inspect.	

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