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PATHFINDER ATOMIC POWER PLANT

MASTER

FUEL HANDLING AND TRANSFER SYSTEM DEVELOPMENT

Submitted to
U. S. ATOMIC ENERGY COMMISSION
NORTHERN STATES POWER COMPANY
and
CENTRAL UTILITIES ATOMIC POWER ASSOCIATES
by

ALLIS-CHALMERS MANUFACTURING COMPANY
ATOMIC ENERGY DIVISION
Milwaukee 1, Wisconsin

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by D. A. Patterson and D. E. Fortunato

Submitted to

**U. S. ATOMIC ENERGY COMMISSION
NORTHERN STATES POWER COMPANY**

and

CENTRAL UTILITIES ATOMIC POWER ASSOCIATES

by

ALLIS-CHALMERS MANUFACTURING COMPANY

Under

Agreement dated 2nd Day of May 1957, as Amended
between

Allis-Chalmers Mfg. Co. & Northern States Power Co.
under

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PATHFINDER ATOMIC POWER PLANT
FUEL HANDLING AND TRANSFER SYSTEM DEVELOPMENT

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FOREWORD

One of a series of reports on research and development in connection with the design of the Pathfinder Atomic Power Plant, this particular report deals with Fuel Handling and Transfer System. The Pathfinder Plant is located at a site near Sioux Falls, South Dakota and is scheduled for operation in 1964. Owners and operators of the plant will be Northern States Power Company of Minneapolis, Minnesota. Allis-Chalmers is performing the research, development and design, as well as being responsible for plant construction.

The U.S. Atomic Energy Commission, through Contract No. AT(11-1)-589 with Northern States Power Company, and Central Utilities Atomic Power Associates (CUAPA) are sponsors of the research and development program. The plant's reactor will be of the Controlled Recirculation Boiling Reactor type with Nuclear Superheater.

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1.0 INTRODUCTION AND OBJECTIVE

The Pathfinder Atomic Power Plant includes a boiling water reactor with an integral nuclear superheater. This report summarizes the design of the refueling system for the reactor.

The objective of this project was to perform conceptual engineering and experimental work as required for development of simplified but reliable fuel handling tools and special tools for repairing or replacing reactor parts.

2.0. GENERAL PLANT LAYOUT

2.1 Initial Concept

The initial concept of the plant layout had the reactor and storage pool located together in the same building. A single segmented pool with a transfer door was envisioned. This system required a single movable handling bridge, a single set of tools, etc. A sketch of this system is shown in Fig. 1. The plant arrangement was later changed to include a separate containment closure around the reactor. The storage pool was then located in and at the end of the turbine building. A separate building and separate services were thus avoided and the large overhead crane could be used for handling the heavy fuel shipping cask. Transfer of the fuel would take place through an underground tunnel. The overall concept was again changed in order to isolate the handling, loading and storage of fuel from routine plant operation. A separate Fuel Handling Building was designed to include a spent fuel storage pool, a new fuel storage vault, a loading and unloading area, etc. The final arrangement is shown in Fig. 2.

Figure 1...Initial Concept of Refueling Arrangement

Figure 2...Pathfinder Plant - Plan View (211392)

2.2 Pool Requirements

From the very beginning, it was decided to perform refueling operations through a water shield which allows direct visual access to the core. This necessitated a pool, called the Shield Pool, located directly above the reactor vessel. The cover of the vessel forms a part of the pool floor.

Requirements for this pool include a sufficient depth to provide shielding during refueling, space for the fuel transfer mechanism, and room to store the vessel cover and various reactor internals during refueling operations.

The Pathfinder shield pool is a stainless steel tank contained within a concrete pit. There are lugs welded to the bottom to position the various items to be stored. The pool is pictured in Fig. 3.

The spent fuel storage pool, known as the Storage Pool, is a concrete walled pit. This pool must contain sufficient space to store spent reactor fuel elements, control rods and other radioactive materials. Also, it must provide sufficient shielding and space to load the fuel, etc. into shipping casks. Other handling requirements exist, such as any remote disassembly or cutting equipment and space for one end of the fuel transfer mechanism.

The final pool design is shown in Fig. 4. It contains storage racks capable of storing two boiler cores and three superheater cores of fuel

Figure 3...Reactor Shield Pool (43-202-761)

Figure 4...Fuel Storage Pool (43-202-755)

elements. There are also separate racks for storing 16 boiler control rods and six groups of superheater rods. One section of the pool is deeper to accommodate the shipping cask and provide the required shielding while loading it with fuel. The pool depth is 21 feet overall and 29 feet at the depressed portion.

As shown in the illustrations, both pools include racks along one side for storing the handling tools.

2.3 Fuel Transfer Chute

When the plant layout necessitated two pools in separate buildings, the problem of transferring the fuel from one pool to the other presented itself. The first concept showed the storage pool a few feet deeper than the shield pool. An inclined chute connected the two pools. A cover at the top of the chute was needed to seal off the containment vessel from the rest of the plant. Two methods of moving the spent fuel through the chute were considered. One involved lowering the element with a crane. This presented a problem with the handling tools and the crane design. The alternate method was to allow the element to slide down the chute into the storage pool. This required a mechanism in the storage pool to cushion the shock of the sliding element. Two disadvantages were evident with the inclined chute. First of all it became very difficult to transfer the approximately 15 foot long control rod through the chute. Also, there was no method of moving irradiated fuel back into the shield pool, as would probably be necessary at some

future time. For these reasons, a horizontal chute was considered. This method also saved considerable expense in fabricating the storage pool since it could be more shallow.

A horizontal chute, or tunnel, obviously would utilize a cart or carriage which would run on rails and on which the components would be placed. There were two primary problem areas, the underwater drive and controls for the carriage, and the technique for moving the fuel from the vertical position, as it is handled, to the horizontal position for its trip through the tunnel.

One of the initial concepts for this horizontal arrangement is shown in Fig. 5. This shows a pulley system which is manually actuated. The requirements for this system were sent to a few companies for design bids. Two bids involved pulley systems actuated by electrical motor drives. A third proposal submitted by General Mills, Inc. featured a long rack mounted beneath the transfer carriage with a pinion gear at each end of the tunnel for driving. It also had the electric motor drives located above water. The G.M.I. scheme was selected and it is shown in Fig. 6.

The other area of consideration involved the tilting of the components from the vertical to horizontal position and back again. The most straightforward approach seemed to be a tilting mechanism built into the transfer carriage. Several methods were looked at. These included

Figure 5...Fuel Transfer Chute - Horizontal Type (43-201-657)

- NOTE:
1. ALL SUBMERGED EQUIPMENT TO BE STAINLESS STEEL EXCEPT BRONZE BEARINGS
 2. ALL NON-SUBMERGED MATERIAL TO BE SPLASH-PROOF, CORROSION-RESISTANT OR SUITABLY PAINTED
 3. REF GMI SKETCH SK 229752-B FOR CARRIAGE TILT MECH'M.

hydraulic cylinder, motor driven screw, crane operated, and pulley driven mechanisms. However, it was decided to ask G.M.I. to come up with a design to be compatible with their transfer scheme. Their proposal is shown in Fig. 7. It features a gear arrangement with an above water electric motor drive. This system proved to be quite expensive and an alternate method using a separate transfer box was investigated.

The transfer box concept as first conceived is shown in Fig. 8. A plastic model was built to demonstrate its principle of operation. The box as conceived would hold four boiler fuel elements, a boiler control rod, or any of the other components requiring transfer. This system includes the following features:

1. Separate stations are provided in each pool to hold the boxes while being loaded and unloaded. These are called vertical support racks, and are shown in Fig. 9.
2. The components are loaded into the transfer box in its vertical position.
3. A rigid "T-bar" tool is used to pick up the box by inserting it into "J" slots in the top sides of the box. This only requires the use of existing equipment, namely the bridge crane.
4. The box, with off-center trunnions is placed into slots on the carriage sides, and is slowly lowered into the horizontal position.

Originally, one tilting transfer box was designed to hold all core components. However, additional physics calculations revealed that a special

Figure 7 ... Transfer Box Tilting Mechanism

Figure 8...Tilting Transfer Box Concept (43-002-272)

APPROX. WT. 37

box made of boron-stainless steel will be necessary to safely transfer the 3.2 per cent enriched boiler fuel elements. For this reason, two different transfer boxes were designed (shown in Fig. 10), one for transferring fuel elements and the other for the boiler boxes and control rods. The fuel element box has the three walls and the internal plate made of $3/8$ in. thick 1 per cent boron stainless in the region of the fuel. The four nozzle sleeves were made of 17 4-PH stainless steel in order to protect the element nozzles from galling and scratching. The components box was sized to hold the quad box and is fabricated of $3/16$ in. 304 stainless steel. The trunnions of both types are also 17 4-PH stainless steel.

The original design of the tilting transfer box tool is shown in Fig. 11 and is of rather simple design. The long handle was designed primarily to guarantee a minimum 9 ft 4-1/2 in. shielding cover of water. This minimum depth is attained when the crane is in the "fully up" position. A transfer box with four boiler fuel elements provides the worst case as far as dosage is concerned. This dosage, however, is well below the safe limits established for this operation.

A problem arose, however, in the design of the shield pool crane. It became necessary to place the crane trolley on the opposite side of the bridge. This meant that tilting of the transfer boxes could not take place as envisioned earlier - namely, with the bridge in a fixed position. Two possible approaches existed. One was to move the bridge in increments

TRUNNIONS FIT IN
SLOTS ON TRANSFER
CARRIAGE

LIFTING SLOT
(SAME FOR BOTH
BOXES)

VIEW "A"- "A"

COOLING HOLES

SUPPORT SLEEVES FOR
FUEL ELEMENTS

FUEL ELEMENT TRANSFER BOX

9'-0"

"A"

"A"

COMPONENTS TRANSFER BOX

Figure 10...Tilting Transfer Boxes (43-202-753)

NO.	DESCRIPTION	MATERIAL	PART NUMBER	WT.
1	TILTING TRANSFER BOX HANDLING TOOL		43-401-275	501
2	TUBE - 1/2" O.D. x 10 GA. (0.049) WALL x 211" L.G.	ALUM. 8010	THIS	005
3	HANDLING TOOL EYE	ALUM. 8010	43-201-266	501
4	TEE BAR ASSEMBLY	STEEL	43-201-266	501
5	CONNECTOR PIN	STEEL	43-201-265	501
6	FLANGE	STEEL	43-201-279	001
7	GASKET - 1/2" THK. x 3 1/2" O.D.	BRASS	THIS	001
8	1/2" - 20 UNC. - 2A - 1/2" LG. NUT x 5/8" HEL. BOLT	ALUM. 8010	Q010454	001
9	CLEANING PROC. SPEC.		43-201-641	001
10	WELD ROD	STEEL	THIS	010
11	HANDLE - 1/2" O.D. x 10 GA. (0.049) WALL x 61 1/2" L.G.	ALUM. 8010	THIS	011
12	1/2" - 20 UNC. - 2B. NUT. x 5/8" HEL. BOLT	STEEL	Q010610	001
13	WASHER - 1/2" THK. x 3/4" I.D. x 1 1/2" O.D.	STEEL	THIS	013
14	PLUG - 1/2" THK. x 1 1/2" O.D.	STEEL	THIS	014

Figure 11...Tilting Transfer Box Tool, Original Design (43-401-275)

as the box was being raised or lowered. This was felt to be too awkward an operation for standard procedure. The second method involved a redesign of the tool so that the rigid pole was replaced by a flexible cable. This, together with a pulley on the bridge would permit the boxes to be tilted without moving the bridge. The latter scheme was adopted. The redesigned tool is shown in Fig. 12.

The transfer box tool includes a special feature to allow the operator to easily insert the lugs into the box slots while leaving only a cable for the handling operations. A long aluminum handle with a special end fitting was designed. This end fitting is inserted into two slots in the head of the "T-bar." Spring operated catches hold the handle to the bar. However, as the weight of the box acts on the cable, the catches are released and the handle can be removed.

The handle was designed so that when fully assembled, it would float in the pool. The tools for the two pools were made the same for simplicity.

2.4 Description of Final Arrangement

The final pools and transfer equipment arrangement is shown in Fig. 13. The large gate valve in the transfer tunnel is used to isolate the reactor during operation. The valve is opened only during refueling. The controls for the transfer carriage are arranged so that the plant operator can only drive the carriage toward himself and only after the operator in the other

Figure 12...Tilting Transfer Box Tool, Redesigned (43-202-754)

pool has released the carriage. The complete carriage and valve operation is described in the Installation-Operation and Maintenance Manual, Fuel Transfer System by the General Mills Electronics Group.

The new fuel storage room contains racks for storage of 156 boiler fuel elements and 550 superheater fuel elements. The boiler elements are stored at a slight angle to the vertical position. The superheater elements are stored in horizontal racks.

3.0 GENERAL HANDLING REQUIREMENTS

3.1 Boiler Fuel Handling Requirements

The Pathfinder boiler fuel element is shown in Fig. 14. It weighs 227 lb in water and therefore requires a crane to lift. It is 99 inches long. All handling operations require that no damage shall be incurred on the elements. In particular, the oxide coating on the Zircaloy fuel pins (the outer row of which is exposed) must be protected, along with the element nozzle.

Shielding for the boiler fuel was originally set at 10 ft of water. This assumed that the element was in the vertical position and was irradiated for 18 months at full power. The shield pool was designed to provide this depth as the element cleared the vessel flange during handling. Further design work on the equipment involved resulted in a minimum water cover of 8 ft 11., which gives a dose of 10 mr/hr at the surface.

3.2 Superheater Fuel Handling Requirements

The Pathfinder superheater fuel element is shown in Fig. 15. It weighs only about 5 lb and thus can be handled with manual tools. The total element length is 79-1/2 inches. Although the element is made of stainless steel, it requires careful handling because the outside cladding is only .007 inches thick and the entire element is also very susceptible to being bent or bowed.

Shielding requirements for this element are less than for the boiler element (about 7 ft), but to reduce exposure to the operators as much as possible, the same shielding depths are used for both elements.

3.3 Description of Underwater Handling Test Facility

The 40 ft deep, underwater test facility (at A-C Greendale Laboratories) for mechanical handling of fuel elements and other reactor internals is shown in Fig. 16. The tank has underwater lights, bridge, and handling crane, and is able to duplicate any underwater problem anticipated in the Pathfinder reactor.

Equipment simulating various reactor internal structures was built and lowered into this tank in order to test tools and procedures. Some of the lab personnel were trained in deep water diving in order to assist in these operations. The tank contains portholes at three depths close to the bottom to assist in viewing underwater operations.

The handling crane has a capacity of one ton. It is a two-cable crane which results in a straight-line pull. The lamps are described in Section 3.6.

3.4 Reactor Core Mock-up

A full scale mock-up of one-eighth of the reactor core was designed and built. It is shown in Fig. 17. The mock-up includes fourteen dummy boiler fuel elements made of aluminum, since this was the reference core material at the time. Also, there is a simulated portion of the superheater structure containing 15 tubes. Fifteen dummy superheater elements were fabricated of stainless steel. The stand includes two control rod guide channels.

Figure 16...Underwater Handling Test Facility (43-201-655)

Figure 17...Reactor Core Mock-up (43-500-653)

The boiler fuel elements included some with aluminum nozzles, some with 304 stainless steel nozzles, and others with chrome plated stainless steel in order to see the effects due to handling. The lifting bail designed for these was a simple basket handle with a flat shoulder at its base for the holddown to rest on.

The superheater elements were wrapped with spiral wires for spacers. A technique was developed to wrap these wires. A test was set up to see how big the wire could be (i.e., how small the clearance) and still allow handling. Elements with various diameters of wire were inserted into an inner insulating tube which was purposely bowed. A clearance of .008 inch on the diameter was determined as the smallest which still allowed insertion and withdrawal without hangup.

3.5 Lighting Test

A program was initiated to determine the type, number and required location of underwater lights to be used in refueling operations. An object resembling the top part of the reactor core and superheater structure was placed at the proper depth in the 40 foot tank. Lights were placed at various positions above it to study their effectiveness. Baffles were placed at the sides of the tank to simulate the vessel opening in the floor of the shield pool. A schematic of the test setup is shown in Fig. 18.

The top of the boiler core was simulated by painting the outline of the fuel elements on a large piece of sheet metal. The superheater chimney

Figure 18...Underwater Lighting Test Setup (43-024-165)

was simulated by welding three oil drums together and attaching this unit to the sheet metal. The superheater tube sheet was simulated by the bottom plate of the uppermost drum.

Two types of underwater lamps were tested. One was a 1000-watt diving lamp that is relatively light in weight and is supported by its electric cable. The other lamp is a standard 400-watt swimming pool light that is relatively heavy and requires a separate support. This lamp is mounted on a yoke that permits adjustment of the beam angle.

Both types of lights were tested at various depths in the following positions: (a) at the sides of the tank above the aforementioned baffles, (b) at the sides of the tank below the baffles, which would simulate a position within the reactor vessel, (c) in the center of the tank directly over the superheater section, (d) at various distances from the center to the outside.

As a result of these tests, the following recommendations for reactor lighting were made:

- a. Two 1000-watt lamps similar to those used in the test should be hung about two feet below the flange, inside the reactor vessel, close to the sides, and 180 degrees apart during refueling operations. These lamps would best be hung from two booms that would allow them to be readily swung out of the way when not needed. Support cables should be mounted on some type of reel so that the lamps can be maintained at any position and easily raised or lowered.

- b. Two other lighting requirements were noted at the time of this test, namely a narrow beam light for working on the superheater or any small area of particular interest, and general lighting required over the transfer carriage. At first, these additional lamps were thought necessary. However, by designing the booms for the first-mentioned lamps in the proper manner, they could fill all needs.
- c. To further increase ease of handling fuel, it will be desirable to turn off all lights above water to eliminate surface reflections; and to use a viewing box to reduce surface disturbances caused by crane cables and tools. Design of the viewing box is described in Section 6.3.

The final light boom design is shown in Fig. 19. It incorporates a telescoping arm which permits its use over a large area of the pool. The light cord reel is hand-crank operated and is self locking in any position. The entire boom is rotated by hand using two handles attached to its vertical shaft. The telescoping boom feature is operated with a cord and pulley system.

Lighting for the storage pool was determined by hanging a 1000-watt lamp in the actual pool with water. It was thus determined that two lamps hanging from the bridge would give sufficient light. Brackets were designed to allow vertical adjustment of the lamps.

Figure 19 ... Light Boom

3.6 Handling Bridge Concepts and Design

From the beginning, it was decided that the personnel would perform the refueling operations from movable bridges. These bridges would cover the entire area over the two pools. At first a separate crane was conceived, but later it was decided to include the crane on the bridges. The bridge motion gives the crane one motion while a trolley on the bridge allows motion in the other direction. This arrangement permits the operators to have direct access (with the additional use of the crane) to all areas of both pools.

Hand-crank drives for the two motions were considered at first. This would permit rather accurate movements to get the crane directly over the fuel elements, etc. The crane lift was always to be electric motor driven. However, since the bridge is quite heavy, motor drives were selected for the bridge motion also.

Since two of the three motions were motor operated, it was decided to make the trolley motion also motor driven. Multiple speeds were specified for the crane drive. Those for the crane lift are 10 and 30 ft/min. The trolley speed of 40 ft/min was tested at the site and found to be too fast; it was subsequently changed to 10 ft/min (the same as the bridge speed) which was satisfactory.

A load cell was added to each bridge to avoid damaging the boiler fuel elements through excessive-force pulling if the elements should get stuck. These cells are set to cut off the crane power at a load of 2000 lb.

When it was decided to have the new fuel storage room next to the pool, it became necessary to design a system to transfer the fuel from this room into the pool. This is done because one item of the fuel loading philosophy states that the new fuel shall be moved to the reactor through the transfer tunnel. A trolley beam system was built with an inter-connecting link so that the crane can be driven onto the bridge rail directly from the storage room. The trolley beam has a hand-chain operated drive.

4.0 BOILER CORE HANDLING TOOLS

4.1 Basic Requirements

The basic requirements for handling the boiler fuel elements are described in Section 3.1.

The other items to be handled from the boiler core include the control rods and the two types of boiler boxes. All three tools require the use of the crane and therefore were designed to be similar to the fuel handling tool.

Required shielding for the control rod (shown in Fig. 20) is less than the actual 1-1/2 ft while the rod is in a vertical position. Required shielding for the Zircaloy boxes is approximately 6 ft, also in the vertical position. In actual handling, these boxes have approximately 9 ft of water shield.

4.2 Initial Concepts of the Boiler Fuel Element

Since the original philosophy was to latch the tool to the element by hand, it was determined that a rigid connection between the operator and the tool head was necessary. A simple bayonet type latch was conceived as shown in Fig. 21. This tool featured a telescoping pole which would permit the transmission of torque by hand to operate the tool. The top of the fuel element had a spring at this time which doubled as a holddown spring and a device to keep the tool latched

NOTE 1:

- CLAMP IT 7, IT 8 TOGETHER AND LEAVE NO WELDING GAP.
- WELD AS PER INDICATED AT (H-2) ON DIAGRAM "X".
- GRIND RADIUS ON EDGES OF IT 8 TO BLEND WITH RADIUS ON IT 7.
- CLAMP IT 7, 8, 16 TOGETHER USING LOCATING TOOL.
- WELD AS PER INDICATED AT (H-5) ON DIAGRAM "X".
- POLISH ALL EXCESSIVE GAGES AND DYE PENETRANT INSPECT AS DIRECTED BY DEPT 3043 ENGR.

NOTE 2:

- CLAMP IT 4, IT 5 TOGETHER AND LEAVE NO WELDING GAP.
- WELD AS PER INDICATED AT (H-2) ON DIAGRAM "X".
- GRIND RADIUS ON EDGES OF IT 5 TO BLEND WITH RADIUS ON IT 4.
- CLAMP IT 4, 5, 13 TOGETHER USING LOCATING TOOL.
- WELD AS PER INDICATED AT (H-5) ON DIAGRAM "X".
- POLISH ALL EXCESSIVE GAGES AND DYE PENETRANT INSPECT AS DIRECTED BY DEPT 3043 ENGINEERING.

NOTE 3:

- CLAMP (2) OF MK 501 & (1) OF MK 502 INTO WELDING FIXTURE, TOOL # 97-501-404-601.

- WELD (1) OF MK 501 TO MK 502 WITH A SERIES OF 1/8 (MAX) FILLET WELDS, (SEE SECTION A-A) FOLLOWING THE SEQUENCE IN DIAGRAM "X" (51-67).
- ROTATE FIXTURE 180°; WELD (3) OF MK 501 TO MK 502 FOLLOWING THE SEQUENCE IN DIAGRAM "X" (68-76).
- REMOVE FROM TOOL AFTER COOLING.
- BLEND ENDS OF EACH FILLET WELD LENGTH WHERE NECESSARY.
- MARK ASSEMBLY PER NOTE "X".
- STRESS RELIEVE CRUCIFORM WELDMENT AT 1000°F IN AIR IN A FIXTURE & TO R. PROCEDURE APPROVED BY NUCLEAR POWER DEPT GREENDALE.
- CLEAN BY VAPOR BLASTING.

NOTE 4:

- CLAMP (1) OF IT 12 & (2) OF IT 15 INTO WELDING FIXTURE, TOOL # 97-503-405-601.
- WELD (1) OF IT 15 TO IT 12 WITH A SERIES OF 1/8 (MAX) FILLET WELDS (SEE SECTION C-C) FOLLOWING THE SEQUENCE IN DIAGRAM "Y" (77-91).
- ROTATE FIXTURE 180°; WELD (1) OF IT 15 TO IT 12 FOLLOWING THE SEQUENCE IN DIAGRAM "Y" (92-106).
- REMOVE FROM FIXTURE AFTER COOLING.
- BLEND ENDS OF FILLET WELD LENGTH WHERE NECESSARY.

NOTE 5:

- CLAMP (1) OF MK 503 & (1) OF MK 506 IN WELDING FIXTURE, TOOL # 97-501-404-601.

- WELD AS PER INDICATED IN DETAIL "E" FOLLOWING SEQUENCE, (107-112).

NOTE 6:

- SET CONTROL ROD ON FLAT SURFACE.
- SLIP ITEM 17 OVER END OF TAIL ROD JUST TO MEET OVERALL LENGTH DIMENSION.
- CLAMP IT 17 SECURELY USING TOOL # 97-501-404-602.
- WELD AS PER INDICATED IN DETAIL "C".
- INSPECT FINAL DIMENSIONS USING TOOL # 97-501-404-601 TO INSPECT EQUIVALENT.
- ATTACH IT 25 AS PER SECTION "E".
- MARK ASSEMBLY AS PER NOTE "X".
- PICKLE ASSEMBLY AS PER ITEM 33.

NOTE 7:

- OF THE PLANES OF IT 17 & REMAINDER OF BOILER CONTROL ROD SHALL BE WITHIN .002 I.D. OF EACH OTHER.

NOTE 8:

- HELIC ARC WELD 13 PASS BOTH SIDES WITH MINIMUM BACKUP 1/16 FILLER METAL AT 140 TO 150 AMPS ON TIP END & 165-170 AMPS ON CONNECTOR END. LIQUID PENETRANT INSPECT, RADIOGRAPHIC INSPECT, COMPLETE WELD PER IT 28.

ITEM	DESCRIPTION	MATERIAL	PART NUMBER	QTY
1	BOILER CONTROL ROD		43-500-970	500
2	BLADE ASSEMBLY		43-500-970	500
3	BLADE SUB-ASSEMBLY		43-500-970	500
4	BLADE		43-500-970	500
5	TIP		43-501-136	500
6	BLADE SUB-ASSEMBLY		43-500-970	500
7	CONNECTOR		43-501-136	500
8	TAIL		43-501-136	500
9	TAIL SECTION ASSEMBLY		43-500-970	500
10	TAIL SUB-ASSEMBLY		43-500-970	500
11	TAIL		43-501-136	500
12	CONNECTOR		43-501-136	500
13	TAIL		43-501-136	500
14	CONNECTOR		43-501-136	500
15	CONNECTOR		43-501-136	500
16	CONNECTOR		43-501-136	500
17	CONTROL ROD LATCH ADAPTOR		43-501-136	500
18	FILLER WIRE: 3/16 DIA ASTM A311 CL ER 308	THIS	019	
19	ANTI SPATTER (TUNGSTEN ARC)	THIS	019	
20	FLUID PENETRANT INSPECT SPEC	THIS	019	
21	CLEANING PROC. SPEC	THIS	019	
22	MARKING SPEC	THIS	019	
23	FABRICATION SPEC	THIS	019	
24	WELD PROC. SPEC. MANUAL GAS TUNGSTEN ARC	THIS	019	
25	WELD PROC. SPEC. MANUAL METAL ARC	THIS	019	
26	PICKLING PROCEDURE	THIS	019	
27	WELD WIRE: 3/16 DIA ASTM A311 CL ER 308	THIS	029	
28	FILLER WIRE: 3/16 DIA (WITH REM. CLEARANCE)	THIS	029	
29	FLUID PENETRANT INSPECT SPEC	THIS	029	
30	WELD PROC. SPEC. MANUAL METAL ARC	THIS	029	
31	PICKLING PROCEDURE	THIS	029

NOTE "X"

- EACH ASSEMBLY IS TO BE STAMPED AT THIS LOCATION WITH 1/8 HIGH NUMBERS IN NUMERICAL SEQUENCE USING #43-0226-1-1. THRU #43-0226-1-17. THIS NUMBER MUST BE IDENTIFIED WITH THE INDIVIDUAL PIECE PART HEAT NUMBER AND ALL OTHER IDENTIFICATION.

DIAGRAM "X"

DIAGRAM "Y"

DETAIL "C"

DETAIL "E"

- ALL TWIST & WARP TO BE HELD TO A MINIMUM SO THAT THE BLADES OF THE TAIL SECTION ASSEMBLY FIT WITHIN THE 5/16 ENVELOPE FOR THE ENTIRE 8'-10 1/2" LENGTH.

SECTION "E-E"

SECTION "B-B"

SECTION "A-A"

- NOTE "Z": ALL TWIST & WARP TO BE HELD TO A MINIMUM SO THAT THE BLADES OF THE BLADE ASSEMBLY FIT WITHIN THE 3/16 ENVELOPE FOR THE ENTIRE 8'-10 1/2" LENGTH.

01	3-29-61	SECTION "E-E" IT 25
02	3-29-61	ADDED
03	3-29-61	ADDED
04	3-29-61	ADDED
05	3-29-61	ADDED
06	3-29-61	ADDED
07	3-29-61	ADDED
08	3-29-61	ADDED
09	3-29-61	ADDED
10	3-29-61	ADDED
11	3-29-61	ADDED
12	3-29-61	ADDED
13	3-29-61	ADDED
14	3-29-61	ADDED
15	3-29-61	ADDED
16	3-29-61	ADDED
17	3-29-61	ADDED
18	3-29-61	ADDED
19	3-29-61	ADDED
20	3-29-61	ADDED
21	3-29-61	ADDED
22	3-29-61	ADDED
23	3-29-61	ADDED
24	3-29-61	ADDED
25	3-29-61	ADDED
26	3-29-61	ADDED
27	3-29-61	ADDED
28	3-29-61	ADDED
29	3-29-61	ADDED
30	3-29-61	ADDED
31	3-29-61	ADDED
32	3-29-61	ADDED
33	3-29-61	ADDED

Figure 21...Boiler Element Tool Initial Concept

while the element was hanging. This design was felt to be too complicated and a simple hook was envisioned.

A simple hook was then designed which would grasp the basket-type handles described in Section 3.4. A prototype was built.

4.3 Design and Testing of Hook Concept

The 40-ft tank was filled with reactor-grade demineralized water and the core mock-up lowered into it and placed on the bottom. The half-ton crane was used to handle the dummy boiler elements. At first the simple hook was used with some success, but it was found that an element could easily unhook and drop. Therefore, a locking device operated by a push-pull cable as shown in Fig. 22 was attached to the hook. There was some difficulty in swinging the hook sideways to insert in over the lifting bail. It was subsequently determined that a hook latching in a vertical position would be easier and faster to use.

An assist pole was designed and built to help guide the elements into their core positions. However, it was found to have limited usefulness and was discarded. It was also determined that a straightline pull by the crane was not absolutely necessary to remove the elements from the grid plate, although preferable.

4.4 Quick-Release Concept

Several designs which would latch straight down were investigated. The most promising appeared to be the quick-release pin concept. A design, Fig. 23, was drawn up which used four balls and a push-pull cable to

Figure 22...Hook Type Boiler Element Tool (43-024-140)

Figure 23...Boiler Element Tool, Quick Release Concept (43-002-216)

actuate the inner piston. The tool was designed to fail safe, since the piston would fall by gravity and push the balls out.

The tool was also checked to see if the balls could be released with the element hanging from the tool. Although there was considerable friction force on the piston, a redesign made this event impossible. The piston has a shallow slot where the balls rest. In order to release the balls with the element hanging, the entire weight of the element would have to be lifted. Thus the tool was made self locking.

4.5 Long-Handle Concept

This concept was conceived to take care of the shielding problem, to guarantee that the element could not be brought too close to the surface. At first the idea was to put a long cable on the tool so that the hook would hit the stop on the crane while the water shielding was still sufficient. However, it was decided to use a long handle instead, so that when the tool was in its "up" position the operator would have the additional advantage of a rigid link to the element. This handle, made of stainless steel for strength, is a hollow tube open to the water so that radiation streaming is prevented. The final design of the tool is shown in Fig. 24.

4.6 Actuation System Ideas and Design

Actuation of the tool was investigated further. The push-pull cable had some disadvantages. It required a lot of pull to release the tool when the cable had several bends in it. A cable reel was considered impractical

Figure 24...Boiler Element Tool, Final Design (43-202-758)

(experience at Elk River proved this). Also, since the tools were to be left in the water and a stainless cable was not available, the cable would tend to rust.

Hydraulic cylinder actuation was considered next. A cylinder was mounted on top of the tool head. It would pull the internal piston up when pressure was applied. A return spring in the cylinder pushed the piston back. A stainless steel tube ran up the pole to a quick-disconnect at the top where a flexible hose would be attached. A hydraulic power unit was designed to operate this and all other power-actuated tools. The hose was first designed to coil up on a spring reel. However, this became too complicated and expensive. It was determined that the lengths involved made it possible for the hose to merely hang from the top of the bridge railing and it would not get in the way when the tool was in its full up position. The hose selected was a water resistant grade, wire reinforced to prevent kinking under its own weight.

The hydraulic system was sent out for bids which came back fairly high in cost. A pneumatic system was then considered. At first it was feared that this system might leak under water and cause a loss of sight of the operations. However, a cylinder supplier was consulted who assured us that the packing would prevent leaking. A cylinder was borrowed and tested under water and it was leak tight. The entire actuation system was therefore redesigned around pneumatic actuation. A simple two-way valve is fastened to the bridge with a plant air inlet and a filter, and quick-disconnect coupling for the tool hose. This is considerably simpler and less expensive. This system is pictured in Fig. 25.

Figure 25...Pneumatic Actuation System (43-202-760)

Material for the cylinders was selected as brass, with butyl rubber packing. The piston rod and tie rods are stainless steel.

4.7 Boiler Control Rod Tool

Once the above system was conceived for the boiler tool, the effort on the control rod tool was for similarity. It also has the long handle to prevent loss of shielding. The grappling head was designed to also latch in a vertical position. The latch adapter on the rod was the only thing available for picking it up without considerable redesign of the rod.

The tool conceived merely hooked under the lugs on the adapter. A spring return cylinder normally holds the hook in the latched position. Applying the air pressure slides the hook section back so that it may be put on or taken off the control rod. The final tool design is pictured in Fig. 26.

4.8 Boiler Box Handling Tools

The two types of boiler boxes present a unique handling problem in that no handles or special lugs may be added to facilitate handling. The box wall is restricted on both the inner and outer surfaces so that only holes in the walls are permitted for handling. This meant that a tool with lugs that move outward into the holes had to be designed. Various systems involving rotating arms or right angle drives were investigated, but since the other tools were using an air cylinder, this was incorporated

Figure 26...Boiler Control Rod Tool (43-202-763)

here also. Two lugs were necessary to balance the load. It was determined that two cylinders with a sufficient stroke would fit in the allowed space. The lugs were designed to be pushed straight out by the cylinders, in such a manner that the load would be carried by the tool body and not the cylinder shaft. This concept is shown in Fig. 27 for the two types of tools involved. These tools also use the long pole for the same reasons as before. Note that these tools, too, are latched to the component in the vertical position. The cylinder pressure pulls the lugs in for insertion or removal of the tools. The cylinders are spring-return type and the lugs have a lip to prevent accidental dropping of the box should the air pressure be applied while the box is being moved.

5.0 SUPERHEATER CORE HANDLING TOOLS

5.1 Description of the Arrangement

The fuel element and control rod arrangement in the reactor core is shown in Fig. 28. The fuel element handling tool must reach down through the long tube to reach the fuel element. This restricts the diameter of the tool.

The control rods are assembled in the yoke shown in Fig. 29. Tools were required to disassemble the yoke, and pick up and handle the individual control rods.

5.2 Initial Concepts and Testing

Two different heads for the superheater tool were designed and built and are shown in Fig. 30. Tool No. 1 is a bayonet type that requires a twist to latch and unlatch. Tool No. 2 has a spring-loaded mechanism that is triggered to latch by the weight of the tool and released by using a push-pull cable. Both tools were used on the end of the long handling pole. Tool No. 2 was also operated while attached to the crane cable.

Both tools performed well on the end of the pole whereas the cable arrangement was awkward. Tool No. 2 was chosen for advanced design since Tool No. 1 has the disadvantage that the element may turn in its tube and make it difficult to latch. Tool No. 2 should work very quickly. This is important since there are a great number of superheater elements to handle.

Figure 28...Reactor Core Vertical Section (43-202-791)

Figure 29...Superheater Control Rod Support Yoke (43-202-782)

An improved version of the superheater handling pole was built and is shown in Fig. 31. This design features a bouyancy chamber and a long hollow handle that is open to the water. Lead shot was added to the bottom of the tool so that its center of gravity remains below the center of bouyancy. The pole has a vertical travel of 19 feet during refueling operations. The push-pull cable was attached to the side of the tool. The tool was used in the tank and performed very satisfactorily.

5.3 Final Design of Grappling Head

After testing of the tool, it was redesigned for better operation and easier fabrication. The internal torsion spring was calculated so that it could be pushed down by the coil spring located above it. The two springs were attached to a piston affair for better lineup. The tool is threaded (rather than welded) onto the pole for easier maintenance. The body is chromeplated inside and out to prevent galling of the stainless steel. The clearance between the internal bore of the tool and the diameter of the top end fitting of the superheater fuel element was 0.003 in. This close clearance was required to prevent misalignment of tool and element, and bending of the upper end fitting. The jaws were carefully sized so that the element would have to drop off when they were in the "up" position. A detailed view of this tool head is shown in Fig. 32.

Figure 32...Superheater Element Tool, Final Design (43-202-771)

5.4 Manual Vs. Pneumatic Actuation

Actuation of the tiny grappling head at the end of the long pole and at two levels 19 ft apart presented some unusual problems. Pneumatic actuation similar to that used for the boiler tools was considered. However, cylinders small enough to fit into the tube are hard to obtain, so this system was discarded in favor of a simpler push-pull cable.

A push-pull cable was purchased from American Chain & Cable for the initial testing program. Attaching the cable over the major part of the length of the pole made it work fairly well since only two bends resulted. Since there is some difficulty with rust forming in the cable, the tool was designed to allow this cable to be stored out of water. The handle end of the cable is attached to the bridge railing during operation so that it is easier to push and pull. The cable selected has a locking device to prevent accidental actuation.

5.5 Final Design of Superheater Element Tool

The final tool design is shown in Fig. 32. It features a separate handle which allows for easier storing and shipping as well as being useable on other tools. The handle was designed to be very light so that the tool assembly would float upright in water. The tool without the handle is designed to float about a foot out of the water so that it will be easy to reach while attaching the handle. The top few feet of the handle itself is sealed so that it will float by itself in case it is dropped. The handle is designed for dry storage so that the attached cable will not be exposed to water for long periods of time.

The body of the tool includes the float chamber which supports all the weight of the tool. It is therefore specified for leak testing. The assembled tool will just float with the element attached. The stainless steel section was constructed to hold the cast lead which was needed for weight and shielding. The cast lead was used instead of lead shot to help lower the center of gravity. The float chamber clears the top of the superheater baffle so that the tool will fit into a corner fuel element position. The small diameter tube is long enough so that it clears the support yoke. This tube was made of the thickest wall available since it wasn't possible to add lead in this region.

The tip of the tool, as designed, will rest about a foot over the superheater tube sheet without an element. It requires 1.5 pounds push to get it to the bottom of the tube and 8.2 pounds pull to pick it up to the maximum height with an element attached.

5.6 Handling Basket Design

Since the elements and control rods are so small, and there are so many of them, it seemed reasonable to handle them in groups.

The handling basket concept for the superheater elements requires that the basket be inexpensive since it is expendable. Thus a basket was designed which consisted of a single pipe with a base and two sections made of bent stainless steel sheet metal. This was hung in the tank but it proved very difficult to place elements into it. Then some tubes were added and it was found to be much easier to insert the elements into the tubes.

A basket was designed using the tube concept to hold 16 elements and is shown in Fig. 33. The basket has the same outside dimensions as the boiler fuel element so that it will fit in the same transfer box and storage rack. The basket has a handle that swings out of the way while the elements are being loaded. The basket is designed to hang from the superheater baffle in any of eight locations. The identical design, except for the length, is used for the control rods. The "nozzle" on the bottom of the element basket is for fitting the basket into the transfer box and storage rack.

A tool was designed to handle these baskets. It includes a telescoping feature to permit its use at different lengths. It also contains a locking feature as shown in Fig. 34.

5.7 Design of Superheater Control Rod Tool

The design of this tool closely paralleled that of the element tool. One big problem proved to be the increased weight of the control rod, i.e., 13 pounds. At first, since this plus the 8.2 pounds (see above) would be too much to lift and then insert a rod into a small hole, the tool was designed for crane operation. Previous testing had shown this system to be quite awkward, so further investigation of a hand-controlled tool was made. A larger float chamber makes it more difficult to push the tool down, but easier to pick up larger weights. It was felt that 8.5 pounds was not too much to push down and 8.0 pounds was satisfactory to pick up since the tool is only used approximately 24 times per refueling. Since this tool could get directly at the tops of the control rods and had more clearance in the corners than the element tool, the lead weight could be easily added in the bottom section of the tool.

Figure 33...Superheater Handling Basket (43-202-781)

Figure 34...Superheater Basket Tool (43-202-773)

The pick-up head is a simple pull-type, quick-release pin. The top of the control rod has an internal shoulder under which the balls lock to pick up the rod. The same handle and push-pull cable used on the element tool is used for this tool. The tool is pictured in Fig. 35.

5.8 Design of the Superheater Support Yoke and Handling Tool

The design of the support yoke was based primarily on handling considerations. Therefore a lot of the design effort of the tools for this component was put into the yoke itself. One of the first concepts examined involved a single-piece yoke which contained holes for the insertion of the individual rods. Each rod contained a mechanism in its upper end which would lock it in place. The overriding difficulty with this design was that no access to the central control rod position was provided. Also, it would be preferable to avoid having a locking mechanism included on each control rod.

A two-piece yoke which would trap the upper flanged end of each rod was decided upon. The next consideration involved a scheme for assembling and disassembling the two parts using remote handling tools. One method investigated utilized a single centrally-located quick-release pin. However, this involved a rather complicated handling tool.

The yoke design decided upon (see Fig. 28) can be disassembled by merely twisting and lifting the upper flange portion. The locking pins have a head attached to the release button of the two-way quick-release pins which has the same internal structure as the control rods. This enables the same tool to be used to handle the control rods as is used to actuate the locking pins.

Figure.35...Superheater Control Rod Handling Tool (43-202-774).

The unique feature of the locking pins is that they remain fixed in the "up" position for assembly or disassembly of the yoke, and in the "down" position during reactor operation. Only by pulling or pushing on the pin release buttons can they be moved.

The design of the yoke tool first involved a long rigid handle to transmit the torque. The grappling head was designed to lock onto the latch adapter similarly to the boiler rod tool. A long rod and, in another design, a Teleflex cable were used to actuate the lugs. However a much simpler design with no moving parts was conceived. This imitated the latch on the control rod drive. It is possible to drop the yoke with this tool but since it always remains within the baffle, it can't go anywhere and can be easily picked up again if dropped. The tool has a long floating handle of aluminum tubing and a bottom section of stainless steel, half filled with lead for floating stability. The pole floats a couple of feet above the top of the latch adapter. With the yoke attached, everything can rest on the tube sheet. The tool is shown in Fig. 36.

5.9 Materials Selection

Alloy 5052 was chosen as the aluminum material to be used in all these tools because of good resistance to water corrosion, weldability, and high strength in the annealed condition (i.e., as welded).

The bottom sections of all the tools are stainless steel to help add weight and to avoid any aluminum being left in the superheater. Gaskets of formica are used in all flanged joints to minimize galvanic corrosion of the aluminum due to the stainless steel.

Figure 36...Superheater Yoke Handling Tool (43-202-779)

6.0 OTHER HANDLING EQUIPMENT DESIGNS

6.1 Poison Shim Tool and Handling Rack

The addition of poison shims to the boiler core (see Fig. 37) necessitated the design of a tool to remotely load and remove these shims. Since the shims are fairly light, about seven pounds, it was decided to use a design similar to the two superheater tools. The same long handle would be used. There is a large float chamber of aluminum and a heavy lower section, for balance, made of a heavy wall stainless steel pipe.

The shim grappling tool presented some problem since the shim is located between two boiler boxes and its head rests between adjacent fuel elements. It was finally concluded that it was impossible to have a tool which could go between the elements to grasp the shim, and that the two elements would have to be removed first. The grappling tool was then designed as shown in Fig. 38. The hook swings into the slot in the head of the shim when the long rod is moved by the cable. The tool is designed so that when the shim is hanging from the tool, it cannot be released.

The handling rack shown in Fig. 39 was designed to rest on top of the superheater tube sheet. It will hold fourteen shims which is one-quarter of a normal core loading. The rack is handled similarly to the superheater baskets using the same tool. It was designed to fit into the components' transfer box.

NOTE #1:-
126/ ALL OVER

NOTE #2:-
C'S OF IT'S 24'S MUST BE
IN LINE WITHIN .010 T.I.R.

NOTE #3:-
SURFACES MARKED X' & Y' MUST BE
PARALLEL AND FLAT SO THAT THERE
IS NO MORE THAN .060" CLEARANCE
WITH REFERENCE TO A FLAT
SURFACE PLATE.

MR. 502 REQ.	MR. 501 REQ.	ITEM	DESCRIPTION	MATERIAL	PART NUMBER DRAWING MM.	WT.
		1	BOILER POISON SHIM		43-301-925 502	6.5" R.
1		2	SHEET PER SPECIFICATIONS		43-301-925 501	
		3	SHEET-100" TH'K. X 2 1/2" X 82 LG.		THIS 003	6.9" R.
	YES	4	MATERIAL SPEC. (PULTRAPOLYMER 1000)		43-101-360 404	
1		5	END FITTING		43-202-499 502	
.02"		6	FILLER WIRE-3/32 DIA. ASTM A 298 CLE. 308 13 OR 16		THIS 006	
YES		7	FLUID PENETRANT INSP. SPEC.		43-101-173 401	
YES		8	CLEANING SPEC.		43-201-661 402	
YES		9	FABRICATION SPEC.		43-101-216 401	
YES		10	WELD PROCEDURE SPEC.		43-101-207 401	
YES	YES	11	MARKING SPEC.		43-101-202 401	
YES	YES	12	BOILER POISON SHIM PRODUCT SPEC.		43-101-599 401

BOILER POISON SHIM

UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE TO BE HAD TO THE FOLLOWING TOLERANCES:

FINISHES	UP TO 1/16 INCL.	OVER 1/16 TO 1/8 INCL.	OVER 1/8 TO 1/4 INCL.	OVER 1/4 TO 1/2 INCL.	OVER 1/2 TO 1 INCL.
PRECISION	1/16	1/32	1/64	1/32	1/16
GENERAL	1/16	1/32	1/64	1/32	1/16

PROPERTY OF
ALLIANCE MANUFACTURING CO., ALBUQUERQUE, N.M.

NUCLEAR POWER
CH-10-5-4 JFW

9-22-61

01 10-5-61

CH-10-5-4 JFW

(B-B) WAS .030

(B-7) WAS .010

(I-5) WAS HAND GRIND

(C-2) NOTE ADDED.

(A-2) DIM. DELETED.

(E-2) DIM. ADDED.

(F-2) WAS 80

IT WAS 71 LG.

1/32" X 7/8" X 1/4" & 1/16"

CANCELLED

IT WAS ADDED.

TITLE WAS "BOILER SHIM"

DE 12-21-61

12-21-61 JFW DEP

43-301-925 02

Figure 37...Boiler Poison Shim (43-301-925)

Figure 38...Poison Shim Handling Tool (43-202-767)

Figure 39...Poison Shim Handling Rack (43-202-768)

6.2 Tools for Handling New Components

A set of tools was designed to handle all the fresh core components during unloading and preparing for insertion into the core. The tools for new boiler elements, new boiler control rods and baskets of fresh superheater components are all shown in Fig. 40. All three are simplified versions of the previously-described tools. The new boiler element tool has an internal spring added and a ring for hand operation. The control rod tool has a hand operated slide that can be released by pulling on the ring. The tools for new boiler boxes are shown in Fig. 41. They incorporate swinging arms to move the lugs into the box holes, and also include a ring for releasing.

All five tools are designed so that components can be lowered into the pool and released by pulling on a long cable which has been previously attached to the ring. The tools cannot be used to pick up a component remotely. This eliminates the danger of bringing an irradiated component too close to the surface.

Two simplified tools for handling the superheater elements and control rods were also designed and built. They are shown in Fig. 42. They use the same heads as the previously-described tools and are operated by pulling on a ring attached to a long cable. The bodies of the tools are thin-wall stainless steel tubes. An extension piece is provided which makes the tools longer for certain uses in the storage pool. The tools were originally designed to assist loading the first core of fuel elements and control rods into the reactor.

NEW B.F.E. TOOL

PULL CABLE EXTENSION

NEW B.C.R. TOOL

TOOL FOR BASKETS WITH
NEW S.H.F.E. & S.H.C.R.

Figure 41...Tools for Handling New Element Boxes (43-202-780)

Figure 42...Dry Loading Tools for Superheater Elements and Control Rods (43-202-769)

6.3 Floating Viewing Boxes

The underwater lighting test (see Section 3.5) showed that some device would be necessary to overcome disturbances in the surface of the water. Therefore, design of a viewing box was initiated. It was decided that a floating box would be the most flexible since it could easily be moved to any part of the pool where it was required.

The first designs were of aluminum construction with a glass bottom. One of them with a circular window is shown in Fig. 43. The other was similar in construction with a rectangular shape. These boxes included a handle of aluminum tubing so that the box could easily be reached from the bridge. This design is rather expensive and although is very sturdy, it was discarded when it was learned that other installations had successfully used boxes of all plexiglas construction. An all-plexiglas box was then designed as shown in Fig. 44. It was felt that it was inexpensive enough so that if it became damaged or badly scratched it could be readily replaced. In any event, in order to make the box as sturdy as possible it was constructed of one-half inch thick plexiglas sheet. The box also includes a top piece of plexiglas which prevents sinking and permits picking up one corner of the box to get rid of bubbles which may collect on the bottom surface. This also makes it easier to clean off the box, since it will tend to collect dirt.

The problem of moving the box around was solved by designing a separate aluminum handle with a hook that could grasp the hook-eyes in the top of the box.

7.0 FINAL TESTING PROGRAM

7.1 Test Equipment

A test program was initiated to test each of the actual handling tools and handling operations. Three rigs were designed and built. Two are shown in Fig. 45. The first (Fig. 45-A) is capable of holding a single boiler box, a boiler fuel element, a boiler control rod, and a boiler poison shim. The components tested included a dummy boiler element, the control rod from a control rod drive test, a stainless dummy box, and an actual shim.

The second rig (Fig. 45-B) is the superheater control rod test stand, slightly modified. A spare support yoke with the dummy control rods was installed in the rig. The rig also includes a number of tubes for insertion of fuel elements. A section simulating one portion of the superheater baffle was added, to provide a location for hanging the superheater baskets. Another plate was added upon which the poison shim rack could be placed. An actual superheater fuel element, made in a fuel development program, with a modified top was used to check out the superheater tools.

A third stand was constructed to hold the various components as they are being handled. The fuel elements, baskets, box, and control rod can fit in this stand. Another structure simulating the top of a transfer box was made for testing of the transfer box tool.

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7.2 Actual Testing

All the Pathfinder handling tools were shipped to the Greendale Labs for testing in the handling facility. All of them, except for the quad-box tools, were tested in actual handling operations. As a result of testing the various tools, some small modifications were made for improved operation. These changes are listed in Section 7.3. In general, all the tools performed satisfactorily after the modifications were made. Also, all handling operations as designed were performed and proved out.

In particular, viewing requirements were more carefully determined. A pair of binoculars proved helpful during certain operations, even though magnification became a problem at times. The binoculars were used in conjunction with the plexiglas floating viewing box. It was determined that for most handling operations two men are required. The best system was to have one man control the crane and be looking through the binoculars. The other man would then control the position of the tool with his hands on the crane cables. This man controlled vertical line-up while the other, controlling the crane and standing to one side, could see when the component was about to enter the core and subsequently control its movement.

7.3 Tool Modifications During Testing Program

During the above discussed testing program of the reactor tools several modifications were made to improve tool performance. These are listed as follows:

1. The shim tool originally had the lifting head located on the tool centerline. This made viewing difficult when inserting the tool over the shim head. Also, the pivot point on the lifting lug was positioned so that it struck the shim head. Moving the head to one side of the tool and shifting the pivot point made the tool operate much better.
2. The lifting lugs on the box handling tools were originally held on with snap rings. These proved to be too flimsy (i.e., they could be pulled off) and were therefore replaced with special nuts threaded to the cylinder shafts.
3. The air cylinders were modified to make them operate better under water. The leather packings were replaced with Teflon packings. The pistons were lubricated with water-insoluble silicone grease. The carbon steel tie rods were replaced with stainless steel rods.
4. The lifting heads of the two superheater element tools were modified for better operation. The internal compression springs were replaced with heavier springs to make the jaws close more surely. The bore which receives the element head was bored out to provide a 0.010 inch clearance. This eliminated a binding problem which at times made it difficult to release the element.
5. The Type 416 stainless steel handles on the superheater baskets were rusting in the tank, and were subsequently chromeplated.

6. The two superheater handling tools were floating too high out of the water. Since plugs had been provided in the bottom of the float chambers, it was possible to add water to them to allow the tools to float at the proper depth. The shim tool floated properly without modification.
7. It was noted that the quick-release pins on a couple of the tools were experiencing a corrosion problem. The pins were of stainless steel construction with aluminum push buttons. These buttons were corroding, due to galvanic action. The vendor was contacted and the pins were replaced by ones with stainless steel buttons.

8.0 UNDERWATER CUTTING FACILITY

8.1 Control Rod Cutting Requirements

The boiler and superheater control rods are 15 and 13 feet long, respectively. These are too long to place in the standard shipping cask for disposal. The rods are entirely of welded construction, so a remote, underwater cutting technique is necessary. The boiler control rod can be cut through the 3-inch cruciform section which is made of 304 stainless steel. This material is one-quarter inch thick. The superheater rods are to be cut through the extension tube which is 3/4 inch diameter by 0.060 wall 304 stainless steel tubing.

It is conceivable that it may be necessary to cut other irradiated components, especially for inspection purposes. Therefore, it is desirable that the techniques developed for the rods be flexible enough to cut boiler boxes, ends of fuel elements, etc.

8.2 Initial Concepts

The first consideration for an underwater cutting facility involved soliciting bids from saw manufacturers for a saw to cut the ends off of fuel elements as well as control rods. One such bid was received from a tool company for an underwater circular saw, but the price quoted was for many thousands of dollars. This was entirely too expensive and elaborate. Simpler methods were then investigated.

Standard hack saws modified for underwater use and remote control were looked at but proved also to be very expensive. An underwater power

shear was looked at. It had the primary advantage of producing no chips to contaminate the water. However, the forces involved were so great that the framework would be too large for the pool. Also, the shear would only work for the control rods and not for other components.

The next method to be investigated was underwater torch cutting.

8.3 Testing of Underwater Torch

This experiment was performed to determine the feasibility of using an arc-oxygen cutter to cut irradiated control rods. A standard off-the-shelf underwater cutting torch was used for this experiment.

The underwater cutting torch consisted of a head mounted at a 90 degree angle with the supply oxygen and d-c power lines. The electrode was mounted in the head by means of a swagelock-type fixture. The electrode itself consisted of tubular steel with a flux clad on the outside surface. The opening in the center of the electrode provided a passage for the oxygen. In operating the cutter, an arc was struck, followed by an application of oxygen. To cut, the electrode was dragged across the plate on the line to be cut. This was necessary so that the circuit would not be broken.

The arc-oxygen cutter was energized by the standard shop direct-current welding machine. The piece to be cut was a short section model of the actual control rod. The section used was approximately 14 inches in length. An ordinary 60-gallon drum was cleaned and painted with an

aluminum oxide paint to contain the water in which the cutting was to take place. The specimen was then mounted between two cement blocks to raise it off the bottom of the drum and to provide a rigid support. A tank was then filled to the half-full mark or about 30 gallons.

The shop welder performed the test, maneuvering the torch directly by hand. The test was performed under three conditions as follows:

- a. Welder set at 200 amps, oxygen at 25 psi.
- b. Welder set at 300 amps, oxygen at 25 psi.
- c. Welder set at 300 amps, oxygen at 35 psi.

The machine cut best at 300 amps. The higher oxygen pressure merely made a wider cut in the specimen.

Three results are herewith analyzed: cutting ability, water contamination, and gases produced.

1. Cutting Ability - The machine provides adequate cutting ability during operation at this close range. However, it is questionable that one could attain the same quality of operation if manipulating it from the end of a 25-foot long pole, as would be necessary in the case of an irradiated rod. It is estimated that the time to cut through this specimen would be about four minutes. It was noted that an eye shield was not necessary.
2. Water Contamination - After operating the cutter in the water for approximately 30 seconds, the water took on a brownish tint. After testing in the water for an estimated two minutes, the water had a muddy appearance. One could not see an object located ten inches

below the surface of the water at the end of the two minutes of testing. Upon emptying the contents of the water pool, slag and metal particles were found.

3. Gases - As the testing proceeded, gases of a disagreeable odor boiled out of the water. The gas was very heavy and after a short time, not even the water surface could be seen.

Due to the contamination of the water, it is not advisable to use this method of cutting. Aside from this, it is believed that it would be hard to control the torch from a distance of 25 feet since it required a good degree of steadiness to operate it directly.

8.4 Hack Saw Concept

Further investigations were made on slow moving hack saws. It was noted that Argonne National Laboratory was using a modified standard pipe cutting saw for their underwater control rod cutting. The saw they used is an E. H. Wachs' Guillotine Pipe Hack Saw. The big advantages of this saw over others considered are as follows:

- a. It can operate in any position, including horizontal, which will allow cutting the rods in a vertical position.
- b. It is light and portable.
- c. The main body is of aluminum.
- d. The reciprocating motion is by air motor which can be adapted for underwater use.
- e. The feed is by hand crank.
- f. The basic saw cost is less than \$1,000.

For these reasons, a saw facility was designed around this saw. The saw was demonstrated to show its ability to cut through the 3-inch 304 cruciform.

8.5 Design of Cutoff Stand

The basic concept developed for the underwater cutting facility involved a large tube into which the control rod would be placed, with a structure on its top to hold a platform on which the saw and clamping device would be mounted. The stand would be a permanent part of the pool equipment and the saw platform would only be lowered into the pool for cutting operations and then be removed.

A drawing of this stand is shown in Fig. 46. The two primary functions of this stand are to support the control rod and to collect the chips. It is expected that the chips created by the slow-moving hack saw blade will, for the most part, fall into the stand. The stand is entirely of stainless steel welded construction and is bolted into place in the pool. The two rails on top of the stand support the saw platform.

8.6 Design of Clamping Device

It was decided early that a hydraulically-operated clamp would work the best. ANL used two opposing cylinders on their clamp. As with the ANL design, a hand pump would be the simplest power source.

The space provided in the pool between the control rod storage racks is not very much, so the straight-forward approach of two opposing cylinders is not possible. Various designs using linkages, racks, angle drives, etc., were considered. The final design is shown in Fig. 47.

This design uses one cylinder for one jaw and a double rack and pinion mechanism to drive the second jaw. This clamp always holds the part exactly in the center. The jaws are of 410 stainless steel, hardened and passivated; with a knurled face to help grip the parts. The cylinder is double acting so that the jaws are also driven apart. A valve switches the pressure from one side to the other. The hydraulic cylinder is chromeplated outside and inside for corrosion resistance.

8.7 Final Design of Underwater Saw

The underwater saw facility is shown in Fig. 48 (A and B).

The facility is made up of three units. The cut-off stand is bolted to the underwater control rod racks and is not intended to be removable. The saw platform assembly includes the air motor powered hack saw and the hydraulic clamp. This platform is lowered into the pool when some cutting is to be done. It is rested on the braces provided on top of the cut-off stand. The lifting handle on the platform is positioned at the center of gravity so that the saw can be lowered in a horizontal position by the bridge crane.

NOTE #1-
FIN ALL OVER UNLESS
OTHERWISE SPECIFIED.

NOTE #2-
~~ALL (16) & (20) TO BE PLASH CHROME PLATED SO THAT~~
~~ALL SURFACES (INCLUDING IRREGULARITIES) ARE COVERED.~~

NOTE #3-
(1) (2) & (7) TO BE HEAT TREATED.
TO ROCKWELL C 39 AFTER MACHINING.

NOTE #4-
SURFACE "X" TO BE MACHINED PARALLEL
TO SURFACE "Y" AFTER BOLTING AIR CYLINDER
BASE TO BASE PLATE 1" & 2"

Figure 47...Saw Clamping Device (43-501-178)

Figure 48-A...Underwater Saw Facility, Vertical View (43-202-800)

Figure 48-B...Underwater Saw Facility, Plan View (43-202-795)

The saw control unit is on a separate panel. The panel is attached to the bridge railing and the hose connections are made to the saw platform, as shown in Fig. 49, before the platform is lowered into the pool.

The clamp is operated by first moving the lever on the 4-way valve toward the valve body. The hand pump will then move the jaws together. The hydraulic gage gives the clamping pressure. By moving the valve lever to the opposite position, the jaws will move apart when the hand pump is operated.

The hack saw is turned on by moving the lever of the air valve to the "on" position.

Following is the procedure for cutting the extension from a boiler control rod:

1. Set up the saw and the controls as stated above.
2. With the boiler control rod handling tool, pick up the selected rod from its storage rack and lower it between the clamp jaws into the cut-off stand. Do not release the tool.
3. The rod is then clamped by operating the hand pump. The saw motor is turned on.
4. The saw feed handle shown in Fig. 49 is placed over the feed drive head and is used to feed the blade into the rod by hand.
5. After the rod extension is cut, the saw blade is returned to its original position. The tail, still hooked to the handling tool, is moved to the shipping container for disposal.

Figure 49...Saw Control Panel and Tools (43-202-801)

6. The lower part of the control rod must be moved. This is done by adding the auxiliary hook to the tilting transfer box tool as shown in Fig. 49. The two lugs on the hook are rotated into two of the four 2-inch holes in the blades of the rod. The rod is then lifted out of the stand and placed into the shipping container for disposal.

The following is the procedure for cutting the extensions from a superheater control rod:

1. The extension section is added to the superheater control rod dry-loading tool. This tool is then used to pick up an individual rod from its storage rack.
2. One superheater control rod disposal can (shown in Fig. 50) is lowered into place in the cut-off stand using the superheater basket tool. A rod is placed in one of the seven positions provided in the row parallel to the clamp jaws.
3. In order to clamp the rod properly, lower it to the bottom of the can, then raise it 6 inches and clamp in place.
4. Start the saw and cut the rod.
5. Release the clamp and the bottom portion of the rod will drop down. This will allow clearance for the jaws to clamp the next rod.
6. The extension portion of the rod, still attached to the handling tool, is then lowered into the open area of the disposal can and released.

Figure 50...Superheater Control Rod Disposal Can (43-401-411)

8.8 Testing of Underwater Saw

Initial testing of the saw was carried out in air. Cruciform sections and thinwall tubing were both clamped in the jaws and cut with the saw.

Six-pitch and ten-pitch saw blades were available, and both were given a trial. The 6-pitch blade was definitely too coarse for the tubing, but the 10-pitch blade worked fine. Since the 10-pitch blade also cut the cruciform satisfactorily, it was decided to use this blade for all operations.

During the cutting of the tubing it was noticed that the clamp jaws did not hold the tubing tight enough. The contour of the clamping surface on the jaws was therefore changed to provide a series of serrated "V" notches. This worked out fine for both the tubing and the cruciform.

The air motor used for driving the hack saw was checked to see if there would be any leakage of air under water. There was considerable leakage. To remedy this, the sealing surfaces of the exhaust manifold were machined flat and all joints were sealed with Permatex Form-A-Gasket.

There was also considerable leakage around the motor shaft. A vent (running to the exhaust) was added to the front gear housing to reduce the pressure on the shaft bearing. The original shaft bearings were replaced with sealed bearings, and additional wiper seals were added on the shaft. The motor was then checked out under water and did not leak.

After the saw was completed, it was set up with the stand and was used to cut a dummy superheater control rod. A section of the boiler control rod extension was also cut. The saw performed extremely well. Indications were that it would be satisfactory for use at the Pathfinder site.