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THE DESIGN AND CONSTRUCTION OF THE EBR-II
INITIAL FUEL LOADING FACILITY

by

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ABSTRACT

The need for the first core for EBR-II has resulted in the design and construction of the Initial Fuel Loading Facility for this reactor. The plant was built to provide the required initial loading, to train personnel, and to test prototype equipment for the remote reprocessing of fuel materials in the EBR-II Fuel Cycle Facility.

This facility is located in Building 6 on the DuPage site of Argonne National Laboratory. The facilities include: remotely manipulated melting, casting, and pin processing equipment, a degreaser, hoods and their atmospheric control system, a gas-purification system, fuel-element-assembly equipment, mold-preparation and balance room, bonding furnaces, a maintenance shop, and a change area.

The schedule necessary to meet the dry critical requirements, predicted at the time of design, was such that an accelerated program was dictated. In order to save time, a labor-only contract was negotiated for the installation of machinery. Design and material procurement was carried on until near the end of the labor contract. Time was saved by concurrent procurement, design detailing and erection. Laboratory stock was a principal materials source.

I. PURPOSE

The primary objective of design, construction, and operation of the facility described was to produce a sufficient number of acceptable fuel pins, assembled into core elements, for the initial fuel loading of EBR-II. Secondary objectives of this program were to test processes and prototype equipment, to train personnel, and to assess the requirements of the Fuel Cycle Plant of EBR-II more accurately.

This report deals with the design, construction, and installation of equipment and services for the Initial Loading Facility. At this point it should be noted that wherever possible the design limitations and requirements impressed upon the EBR-II Fuel Cycle Facility⁽¹⁾ were considered binding upon the Initial Loading Facility.

II. FUEL FABRICATION OPERATIONS

A flow diagram of the operations required to produce the fuel elements for EBR-II is shown in Figure 1. Briefly, the description of the stages of manufacture are as follows. A pyrometallurgically treated billet of a uranium-fissium alloy is charged to a refractory-coated graphite crucible. Coated Vycor molds, crucible, and metal are charged to the furnace and the casting cycle is carried out.⁽²⁾

After casting of the fissium alloy into the molds, the array of filled molds is removed from the furnace and placed in a pin-processing machine. This machine feeds pins, one at a time, into a jaw crusher which crushes away the Vycor mold and passes the pin into a double-ended shear, where the pin is cropped to a length of 14.22 in. It is then inspected for diameter, internal porosity, weight, and length. The acceptance or rejection of any fuel pin is dependent upon predetermined norms for these quantities. The pin diameter is measured by a pneumatic ring gauge using argon gas. Internal porosity is detected by eddy current techniques; weight and length are determined by the use of differential transformers.⁽³⁾

Upon acceptance, the fuel pin is moved to a transfer table where it is advanced into a magazine which, when loaded to capacity, is given over for jacketing, settling, and end closure. In the event a pin fails to pass inspection, it is rejected to a chopper where it is reduced to one-inch fragments. These and the casting heel are returned for pyrometallurgical reprocessing, or are remelted in a subsequent casting cycle.

The sodium filling, jacketing, settling, and welding of the fuel rods requires the protection of an inert atmosphere. Protective enclosures⁽⁴⁾ employing purified, circulated argon gas were chosen to simulate the atmosphere expected in the Fuel Cycle Facility. The hood which enclosed the decanning equipment was the original prototype hood assembly constructed for the Facility 350 mockup.

The manufacture of the fuel rod requires the melting of sodium into a barrel which is placed into an extruder. Extruded sodium slugs and acceptable fuel pins are placed in fuel rod tubing, one end of which is closed by a welded-in adapter and about which is wound a spacing wire. The jacket, containing fuel pin and sodium, is placed in a basket which is

Fig. 1. Flow Diagram of EBR-II Initial Fuel Fabrication

mounted on a settling furnace where the unit is heated and vibrated. This is intended to settle the pin into the sodium and to bring about a continuous annulus of sodium between the fuel pin and the inside wall of the jacket. After settling, a restrainer is placed in the open end of the tubing and the basket of jacketed pins is transferred to a welding machine. The top section of the restrainer is so designed that a "pop" weld may be accomplished, sealing the fuel rod assembly. Upon completion of the welding operation, the fuel rod is transferred out of the assembly hood for inspection.

The acceptability of fuel rods is determined by leak and bond tests. A cluster of rods is placed in a bonding furnace where it is vibrated and "soaked" at elevated temperature to induce migration of gas pockets into the top of the rod. After bonding is considered complete, each fuel rod is leak tested by being placed in a chamber which is alternately evacuated and pressurized with helium. Finally, the assembly is evacuated and a helium mass spectrometer leak detector is used to indicate the presence of helium being drawn from the assembly. An indication of helium evolution from a rod renders it suspect, and it is either rejected to the decanning operation or returned for rewelding. Each fuel rod is bond tested by an eddy current method to indicate voids in the sodium annulus. Failure to pass the bond test is cause for the return of the rod to the bonding operation. Acceptable fuel rods and upper and lower blanket sections are assembled into core elements and stored prior to use as the initial fuel for EBR-II.

A defective fuel rod is sent to a decanning operation, also carried out in an argon atmosphere. In this operation a single machine clips the spacer wire, shears the end closures from the jacket, strips away the tubing, and chops the pin into fragments. The chopped fuel pin is then returned to pyrometallurgical reprocessing.

The operating equipment to carry out the above steps was already in existence. The principal task involved in this program was the allocation of space, the assemblage of existing equipment, the provision of services and control, the modifications required to permit remote handling, and the establishment of inert surroundings where required.

III. CHOICE OF FACILITY LOCATION

The housing of equipment to carry out the fabrication of the initial loading of EBR-II required approximately 4000 sq ft of floor space. Considerations of time and space availability dictated the choice of a section of Building 6, at the ANL DuPage site, as the location for the fuel fabrication installation. The southeast quarter of this building was already in use as a mockup area for the testing of equipment being designed for use in

the Fuel Cycle Facility of EBR-II. Therefore, such services as a crane, a (General Mills) manipulator, a furnace, some prototype fuel-pin-processing machinery, and some auxiliary equipment were existent in the building.

The entire south bay of Building 6 was made available to the project. The useable space included washroom and locker facilities, a fan loft, and workshop space, in addition to a large area suitable for adaptation into a fabrication room. The fabrication area was of adequate size for the provision of two partitioned rooms: one a balance and instrument room, the other a mold preparation area, in addition to the floor space required for the manufacture of the fuel elements.

The arrangement and layout of equipment and working space in the Initial Loading Facility may be seen in Figure 2. Those units of process equipment which deal directly with the fabrication are noted in letters in the legend of this figure. References to the photographs in this report are made after each operation for which a figure exists.

LEGEND

1 Maintenance Shop	A Injection Casting Furnace (Figs. 3, 4 & 6)
2 Shipping & Receiving Area	B Pin Processing Machinery (Figs. 5 & 6)
3 Anteroom	C Periscope (Figs. 6 & 7)
4 Office	D Mock Window (Figs. 6 & 8)
5 Balance Room	E Degreaser
6 Mold Preparation Room	F Fuel Element Leak Test Apparatus
7 Locker Room	G Core Assembly Area
8 Toilets	H Assembly Hood (Figs. 9 & 10)
9 Shower Room	I Decanning Hood (Figs. 11 & 12)
10 Fabrication Area	J Bonding Furnaces
	K Pressure - Vacuum System (Fig. 13)
	L Gas Purification System (Fig. 14)

Fig. 2. Arrangement and Layout of Working Space and Equipment in the EBR-II Initial Loading Facility

IV. MODIFICATIONS TO BUILDING

Design work for the modifications to buildings and equipment to be installed was commenced in August, 1958. The Plant Engineering Division was provided with a schedule of utilities required for the operation of the necessary equipment and machinery. The responsibilities of the Plant Engineering Division were the engineering services required for building modifications, purchase and installation of conventional units of equipment, and contract supervision. The Metallurgy Division responsibilities were the design and procurement of process equipment, provision of utilities requirements, provision of technical assistance during erection of process equipment, and testing and operation of installed machinery and equipment.

On August 20, 1958, the request for bids on the assembly hood, complete with hood stands, vacuum locks, and hoist rails, was submitted. By October 31, 1958, the Plant Engineering Division had reached the point in the building modification work where a package specification of the Plant Services Division had been issued. This specification covered the removal of two truck hoists, pump assembly and controls, storage racks, an oil-storage house, and the installation of a 75-kva transformer to provide additional electrical service to the building. By December 18, 1958, the Plant Engineering Division had completed drawings and specifications for the required modifications to Building 6 prior to equipment installation.

A contract was awarded to the Russell Acton Company and work was commenced. The work outlined in this contract included repair to and covering of the floor, provision of a mold preparation and a balance room, electrical, pneumatic, and chilled water services, lighting, exhaust ventilation and services, provision of a guard post, office area, emergency showers, and modification of washroom facilities. During the construction and erection of building services process equipment design work was being carried on by the Metallurgy Division.

V. DESIGN, CONSTRUCTION AND ERECTION OF PROCESS EQUIPMENT

A. Melting, Casting, and Pin Processing - The equipment which was in existence at the time of construction included an injection-casting furnace, some pin-processing machinery components, and an untested inspection station. The chief task at hand appeared to be the modifications required to permit remote handling of the various processing units.

The casting furnace, shown in Figures 3 and 4, was essentially unchanged from the original concept. Design effort was directed toward the installation requirements for the high-frequency motor-generator set, the vacuum pumping system, and the pressurizing chamber, and provision of power and cooling water to these units.

Fig. 3. Injection-casting Furnace - Bell Jar in Closed Position

Fig. 4. Injection-casting Furnace - Bell Jar in Open Position

The pin-processing machinery required extensive modification to permit remote operation. Figure 5 shows the pin-processing machinery and inspection station after installation.

Fig. 5

Pin-processing Machinery and Inspection Station

The components planned to operate within the argon cell of the Fuel Cycle Facility are mounted upon the metal gridwork. Since the actuators on this equipment are operated by compressed gas, the piping must terminate at valves outside the confines of the argon cell. This condition is simulated by placing the valve cabinet about 15 ft away from the processing machinery and outside the confines of the grid deck. Concessions in the form of elastomeric gaskets, insulations, and packings were made for the sake of expediency; however, it was planned to replace such items with known radiation-resistant materials as the processes were developed and proven. Pipe runs and service distribution patterns approximated those expected in the EBR-II plant, and their effects upon operations will be determined during the use of the equipment.

Figure 6 is a view of process equipment required within the argon cell of the Fuel Recycle Plant as installed in Building 6. The (General Mills) manipulator, mock window, and periscope are the "tools" and barriers which will be used to simulate remote operation of the process equipment in this facility. The mock window for this facility consists of a mineral-oil-filled tank with a 2-in. laminated glass window at each end. Limited viewing for pin inspection purposes is carried out with the use of a sealed, through-the-shield-wall periscope at 1x or 12x magnification. The operator's side of the periscope (built by the Bausch & Lomb Optical Company) is shown in Figure 7.

Fig. 6. Fuel Cycle Cell Mockup Platform

Fig. 7. "Cold" Side of Periscope

The operation of each unit of pin-process equipment, when not carried out by direct manipulator handling, is actuated by a pneumatic cylinder. In the Fuel Cycle Facility, it is necessary to maintain an inert gas for operations on unclad fuel. Auxiliary and control equipment for these operations will be located in a "hot basement." Activation of controls will be by pushbutton stations in the operation "annulus." Figure 8 shows the pushbutton station mounted on a track below the Building 6 mock window. This station controls all cylinder operations on the fuel cycle mockup platform through valves located in the valve cabinet depicted in Figure 5.

B. Degreaser - A degreaser was designed, constructed, and installed in the fabrication area of Building 6. This device was designed for the cleaning of fuel-element tubing, adapters, and restrainers prior to welding. The degreaser consists of two 15-gal tanks, one containing a heater with temperature control for supply of hot tri- or tetrachlorethylene, the other an ethyl alcohol tank. Each tank is supplied with a pump to move the liquid into a receiver containing the items to be degreased. Compressed air was piped into the receiver for the drying of the degreased items, and a ventilated hood was installed over the degreaser.

Fig. 8. Pushbutton Station

C. Hoods - All work where sodium would be exposed to an atmosphere was to be carried out in inert gas surroundings. In order to accomplish this, two hoods were required: one to house the sodium melting furnace, sodium extruder, settling furnaces, and welder; the other to contain a decanning machine. An assembly hood, measuring approximately 24 ft long by 4 ft wide by 6 ft high, was contracted for and supplied by the Cook Electric Company. The assembly hood with installed equipment is shown in Figure 9. Figure 10 is a photograph showing in more detail the in-hood machinery and the working space within the enclosure. A Facility 350 prototype hood appeared to be satisfactory for use in the decanning operation. The decanning hood after modification and erection is shown in Figure 11.

D. Hood Atmosphere Control - The atmosphere for fuel processing in the Fuel Cycle Facility is argon. The same atmosphere was provided in the assembly and decanning hoods to limit or prevent oxidation of fuel material and sodium. To reduce in-leakage, the control system for the

hood atmosphere was designed to maintain a positive pressure of about 0.75 in. water gauge. This was achieved by piping the hood to a pressure tank and to a vacuum storage through solenoid valves.

Fig. 9. Assembly Hood

Fig. 10. Assembly Hood - Closeup

Fig. 11. Decanning Hood

The pressure control was accomplished through pressure switches (manufactured by the Mercoid Corporation). When the pressure in a hood rises above 1.5 in. water gauge, a pressure switch trips a relay which energizes the solenoid on a valve in the line to the vacuum receiver. Gas is taken from the enclosure until the pressure falls to about 0.75 in. water, at which time the switch, through the relay, de-energizes the solenoid valve which stops the withdrawal of gas from the hood. The low-pressure control point is set at about 0.1 in. water. If the pressure falls below the low-pressure control point, a switch trips a relay which energizes the solenoid on a valve in the line to the pressure tank. Gas is admitted to the hood until the control pressure of 0.75 in. water is again reached, at which time the gas admission ceases by de-energizing the solenoid valve in the pressure system. Suitable regulators and flow-control valves were placed in all lines to control rate of gas flow and thereby to regulate the rate of pressure change within a hood.

The need for shielding gas for the welder and the normal leakage of cylinders operating with inorganic seals appeared to be cause for supplying an alternative method of removing gas from a hood to prevent over-pressurizing. This was accomplished by providing an over-pressure switch set at 1.75 in. water gauge, which opened the hood to the exhaust ventilation system. The pressure in a hood is indicated by a Magnehelic Gauge (manufactured by the F. W. Dwyer Manufacturing Company). Figure 12 shows the decanning hood pressure control system which is identical with the assembly hood system.

Fig. 12. Hood Pressure Controls

The pressure-vacuum system, shown in Figure 13, contains the "pressure sinks" for the movement of argon into or out of a hood. A 13-cu ft vacuum storage tank houses two 3.3-cfm, (Bell & Gosset Company) oil-less air compressors. The vacuum storage is maintained at 7 to 24 in. of Hg absolute pressure. When the pressure in the vacuum storage tank rises to 24 in. Hg, the vacuum switch, operating through a relay, starts both compressors which evacuate the receiver into the pressure tank. When an absolute pressure of 7 in. Hg is reached, the compressors are stopped through the switch and relay system. Chilled water is pumped through a jacket on the periphery of the storage tank to absorb the heat of compression during evacuation.

The pressure tank is maintained at 90 to 120 psig through a pressure switch. Makeup gas is added from a manifold of argon cylinders through a solenoid valve upon signal from the pressure switch. The upper limit of the pressure switch (120 psig) controls another solenoid valve which relieves the pressure tank to the exhaust ventilation system when the pressure exceeds this limit.

Fig. 13. Pressure-vacuum System

E. Atmosphere Distribution - A dry, oxygen-free, argon atmosphere is circulated through each hood for purposes of purification and heat removal. Argon, supplied at 150 cfm, is supplied to a header common to both hoods. As may be noted in Figure 12, this gas is delivered through two 4-in. copper tubes into the bottom extrusions of each hood; slits in the extrusions distribute the gas along the hood floor. The return gas is drawn through top extrusions into a return line and moved to the inlet side of a turboblower. The supply and return lines to each hood are valved to permit control of the rate of gas distribution. The rate of purified gas flow is determined by orifice meters placed in the inlet lines to the hoods. The orifice plates were so specified as to permit a flow of from 25 to 75 cfm through the decanning hood, which has a total volume of 240 cu ft, and 75 to 125 cfm through the 576-cu ft assembly hood.

A number of operations are carried out in the assembly hood that will produce a heat load upon the gas system. Design calculations indicated the need for dissipation of a maximum of about 10,000 BTU/hr. It was determined, upon assumption of an allowable temperature rise of 20°F within the hood, that cooling in excess of that achieved by convection and conduction from the hood surface would be required. As a result, a

chilled water-to-argon gas heat exchanger was installed in the inlet line to the assembly hood. This heat exchanger is shown in Figure 13.

F. Gas Purification - The gas-purification system for this facility is shown in Figure 14. This system had been designed, built, and installed in Building 205 by the Chemical Engineering Division. During the period of design for the initial fuel-loading facility, it was cut into sections according to plan and reinstalled in Building 6.

Fig. 14. Gas-purification System

The return gas from the hoods enters the suction side of a Series 4110-10 stage turboblower (manufactured by the U.S. Hoffman Machinery Corp.). The blower is powered by a 10-hp, 480-volt, 3500-rpm (Reliance) motor; both motor and blower are "canned" in a gastight enclosure. The blower forces argon gas at about 150 cfm through an after-cooler, a catalytic palladium (DeOxo) purifier, and a (Linde) molecular sieve dryer, then out to the supply header to the hoods. The aftercooler is supplied with chilled water from a Heat-X chiller, shown in Figure 14. Purification performance is monitored by a (Manufacturer's Electrical Equipment Company) moisture analyzer. A (Thermco) nitrogen analyzer is employed to indicate accumulated air in-leakage by nitrogen analysis.

Regeneration of the dryer is accomplished by isolating the dryer and passing air, heated to about 260°C, counter-current through the molecular sieve bed. A (Sutorbilt) rotary, positive-displacement blower provides the air flow through the heater and dryer. A hygrometer was placed in the air-discharge line to determine the moisture content of the regenerating gas. Regeneration is complete when the dew point of the exhaust gas is equal to that of the inlet air.

VI. CONTRACTUAL AGREEMENT, INSTRUCTIONS, AND PROCUREMENT

The design of equipment and modifications to existing machinery to be employed in the EBR-II Initial Fuel Fabrication Facility was carried on from August, 1958, until the construction and erection was nearing completion in May, 1959. Figure 15, a bar graph of the time schedules realized, is an illustration of the procedures involved in this project. During the period designated for design, it became apparent that rather extraordinary measures would be required to meet the fuel requirements as predicted at that time. To accelerate the building program, it was decided that a labor contract be negotiated with Midwest Machinery Movers, Inc., who had had considerable experience with work of this type during the erection of equipment in Facility 350. In addition to having available experienced labor at the start of work, our experience with laboratory construction, testing and shakedown of equipment carried on concurrently with subcontractor work had indicated that a high degree of cooperation could be expected from this arrangement. With this in mind, engineering drawings were made covering the shop fabrication and subcontractor installation of all units required for the task. Instructions, rather than specifications, were written to guide the work and to provide workmanship requirements to be supplemented by more detailed or modified instructions as the work progressed.

Fig. 15. Bar Graph of Schedule of Design and Construction for EBR-II Initial Loading Facility

The procurement of materials for the erection of equipment was initiated by the Metallurgy Division. With engineering drawings as guides, lists of materials were assembled for ANL-shop-fabricated items, and for purchased mechanical, electrical, piping, and structural steel needs. These lists were checked against ANL stock and, where possible, items were ordered from this stock. The Purchasing Department was then called upon to provide the remaining items. By the time the contractual arrangements were completed and the work ready to commence, a considerable store of materials had been accumulated near the work site. During construction, the stockrooms were relied upon to provide general items, as bolts, screws, pipe fittings, electrical supplies, paint, etc., which would have been anticipated only through a time-consuming take-off from completely detailed drawings. The procedures which were followed allowed a saving in drawing and engineering time; however, judgment in the extent of detail was vital to prevent the omission of essential items not obtainable from stock. The need for judgment, of course, arises from the realization that completeness of procurement and elimination of confusion during construction is proportional to the extent of drawing detail.

VII. INSTALLATION

The work of installation and erection was commenced within a total subcontract budget on Feb. 16, 1959, and was completed May 26, 1959. During this interim the design group continued to work on EBR-II prototype equipment which, when completed, was fabricated and given to the subcontractor for installation. The complete control system for the push-button operation of casting and pin processing was designed, fabricated, and installed within the erection period. Shop installations, inspection, testing, and equipment shakedown by ANL personnel were carried out during this period.

The philosophy of completing as much work as possible within the framework of established budgets and time schedules resulted in the realization of a facility as nearly complete as practical, leaving less than usual to be completed by Laboratory personnel. This discipline also resulted in a considerable saving of time, as may be noted in Figure 15. The first three lines of this bar graph represent the more general case in which the subcontract work begins after definitive design is complete. A bidding period and a span of time during which the contractor procures materials must necessarily be interposed between the end of design and the start of construction in the lump-sum contract arrangement. This type of negotiation interposes serious limitations to extension of work during the construction period.

In the labor-only contract, such as negotiated in this case, design and procurement may be completed as near the end of the labor contract as is required to present drawings and materials into the hand of the

builder pending his installation. The last five bars of Figure 15 show how this was developed for the EBR-II Initial Fuel Loading Facility. In this case changes, omissions, and additions were dependent only upon the ability to procure materials and provide knowledgeable instruction for installation. The saving in design time, the procurement of materials concurrently with design and construction, and the use of laboratory stock for a material source all resulted in the erection of a facility abreast of design concepts.

VIII. COSTS

The completed job of construction, including Plant Engineering services, building modification, Plant Services work, materials, erection and installation, and excluding design and supervision services of the personnel assigned to the Metallurgy Division, came to a total of \$161,171.80. On December 9, 1958, Work Project No. 3748 - Rev. 1 was established in the sum of \$51,000 with an allowable variation of ten percent. This work project was to provide monies for the required modifications to Building 6. The total cost of these modifications at the termination of work was \$44,660.46. Procurement and installation costs of equipment for the Initial Loading Facility was covered by Work Project No. 3747 issued on October 6, 1958, for a total of \$113,000 with a ten percent allowable variation. Equipment purchases and installation at contract termination totaled \$116,511.35.

Figure 16 is a cost breakdown chart for the EBR-II Initial Loading Facility. This chart shows graphically the distribution of the funds employed in the construction, installation, and erection of equipment and services for the Initial Loading Facility.

Fig. 16. Cost Breakdown Chart for EBR-II Initial Loading Facility

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BIBLIOGRAPHY

1. Bernstein, G. J., Graae, J. E. A., Levenson, M., and Schraidt, J. H., Design for a Remotely Operated Facility for High Temperature Processing of Spent Reactor Fuel, Sixth Hot Laboratories and Equipment Conference, 1958 Nuclear Congress, p. 39-53, March 1958.
2. Yaggee, F. L., Ayer, J. E., and Jelinek, H. F., Injection Casting of Uranium-Fissium Alloy Pins, Nuclear Metallurgy, Vol. IV, 51-62 (Nov 1957).
3. Pokorny, G. J., and Ayer, J. E., The Performance of a Special Differential Transformer and an Eddy Current Coil in a High Gamma Flux Environment, ANL-5988 (July 1959).
4. Shuck, A. B., and Mayfield, R. M., The Process Equipment and Protective Enclosures Designed for the Fuel Fabrication Facility - Facility #350, ANL-5499 (Jan. 1956).