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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

PROGRAM 4400

MARCH 1957

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C-85 Reactors - Aircraft
Nuclear Propulsion Systems

ORNL-2300

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SPECIAL PROGRESS REPORT
PROGRAM 4400

March 1957

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SPECIAL PROGRESS REPORT

March 1957

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

March 1957

PROGRAM 4400 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT (AEC Activity 4401)

Aircraft Reactor Test (ART)

The details of the reactor installation in the cell are being resolved. The thickness of thermal insulation and the heat losses were re-examined and modified somewhat to include the effects of changes in the layout during the past year.

The sodium and fuel pump drive system was re-examined in view of difficulties experienced with hydraulic motors in component tests. Variable frequency m-g sets with induction motors appear to be both less expensive and more reliable than the hydraulic drive system. Further, the installation can be made much more easily and quickly, and it would eliminate many cell wall penetrations. Since the contract on the hydraulic equipment had been held pending component test results, the change to electric motors is now being made and will entail no loss other than design time.

Engineering Test Unit (ETU)

Fabrication and Procurement - Satisfactory fuel-annulus core shells have not yet been produced by the shear spinning process. Dimensional control and metallurgical structure of the material continue to be unsatisfactory. Two island core shells were fabricated by machining and are currently undergoing metallurgical inspection.

The strut load ring assembly of the reactor is progressing satisfactorily and the preliminary machining of the main strut-ring forging was completed.

The B_4C tiles for one of the neutron shielding layers of the reactor are being produced without difficulty, and dimensional inspections of the tiles being received indicate that they are within tolerance.

Welding experiments are being continued on shells and thermocouples. A combination brazing and welding technique is being investigated for the sheath-type thermocouple installations in the reactor.

Work on the reactor north head is still held up pending the successful fabrication of the two sodium-to-NaK heat exchangers.

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Work on the ETU facility is to be reactivated on April 1, 1957, three months in advance of the planned date. Sufficient hardware is on hand to complete the main NaK piping in the two furnace circuits, and it is currently planned to complete this portion of the installation this fiscal year.

Specifications for variable-frequency drive motors to be used for driving the reactor fuel pumps were prepared. Various motor manufacturers were contacted, and at least two indicated interest in bidding on this equipment.

Operation Planning - An outline of the ETU operating program was prepared that incorporates all currently prescribed tests, and the necessary detailed operating procedures are being written. The ETU operating schedule now provides for 2 1/2 months of shakedown tests and 4 1/2 months of operation.

ART Facility Design and Construction

Test Facility - Payment was made during the month for the contract work (package 2) which consisted principally of installation and testing of diesel-generator units, switchboards, and their housing at the 7503 building. A number of items were added to this contract after it was let at an initial price of $58,400.00, and therefore the final payment was $71,557.67.

Package 3A contract work reached the 70.5% completion level at the close of the month. Work performed during the month included installation of conduit and the cable tray in the north basement; completion of erection of the compressor house; installation of electrical distribution centers, induction regulators, and powerstats; and erection of conduit supports between the compressor house and the blower house.

Disassembly Facility - A 1/12-scale model of the ART disassembly hot cell was constructed for better visualization of the cutting, measuring, and handling problems. In addition to planning the detailed hot-cell operations, the locations of samples and methods of taking them were reviewed. Measurements are to be made during reactor assembly from reference points which will also be used during disassembly. Because of the difficulty of getting some of these measurements during disassembly, emphasis is to be placed on replication methods for obtaining creep and stress information.

A variation of the Glenn L. Martin lofting method, whereby a grid is projected on the contour to be mapped, is being studied. Two photographs, one made during assembly and one made in the hot cell, could be examined under nonradioactive conditions to indicate the location and amount of distortion.

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A demonstration of the Brunson optical system indicated its potential accuracy and its limitations. It is too slow for plotting numerous points, but it might be used from outside the cell walls, as a cathetometer, within the range and accuracy of the optical properties of the windows.

The Manco Mfg. Corp. proposal for a hydraulic shear to cut 4-in. pipe was reviewed, and purchase of the shear was recommended. This hydraulic-shearing system, first proposed for ART disassembly, will have other uses, such as a remote sample-severing device required for the HRT.

Controls and Instrumentation

One ART rod-drive mechanism and dummy thimble assembly was received, and preliminary mechanical tests were performed. The actuator and the dummy thimble are being installed in a test system so that an experimental evaluation of the rod cooling system can be made.

Approximately 1870 hr of satisfactory operation have now been logged for a gas-fired test loop on which prototype pressure transmitters are being subjected to endurance tests. Field calibration checks were made on 3 1/2-in. ETU magnetic flowmeters installed in a NaK pump test loop, and final shakedown of equipment is now proceeding prior to tests under service conditions. Five prototype pressure transducers were received from Manning, Maxwell & Moore and are being tested.

Reactor Component Testing

Heat Exchangers - Metallographic examination of the 144-tube component-test fuel-to-NaK heat exchanger which operated for 500 hr at a maximum fluid temperature of 1700°F (IHE test stand B) revealed maximum intergranular penetration to a depth of 16 mils on the fuel side at the hot end of the heat exchanger tubes. General corrosion in this area was between 8 and 9 mils.

A test of the third 25-tube fuel-to-NaK heat exchanger is under way in which the fuel mixture is $NaF-ZrF_4-UF_4$ (56-39-5 mole %, fuel 70). The results of this test will provide a comparison of the effects of fuel 70 with the effects of the fuel mixture $NaF-ZrF_4-UF_4$ (50-46-4 mole %, fuel 30), which was used in previous heat exchanger tests.

Modifications to the fin matrix of the first ART prototype NaK-to-air radiator to reduce stresses were completed, and the radiator is being installed in a test stand. The 1-Mw heat source for the test stand was modified to increase its capacity to approximately 1.45 Mw. This will permit radiator tests at ART temperatures with up to approximately 85% of design air flow. Performance data will also be obtained for air flows above ART design at reduced temperature levels.

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PROGRAM 4400 - REACTOR DEVELOPMENT (Continued)

Dump Valves - As a result of screening tests, cermet materials were selected for valve plugs and seats that give promise of satisfactory service with fuel. Design modifications made to eliminate stem binding have resulted in very good valve operation. The principal modifications were the removal of the inner valve-stem guide and the substitution of a spider-like guide on the valve poppet to eliminate stem binding and seat misalignment, and the installation of a double-bellows stem seal to prevent fuel spillage due to valve bellows failure. The ETU NaK system dump valves were ordered from Black, Sivalls & Bryson. These valves will have Stellite 6 seats and poppets.

Prototype 3/8-in. NaK and sodium flow control and drain valves for the ETU and ART were tested. Valve stem binding and inadequate throttling control were encountered, and the necessary modifications were made. A modified valve is to be tested soon.

Tests of valve seat materials in $NaF-ZrF_4-UF_4$ (50-46-4 mole %, fuel 30) and in NaK were continued. A cermet combination* of a KM poppet and a K162B seat operated for 1250 hr, including 50 openings and closures at 1300°F, with no leakage; the same combination had operated at 1500°F for 300 hr, including eight openings and closures, with no leakage. A second KM-K162B combination has just been placed in operation, and KM-K152B and K151A-K162B combinations are being fabricated. A Stellite-Inconel combination tested with NaK at 1000°F leaked severely. Two KM-K162B assemblies and two Stellite-Stellite combinations are being fabricated for testing in NaK.

Pumps - A sodium pump endurance test was terminated following successful operation for 2572 hr and 516 thermal cycles from 1050 to 1250°F. The test was conducted at a sufficiently low surge pressure to permit impeller cavitation. Surface damage of the impeller as a result of the cavitation was evident upon visual inspection. The damage had not, however, affected the operating characteristics of the pump.

A fuel pump has accumulated 1752 hr and 282 thermal cycles in the 1100 to 1400°F range with $NaF-ZrF_4-UF_4$ (50-46-4 mole %, fuel 30) as the circulated fluid. This test is likewise being run under slightly cavitating conditions. Performance and cavitation testing of another ART fuel pump that is also circulating fuel 30 continued with 2472 hr of operation accumulated at 1200°F. At the design flow rate (645 gpm) the head is 0.5 to 1.0 ft above that for water. Cavitation data obtained at nine operating points indicate that at the design point of 2700 rpm and 645 gpm, the cavitation parameter is about 13% higher than that found in the water tests, and at 2400 rpm and 700 gpm it is about 18%

*The primary constituents of these Kennametal, Inc., cermets are: KM - $WTiC_2$ plus Co binder; K162B - TiC plus Ni and Mo binder; K151A and K152B - TiC plus Ni binder in different proportions.

lower than in water. The other data points in and around these speeds and flow rates are within 2 to 10% of the water data. Should cavitation cause difficulties during ETU operation a slight increase in surge tank pressure will eliminate it.

The first primary NaK pump high-temperature test has now operated 3400 hr at 1200°F with NaK. For 1700 hr there has been no helium purge flow down the pump barrel, and the pump has suffered no harmful effects.

Liquid-Metal-Vapor Condensers - A sodium-vapor condenser consisting of a 7-ft length of 3/4-in. sched.-40 Inconel pipe heated to 250 to 300°F has operated satisfactorily for 600 hr under conditions simulating purging of the two ART sodium pumps with 1000 liters of helium flow per day through sodium at 1200°F.

Tests of a NaK-vapor condenser consisting of a 12-in. length of 2-in. pipe followed by a 12-in. length of 6-in. pipe containing Demister packing are under way at high gas flow rates which simulate emergency dumps of the ART NaK system. The estimated mean gas flow during a dump of NaK in the ART is 1.7 cfm, and under this condition a test indicated a carryover of about 4 g of NaK into the condenser in 100 cycles. Each cycle consists of a 3- to 5-min period during which helium saturated with NaK vapor at 1200°F is vented through the condenser.

Zirconium Fluoride Vapor Trap - Chemical analyses of fused sections of ZrF_4-vapor traps packed with aluminum oxide showed appreciable concentrations of sodium (9 to 16 wt %). Since the fresh aluminum oxide contained only 0.3 wt % sodium, the reason for the high concentration of sodium is being explored. The $NaF-AlF_3$ complex may have caused the fusion observed in these tests.

Outer Core Shell Tests (1/4-scale model) - Thermal stability testing of the second 1/4-scale model of the ART outer core shell was interrupted because of a leak in the expansion bellows in the test assembly. The bellows was replaced and testing of the core shell will be continued when reassembly and reinstallation are completed.

ART Sodium Circuit Water Flow Tests - The total pressure drop of the sodium circuit of the ART is being determined by calculations and by measurements of the pressure drop in water flow tests of the regions of the circuit which are difficult to analyze. A full-scale mockup of one-half the symmetrical sodium circuit in the reflector entrance region of the ART was tested. The sodium impinges on the circular boron cans located in a pie-shaped depression in the reflector and spreads out over the top of the reflector and to the annulus around the core shell. The result of the first test showed that the coolant holes on the shoulder around the pie-shaped depression were relatively starved. The shoulder

was therefore modified to provide a more gradual transition between the depressed region and the top of the reflector, and the modified assembly will be retested.

In-Pile Experimentation

ART Pump Bearing Housing and Seal Irradiation - The design of the facility for irradiation tests of an ART pump bearing housing and seal assembly is essentially complete. Fabrication was started on the mechanical components and instruments. The test is scheduled for operation at the MTR in July 1957.

Irradiation Tests of Moderator Materials - The second moderator test capsule containing graphite, beryllium oxide, and zirconium hydride samples is being irradiated in the HB-3 beam hole on the MTR. It was inserted in the reactor February 18 and is scheduled for removal on April 1, 1957. Initially, the samples were surrounded by a helium atmosphere. However, the capsule temperatures were low, and the atmosphere was changed to argon to reduce thermal-convection losses. Capsule surface temperatures with argon are 1300 to 1350°F for the beryllium oxide sample, 1500 to 1550°F for the graphite sample, and 1590 to 1600°F for the zirconium hydride sample.

Design Physics

Shielding studies were made of the ART and related equipment, including such components as the fuel fill-and-drain tank, the fuel recovery tank, and the fuel drain line. The gamma-ray dose rate at the surface of the ART shield (4.3 in. of lead plus 31.5 in. of water) was calculated both by the buildup factor method and by tracing the degraded energy spectrum from each source energy group through each component of the reactor, that is, the reflector, heat exchanger, lead shield, and water shield. The calculated dose rates were 1840 r/hr and 1610 r/hr, respectively. The dose rate estimated on the basis of Lid Tank Shielding Facility experiments is about 1500 r/hr. The contributions of various sources to the total dose at the surface of the shield are: heat exchanger, 22%; reflector shell, 35%; reflector, 12%; core shell, 9%; core 22%. Energy fluxes at the shield surface (r = 170 cm) in each gamma-ray energy group are:

Energy Interval (Mev)	Flux (Mev/sec·cm^2)
0.25-0.75	107.5×10^6
0.75-1.25	86.3×10^6
1.25-3	271.3×10^6
3-5	301.1×10^6
5-7	147.0×10^6
7-8	185.3×10^6

Power Plant Engineering

The study of a turboprop aircraft suited to early warning radar systems, logistics transport, tanker, and numerous other applications was completed. The results indicate than an ART reactor with a unit shield would power a 280,000-lb all-nuclear airplane with a payload capacity of about 40,000 lb. Discussions with Douglas Aircraft Co. engineers indicate that their C-133 aircraft is well-suited to this application.

Heat Transfer Research

Probe-traverse velocity measurements and dye-injection motion pictures were made in the full-scale plastic ART core model with an inverted-cone island bellows entrance configuration for unguided entrance conditions (case a) and for guided entrance conditions with a vane-plate combination (GS-2, P-3) and a slotted baffle plate (designated flame holder No. 2). The baffle plate was located approximately 9 1/4 in. above the equatorial plane (case b). Marked instabilities in flow and pressure were observed in case a, with extensive flow separation at the island wall. Flow guidance and the other conditions presented in case b eliminated the reversal and apparently reduced the instabilities. Measurements of transient heat transfer coefficients at various levels throughout the core by means of hot-wire surface probes indicated some reduction in boundary-layer fluctuations for case b.

The program of photographically recording instantaneous velocity profiles made visible by the phosphorescent-particle technique was continued with studies of laminar and turbulent flow in tubes, diffusers, and spirals. The results were made quantitative by superimposing grid photographs on the velocity-profile photographs.

Experimental studies of the effects of thermal cycling on Inconel in an $NaF-ZrF_4-UF_4$ (50-46-4 mole %) environment were aimed at defining a number of the system variables. Tests were performed with the entire 12-in. test unit serving as a heater, and comparison of the results with results of tests made with 4- and 8-in. heater sections showed that the heater length may not be a significant variable in this thermal-cycling system. The effect of cumulative stress overload was investigated by comparing two tests which were similar in that the entire 12-in. test unit served as a heater, but which differed in that one test unit was subjected to approximately four times as many thermal cycles as the other. The greater number of thermal cycles resulted in somewhat deeper attack and fewer but larger voids. Two other tests indicated that the thermal-cycling results were independent of the prior total cycling exposure of the salt mixture and of the system. Both test units showed intergranular stringers and general corrosion to approximately the same depths, although for one test a system and a salt with 250 hr of prior exposure were used and for the other test a new system and a fresh salt were used.

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Metallurgy - Corrosion

Several commercial nickel-base brazing alloys are presently being tested in NaK and in $NaF-ZrF_4-UF_4$ (53.5-40-6.5 mole %, fuel 44) in the seesaw-furnace apparatus at a hot-zone temperature of 1500°F for 100 hr. Under these conditions, an alloy from Handy & Harman, designated Handy-Harman No. 91 and composed of 91 wt % Ni, 4.5 wt % Cr, and 2.9 wt % B, was found to have corrosion resistance equal to or possibly better than that of the best of the previously tested brazing alloys, for example, Coast Metals brazing alloy No. 52 (59% Ni-5% Si-4% B-2% Fe). The depletion of a phase from the brazing alloy fillets was found to be associated with the chromium content. Only those alloys containing chromium showed this depleted area.

Corrosion testing of the nickel-molybdenum alloys in thermal-convection loops has continued with both sodium and $NaF-KF-LiF-UF_4$ (11.2-41-45.3-2.5 mole %, fuel 107). Nickel-molybdenum alloys with niobium additions were shown to have excellent resistance to fuel 107. Aluminum additions appear to be detrimental because of their effect on the depth of attack and because of the buildup of aluminum in the salt during test. All loops operated for 1000 hr at 1500°F with sodium showed mass-transfer deposits in the cold leg, which were found to be predominantly nickel by spectrographic analysis.

Metallurgy - Fabrication

Studies were continued on the alloy series INOR-8, composed of Ni, Mo, Cr, and Fe, and INOR-9, composed of Ni, Mo, Nb, and Fe. Tube blanks of an INOR-8 composition were extruded for processing into seamless tubing for in-pile capsule tests with $NaF-KF-LiF-UF_4$ (11.2-41-45.3-2.5 mole %, fuel 107). Tubing from previously fabricated tube blanks was received from the Superior Tube Company for forced-convection loop corrosion studies. The initial heat of the alloy INOR-8 melted at the Westinghouse Electric Corporation under ORNL subcontract was slightly over the specified carbon analysis and will be remelted. However, a section of forged round of the original heat was received and successfully extruded to provide material for determining tensile and stress-rupture properties, thermal expansion, and thermal conductivity.

The work on the INOR-9 system was devoted to the determination of approximate solid solubility limits, the oxidation characteristics, and the forgeability. In nickel-base alloys containing 10 to 17 wt % Mo, the solubility of niobium (added as ferroniobium) appears to be approximately 5% in the temperature range 1300 to 1700°F. The oxidation rates of the INOR-9 alloys at 1500°F are slightly higher than the rate for Hastelloy B; however, the scale which forms is reasonably tenacious in contrast to the scale on Hastelloy B, which spalls vigorously during thermal cycling. At 1700°F, on the other hand, the oxidation rate of

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INOR-9 increased rapidly, and the rather thick scale that formed spalled on cooling. Thus it appears that chromium additions to these alloys will be required for oxidation resistance at temperatures over 1500°F. The forgeability studies indicate that the alloys of this system can be hot and cold rolled, if the niobium content is 7.5% or less.

Metallurgy - Welding and Brazing

Weldability studies of nickel-molybdenum alloys were continued, and fillet weld test plates of all the available alloys were made. Each plate will be examined metallographically, but mechanical property data will be obtained only on the most promising alloys, since the number of test specimens required for a comprehensive study of these properties is so great. At present, tensile and bend test and hardness specimens are being machined from the test plates of the INOR-8 composition. An effort is being made to develop a high-restraint weld-crack test to supplement the fillet weld test.

The hot-bend furnace is being modified to increase its maximum operating temperature from 1500°F to 1700 to 1800°F. An improved lighting system for low-temperature operation is also being developed. A mercury vapor lamp with a filter system is being studied.

Welding and brazing procedures for the auxiliary heat exchangers and the fuel fill-and-drain tank are being developed. Welding and brazing were completed on an auxiliary heat exchanger sample submitted by the Griscom-Russell Company. One half the 300-tube-to-header welds were made by Griscom-Russell and the remaining 150 were made at ORNL. Backbrazing of the joints with Coast Metals brazing alloy No. 52 was accomplished by heating to 1920°F at a 300°F/hr rate of temperature rise. Visual examination showed brazing alloy filleting on all tubes. The sample is presently being sectioned for metallographic examination.

In initial brazing tests of samples of the tube-to-header joints of the fill-and-drain tank, poor filleting was observed on some of the joints. A modification of the joint design appears to have solved this problem.

Metallurgy - Mechanical Properties

Strain-cycling tests of Inconel, both fine and coarse grained, are under way at temperatures of 1300, 1500, and 1600°F in argon and in NaF-ZrF_4-UF_4 (50-46-4 mole %, fuel 30). Test results to date show that temperature and grain size are the more significant factors affecting the strain-cycling characteristics of Inconel. At 1300°F, both fine- and coarse-grained materials have approximately the same strain-cycling properties. However, as the temperature is increased, the ability of only the fine-grained Inconel to absorb strain is increased. The

coarse-grained Inconel strain-cycling properties do not change with temperature. Results of comparative tests in argon of fine-grained Inconel showed that for a cycle time of 1 min per cycle and 2% plastic strain per cycle, the number of cycles to failure at 1300°F was 290, at 1500°F it was 960, and at 1600°F it was 600.

Most laboratory creep and rupture tests are made under constant load and constant temperature conditions, but, since the actual service conditions will not be constant, tests are being made on Inconel in fuel 30 at a constant temperature but with variable stressing. One test was completed at 1500°F in which the stress was 3000 psi for 168 hr, 5000 psi for the next 27 hr, 3000 psi for the next 186 hr, and then 5000 psi until rupture. The predicted rupture life obtained from existing stress-rupture data was 416 hr, while the actual rupture life was 440 hr.

Metallurgy - Mass Transfer Studies

The rate of diffusion of nickel in lead is being studied in an effort to determine the effect of concentration on the diffusion coefficients for solutes near the saturation concentration when the maximum solubility is low. The results of several tests were analyzed quantitatively, but the results are not yet complete enough to permit conclusions to be drawn.

The study of the kinetics of the solution process of nickel in sodium is progressing. Components for the measuring apparatus are now being fabricated in the machine shop. The sodium still, which will produce high purity sodium for these studies, is also being fabricated. Efforts to design high-quality metal vacuum system components for sodium work is continuing.

The laboratory installation is now essentially completed. Furnaces for heat-treating capsule-type specimens are now being installed. Five Inconel capsules for preliminary studies of the solubility of nickel in sodium in these furnaces were fabricated in the dry box and are ready for testing. These capsules contain a nickel cup, a molybdenum cup, and a quantity of sodium. The sodium will be allowed to reach equilibrium with the nickel cup and then will be poured into the molybdenum cup. The entire contents of the molybdenum cup will then be analyzed. Results of these tests should be available within the next two months.

Chemistry - Fuel Research

The only ternary compound yet found in the system $RbF-NaF-BeF_2$ was localized near the composition corresponding to the formula $6RbF \cdot 4NaF \cdot 5BeF_2$. It melts incongruently to $2RbF \cdot BeF_2$ and liquid at about 585°C and has a primary phase field in the center of the diagram. The join $2RbF \cdot BeF_2-NaF$ is a binary system, and it forms a base for a compatibility triangle with the ternary compound.

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Filtration studies of the reduction of UF_4 (9.2 wt % UF_4 - 4.0 mole %) by Fe^0 in the reaction medium $RbF-ZrF_4$ (60-40 mole %) yielded iron concentrations of 490 and 170 ppm at 600 and 800°C, respectively. These concentrations approximate those found in the other binary alkali fluoride-ZrF_4 mixtures studied, and it may be noted that the values are significantly higher at 600 than at 800°C.

The solubility of HF in $NaF-ZrF_4$ (53-47 mole %) was determined at 600 and at 700°C over the pressure region from 0 to 2.5 atm, and Henry's law was followed within the precision of the measurements. In contrast with the noble gas solubilities in the same solvent, a decrease in solubility of HF with increasing temperature was noted. The numerical values of Henry's law constants expressed as (moles of HF)/(cm^3 of melt) x (atm) are $(12.4 \pm 0.4) \times 10^{-6}$ and $(8.1 \pm 0.3) \times 10^{-6}$ at 600 and 700°C, respectively. Experiments at 800°C are under way.

As the result of interest in an improved method of obtaining oxygen-free yttrium metal, a preliminary study of the YF_3-MgF_2 system and the $LiF-MgF_2-YF_3$ system was made in the visual-thermal apparatus. A mixture containing 28.1 wt % MgF_2 and 71.9 wt % YF_3 was found to have a liquidus temperature of 1005°C and a solidus temperature of about 970°C. A mixture containing 25 wt % LiF, 53.9 wt % YF_3, and 21.1 wt % MgF_2, obtained by adding LiF to the binary mixture, had a liquidus temperature of 715±5°C and a solidus temperature of 640°C, presumably indicating the existence of a ternary eutectic that melts at 640°C. It is reasonable to believe that this mixture can be purified by present techniques and used for production of yttrium metal by reduction with lithium to give an yttrium-magnesium alloy from which the magnesium can be removed by vacuum sublimation.

Chemistry - Fuel and Coolant Production

During March, 16 batches totaling approximately 4000 lb of purified fluorides were processed in the 250-lb capacity facility. One of the two processing units lost six days of production because a receiver furnace burned out. Processing of small batches of fluoride mixtures for special research usage increased slightly during the month.

Shield Design

The Monte Carlo neutron air-scattering code described previously (ORNL-2282, p 13) was modified so that it can be used to determine neutron penetrations of water slabs. A study is under way to compile energy spectra, fluxes, and doses at the backs of slabs of various thicknesses resulting from plane, monodirectional neutrons which enter the fronts of the slabs at various angles and with various energies. The results of these calculations are being used to determine the crew-compartment attenuation of air-scattered neutrons which enter at slant angles.

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Tower Shielding Reactor II (TSR-II)

The radius of the internal water reflector of the TSR-II was established at 17.5 in., since this is the minimum dimension that will enclose the control mechanism. Calculations on the Oracle with the three-group three-region reactor code indicate that the thickness of the core surrounding the internal reflector will be 6 to 9 in., and the aluminum-to-water volume ratio will be 0.7 to 2.0. Analysis of the heat transfer from the fuel plates will fix the final design values.

Some question was raised as to the accuracy of the calculational techniques used to obtain the amount of control that is possible with the TSR-II configuration. In order to resolve this, an experiment is planned in the Bulk Shielding Facility reactor in which a mockup of the control mechanism will be operated in a 6-in.-square water-filled hole in the center of the reactor. The necessary components are now being fabricated. A prototype of the control mechanism that will undergo dynamic tests is also being fabricated.

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