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AEC RESEARCH AND DEVELOPMENT REPORT

ORNL-2317
Reactors-Aircraft
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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

PROGRAM 4400

APRIL 1957

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C-85 Reactors - Aircraft
Nuclear Propulsion Systems

ORNL-2317

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April 1957

Date Issued: MAY 6 1957

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C-85 - Reactors - Aircraft
Nuclear Propulsion Systems

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

April 1957

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

April 1957

PROGRAM 4400 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT (AEC Activity 4401)

Aircraft Reactor Test (ART)

The design work on the details of the plumbing and equipment installation in the reactor cell is continuing. The procedures for installing the reactor support structure, including the columns and bridge, and the NaK piping were worked out so that the reactor will be properly positioned and the static loads on the pump barrels, pressure shell, and NaK piping will be minimized. Full allowance was included for shrinkage in the welds of the NaK piping and for field fitting problems.

Water flow tests on the sodium inlet passages to the ART reflector were completed, and a satisfactory configuration was evolved to assure good flow distribution through the rifle-drilled cooling holes and the core-shell cooling passages. Water flow tests on bundles of parallel tubes closely approximating the ART heat exchanger tube bundle configuration were also completed, and the side loads on the channels were found to be somewhat less than estimated for stress analysis purposes.

The over-all performance of the complete ART system is being reexamined in detail. For example, the factors affecting fuel drain time for an emergency dump were investigated and a number of restrictions in the helium lines were opened up as a consequence.

Engineering Test Unit (ETU)

Design Studies - The information available from metallurgical inspection, stress analyses, and experimental testing was examined carefully to determine as well as possible what weld defects can be accepted in parts for the ETU. It is believed that some tiny porosity indications disclosed by the radiographs made as part of the very thorough inspection procedure are not serious, and the occurrence of these defects in a small percentage (1 or 2%) of the tube-to-header welds in a radiator, for example, will be acceptable provided they are in noncritical zones in the weld and they are satisfactorily backbrazed. A higher incidence of porosity indications is to be considered a sign of improper welding and shall be cause for rejection.

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The problem of installing strain gages on external surfaces of the ETU to check the pressure and gravity stresses was examined carefully, and a layout was evolved which should provide the information needed for a good insight into the stresses that will exist in the outer pressure shell and key points in the NaK piping. Data will be taken with the assembly cold and at temperatures up to about 300°F. These data can be compared with computed values to provide an excellent check on the stress analyses. A total of 144 strain gages will be required to cover lift, pressure, and prestress strain measurements.

Fabrication and Procurement - The parts for two island core shells (shell I) were fabricated by cold forming, welding, and machining. Three of the four pieces were rejected because of excessive porosity in the welds. A change in the weld design has been made, and additional shell parts are to be fabricated. Shells made in this way will not be metallurgically satisfactory for the ART, but the possibility of using them in the nonradioactive ETU is being considered.

It has been decided to produce the parts for the shell which fits around the outside of the reflector (shell III) by forming, welding, and machining rather than by the shear-spinning method previously specified. The shear-spinning process is still being developed for the production of the inner and outer core shells (shells I and II) which form the fuel annulus and for the two 1/16-in.-thick shells (shells IV and V) that cover the boron shielding on both sides of the main heat exchangers. No completely satisfactory shells have yet been produced by this process, but the results obtained thus far indicate that shells can be produced by the shear-spinning process that will be metallurgically satisfactory.

Work is continuing on fabrication of the strut load ring assembly. The struts were welded to the ring without difficulty. Welding experiments were continued on the reactor thermocouples, and a satisfactory welding and brazing installation technique was developed. A second welding experiment was conducted on hoops that simulated the re-design of the pressure shell girth weld. Results of this test indicate that the excessive radial shrinkage problem has been eliminated.

A set of Inconel staple spacers was installed in the two beryllium island halves without difficulty. Work was started on the ETU NaK piping, and the electromagnetic flowmeters and bypass systems were welded into the two furnace circuits. One NaK pump bowl was installed in the support structure, and it is being welded into a NaK furnace circuit. Specifications and requests for bids for the variable-frequency pump drive equipment were sent out on April 4. Bids are to be in not later than May 1.

A valve tabulation for the ETU was completed. In the course of determining the leakage criterion for the valves, it was necessary to establish the ETU system leak-tightness specification. A criterion of

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total permissible leakage of not greater than 0.02 cfm with a 30-psig differential pressure for each NaK, fuel, or sodium system was established. The permissible valve leakage was then determined on the basis of the system criterion.

ART Facility Design and Construction

Test Facility - Package 3A contract work reached the 95.5% completion level at the close of the month. Work performed during the month included installation of conduit and cable in the compressor house and in the blower house; wiring of the water-booster pumps; installation of compressors, aftercoolers, receivers, air dryers, steam unit heaters, motor controller units, and resistor units; and erection of conduit supports between the switch-house and the blower house.

Steps were taken to initiate procurement on the fill-and-waste storage tank and pumping unit for the oil system, the NaK dump-tank dolly, the charcoal for the off-gas system adsorber piping, the hydraulic pumping unit for the louver control system, and the cell and cold-trap tubular heaters and heater cable.

Disassembly Facility - The planning of hot cell operations and the study and testing of the equipment for performing the operations required in the disassembly and examination of the ART were continued. Several proposed methods of taking reactor component measurements during hot-cell disassembly were tested. One method which shows promise involves the use of a cathetometer set up outside the zinc bromide windows of the cell.

Replication of areas of shell I was successfully accomplished with a metalizing gun and lead spraymold wire. Dimensional reproducibility was good, but some problems, such as handling the material in a hot cell and the determination of the points at which the molds are to be separated, still exist. Information is being obtained on "Gunnite" equipment, which includes a mixing gun capable of applying a mortar-like material.

Several cutting tests were performed on Inconel. The end milling and drilling of uniform sized holes was found to be an unsatisfactory means for severing plate, but an interlocking small and large hole arrangement appears to be practical, except that tool life is short. The grinding equipment used for dismantling the ARE is being decontaminated in preparation for hot-cell application tests.

A sealant injection system has been proposed for use in sealing radioactive lines before they are severed. A stud gun was used to successfully demonstrate that two concentric pipes (to simulate the dump

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line) can be pierced with ease and accuracy. Tests are being made of a hollow needle for use in this device.

Reactor Component Testing

Radiators - Installation of the first ART prototype NaK-to-air radiator in IHE test stand C is essentially complete, and high-temperature testing of this radiator is to begin soon. Radiator fin material with edges cut by various methods is being exposed to high-temperature (1200°F) air flow in SHE test stand C to determine the rate of oxidation of the copper of fins not edge-protected. Tests of finished radiators that were cut to relieve stresses on the fins have demonstrated that the edge protection previously thought to be essential may not be necessary. If the edge protection is not required, fin material already on hand can be cut to size and used in the ART radiators without further treatment. Means for providing edge protection are also being studied.

Dump Valves - A design change was made in the fuel dump valve to provide a flange over which an Inconel sleeve and flange may be mounted to serve as a mechanical backup fastener for the plug braze, and materials have been ordered for a test of this design. A prototype valve is now being rebuilt with a guided plug, and the mechanical backup fastener for the plug will be simulated. A valve with a guided plug has completed 27 operating cycles and 1000 hr of operation at 1300°F. The opening force after the 500-hr closure period was only 88 lb. The average leak rate during the 500-hr closure was 0.1 cm^3/hr.

Recent failures of the stems of 3/8-in. NaK and sodium valves have indicated the need for a stronger stem and better plug-to-seat alignment. The ETU requirements have also made it necessary to alter the plug design to improve the valve throttling characteristics. Precise flow control to within ±0.02 gpm can be easily attained with the modified valve by hand operation or by use of a pneumatic operator.

Tests of Kennametal cermet seat and plug materials exposed to NaF-ZrF_4-UF_4 (50-46-4 mole %, fuel 30) at various temperatures were continued. A cermet combination* of a KM plug and a K162B seat operated with no measurable leakage for 1157 hr at 1300°F through 54 cycles, 795 hr at 1500°F through 16 cycles, and 192 hr at 1600°F through 13 cycles. The test was terminated after a leak developed in the connecting line. A second KM-K162B combination tested at 1500°F showed erratic leakage of from 0 to 32 cm^3/hr; however, the leakage decreased rapidly upon closure.

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*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.

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A K151A-K152B combination that had been leaktight started leaking when metal chips became lodged in the seat. A Stellite 6 seat and plug were found to be leaktight in water and will shortly be tested with NaK.

Pumps - Development tests of the ART sodium pump are being made with water as the pumped fluid in a loop which includes a prototype reactor pump barrel and expansion tank. Initial performance data show a lower head for this pump than that found in previous tests in other loops. The lower head appears to be associated with a difference in the axial clearance below the impeller. Further tests are planned to study this region and the degassing characteristics of the pump.

A fuel pump endurance test is continuing with $NaF-ZrF_4-UF_4$ (50-46-4 mole %, fuel 30) as the pumped fluid, and a total of 2544 hr with 446 thermal cycles in the temperature range of 1400 to 1100°F has been accumulated. The surge pressure being maintained is such that the pump impeller should be in a region of cavitation in order to investigate cavitation damage. A performance and cavitation test of a similar pump was terminated after 2880 hr of operation with fuel 30. Performance data were obtained at speeds of 2400, 2700, and 3000 rpm, and cavitation data were obtained at these speeds for flow rates of 600, 645, and 700 gpm. At the design head and flow rate of 2700 rpm and 645 gpm, the head is 1 ft lower and the cavitation parameter is 13% higher than obtained with water.

The first primary NaK pump high-temperature test with NaK has operated over 3900 hr at temperatures around 1200°F with the original impeller and rotary assembly. A second primary NaK pump has operated with NaK for 600 hr at temperatures up to 1500°F. Performance and cavitation data are being obtained, and six electromagnetic flowmeters were calibrated for use in the ETU and ART in the loop in which this pump is operating.

Water Flow Tests of North Head Mockup - Tests with water of the fuel system of the aluminum mockup of the north head demonstrated that helium purging of the fuel under normal conditions will not cause the carryover of fuel into either the dump tank or the ZrF_4-vapor trap. The off-design condition of one pump stopped resulted in liquid carryover of several gallons to the dump tank. This liquid carryover was the result of a liquid level rise caused by loop ingassing. The liquid level at the start of the tests was 3 1/2 in. above the fuel expansion tank floor and the elapsed time for the start of liquid carryover was 15 sec.

Zirconium Fluoride Vapor Trap - The chemical analyses reported last month which showed 9 to 16 wt % sodium in the fused sections of traps containing aluminum oxide were found to be incorrect; the correct sodium

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content of the fused sections was less than 0.5 wt %. It is now believed that the fusion which occurred in these traps was caused by the formation of a low-melting complex by the reaction products and/or reactants.

An experimental version of the ART prototype ZrF_4-vapor trap was fabricated, and air flow tests were performed. The air pressure drop through the trap for a flow rate of 10 scfm is 2.2 psi; it is estimated that the average helium flow during an emergency fuel dump of the ART will be 10 scfm. The trap is being installed for testing at conditions simulating both continuous purging and rapid dumps.

Liquid-Metal-Vapor Condensers - A prototype sodium-vapor condenser has continued to operate satisfactorily for 1200 hr under conditions that simulate the purging of the two ART sodium pumps through a single exhaust line.

Testing of a NaK-vapor condenser for the sump at the high gas flow rates expected in a dump of an ART NaK system was completed. The condenser efficiency varied from 98.8 to 99.9% at gas flow rates of from 2.8 to 1.2 scfm of helium saturated with NaK vapor at 1200°F.

Outer Core Shell Tests (1/4-scale model) - The test rig containing the 1/4-scale model of the ART outer core shell, which developed a leak in an expansion bellows during thermal stability testing, was reassembled. Testing will be resumed as soon as the shell has been measured and the final weld has been completed. The shells will be carefully measured before and after each test to detect any changes which might have occurred during the testing.

ART Sodium Circuit Water Flow Tests - The regions of the sodium circuit which are difficult to analyze are being tested for pressure drop and flow distribution. A test of the reflector entrance region indicated that particular cooling holes on the shoulder around the pie-shaped depression in the beryllium were relatively starved for fluid. The shoulder was therefore remodeled and further testing has indicated that the high loss coefficients for those particular holes on the shoulder were successfully reduced.

In-Pile Experimentation

In-Pile Loop No. 6 - Disassembly of in-pile loop No. 6 is under way. The loop has been sectioned but no metallographical work has yet been started. The lower heat exchanger heater (Calrod), which failed during startup, was found to have melted through the heater sheath. The nose purge-gas sniffer line, failure of which was indicated by a drop in the nose purge pressure during loop operation, was found to be broken adjacent to the weld joining it to the heat exchanger outlet end.

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This loop was subjected to severe thermal cycling during operation which would have caused flexing of the sniffer line in the vicinity of the weld.

The pump has been sectioned in four places: through the sump, on the pump side of the rotating copper block, between the shaft rotor and seal, and adjacent to the bearing housing side of the pump bulkhead. Visual examination showed the sump to be relatively clean. There was a larger quantity of salt present than had been found in the sumps of the pumps of the previous loops. Some oil had solidified in the convolutions of the seal bellows, as it did in previous loops, but no oil was found elsewhere in the pump. Detailed examination is awaiting the availability of a cell with a master slave manipulator.

ART Pump Bearing Housing and Seal Irradiation - The gamma facility which was fabricated at the MTR for irradiation of an ART pump bearing housing and seal was installed in the MTR canal. The lubrication system was tested and shipped to the MTR for installation. The pump bearing housing for the test was assembled and is being tested in conjunction with the hydraulic drive unit prior to assembly into the water jacket. MTR personnel were requested to proceed with the installation of fluid and instrumentation lines prior to arrival of the equipment in order to facilitate installation. The irradiation tests are scheduled to start early in July 1957.

Irradiation Tests of Moderator Materials - In the second irradiation test of moderator materials for use at high temperatures, zirconium hydride, beryllium oxide, and graphite were irradiated. The test equipment was removed from the reactor on April 1 and is scheduled to be prepared by the end of this month for return to ORNL.

Math and Computation

The data obtained during 1351 hr of operation of a 500-kw NaK-to-air radiator were analyzed to determine the effect of temperature and temperature differential on mass transfer and the resultant pressure buildup in the NaK system. Linear terms were not found to relate the friction factor to the temperature and temperature differential, but there were indications that temperature and temperature differential expressed in the form of a quadratic could account for significant portions of the observed variations in the friction factor.

The friction factor was estimated by the method of least squares from measurements of pressure differential and velocity. This method of determining the friction factor eliminates the need for corrections of data from the pressure-measuring devices.

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Power Plant Engineering

A preliminary design of an apparatus for in-pile testing of moderating materials suitable for use in the 1500 and 2000°F range was prepared and is being evaluated. This apparatus was designed to go into one of the two 3 x 3-in. holes in the middle of the ETR core where radiation-heating power densities and the fast-neutron flux will be much higher than in any facility heretofore available. Cooling of the specimens will be accomplished by circulating helium under a pressure of about 10 atmospheres with a small blower integral with the test pod. Samples of beryllium oxide and zirconium or, if possible, yttrium hydride will be tested at power densities closely approaching those of a 200-Mw reactor.

Metallurgy - Corrosion

In the past studies of the corrosiveness of lithium were conducted in type 316 stainless steel thermal-convection loops fabricated according to the standard ORNL design that specifies 1/2-in. sched-40 pipe and 15-in. legs. The standard operating conditions of a hot-leg temperature of 1500°F and a cold-leg temperature of 1100°F were also used. All such loops became plugged with mass-transfer crystals in approximately 500 hr. In order to be able to compare ORNL data with data being obtained under subcontract at NDA, loops are now being fabricated with the cold legs 30 in. rather than 15 in. This change increased the flow rate and cut the time to plug by a factor of approximately 2. It was also found that elimination of the diffusion cold trap at the bottom of the cold leg decreased the time to plug from 290 to 96 hr.

Further evaluation tests were made of the rate of corrosion of nickel-molybdenum alloys in molten sodium. Two Hastelloy B forced-circulation loops were constructed and operated to obtain data for a direct comparison of the mass transfer properties of this alloy with those of Inconel. Both loops were operated for 1000 hr with temperature drops of 300°F, and the maximum fluid temperatures were 1500 and 1300°F, respectively. Cold traps were operated in conjunction with both loops to keep the oxide content of the sodium below the saturation level at 300°F (50 ppm).

Examination of the loop which operated with a maximum fluid temperature of 1500°F revealed somewhat more material deposited in the cold leg than was found in Inconel loops operated under similar temperature conditions. The total weight of deposited material, as determined by mechanically removing the deposits from the cold leg and weighing them, was 17.3 g in the case of the Hastelloy B loop as compared with 13 to 14 g in the case of similar Inconel loops. The deposits obtained from both the Inconel and the Hastelloy B loops were primarily nickel, approximately 97.5%, with small amounts of chromium, iron, and molybdenum.

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The amount of mass-transferred material in the Hastelloy B loop operated at a maximum fluid temperature of 1300°F was very slight, being only 0.4 g, and was quite close to the amount found in Inconel loops operated under similar conditions. Thus the marked increase in the rate of mass transfer with temperature increases, which was well established for Inconel-sodium systems, seems to occur in like manner but to a somewhat greater extent in Hastelloy B-sodium systems.

Metallurgy - Fabrication

Work is continuing on the evaluation of nickel-molybdenum alloys suitable for structural application in fused-salt reactors. The Ni-Mo-Cr-Fe (INOR-8) system appears, at present, to be the most promising. Billet material prepared for ORNL under a subcontract by Westinghouse was received for evaluation. This initial heat of the alloy is higher in carbon content, 0.14%, than the specified range of 0.04 to 0.08%, but its hot- and cold-working properties are nevertheless satisfactory. The material is being examined for its strength properties, as well as its thermal conductivity and thermal expansion characteristics.

Tubing of two nickel-molybdenum base alloys redrawn from tube blanks extruded on a laboratory scale at ORNL was received from Superior Tube Company. The compositions of these materials are 17% Mo-10% Cr-0.5% Al-0.5% Mn-0.06% C-bal Ni and 15% Mo-6% Cr-5% Fe-0.5% Al-0.5% Mn-0.06% C-bal Ni. A sufficient length of tubing of each alloy was received for the fabrication of forced-circulation loops for operation with the fuel mixture $NaF-KF-LiF-UF_4$ (11.2-41-45.3-2.5 mole %, fuel 107).

Studies were initiated to determine the compatibility of type 316 stainless steel and the INOR-8 alloy from the standpoint of interdiffusion. The properties of the diffusion zone are being studied by preparing selected compositions which are intermediate between the two alloys. The ultimate objective is the development of composite tubing and tube sheets.

The extrusion of molybdenum was studied on an experimental basis. A total of 15 billets of molybdenum and molybdenum-base alloys were extruded into rods at temperatures ranging from 2300 to 2500°F. In addition, two tube shells of pure molybdenum were extruded at 2450°F at reductions of 7:1 and 13:1. Reduction of the tube shells to tubing by Floturning, a hydrospinning process, and hot drawing will be attempted by the Universal Cyclops Steel Corporation. A furnace is being constructed for extruding tube shells of the Mo-0.5% Ti alloy at temperatures up to 3100°F.

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Metallurgy - Welding and Brazing

An examination was made of welds in the high-temperature end of Black, Sivalls & Bryson heat exchanger No. 1 (type IHE-8). In this heat exchanger the weld faces were exposed during operation to fuel at an inlet temperature of 1600°F for more than 500 hr. Intergranular corrosion was found in several cases, and the depth of penetration was rather severe, extending in two specimens to a maximum depth of 16 mils. The attack was not characteristic of the usual fluoride fuel mixture attack on wrought Inconel in that most of the voids occurred intergranularly rather than throughout the grain structure. It has been postulated that the corrosion is due to microsegregation of some constituents to the grain boundaries upon solidification. Such segregation, coupled with an unfavorable grain orientation, can lead to quite deep attack.

Metallurgy - Nondestructive Testing

The first model of the Impedograph, a variable-frequency impedance-analysis type of eddy-current instrument for the inspection of tubing, was successful in demonstrating the usefulness of the instrument, but it was too complex for routine testing. The instrument is being redesigned and simplified. A new concept of eddy-current inspection is being studied that involves a Multiplex principle, that is, the instrument scans through a wide range of frequencies and is always in the proper range for any given inspection job.

Metallurgy - Ceramics

Density and expansion data were obtained for ten zirconium hydride samples having hydrogen contents ranging from 1.10 to 1.17%. The linear expansion ranged from 3.0 to 3.2%; the volume expansion ranged from 11.4 to 11.8%; and the density ranged from 5.90 to 5.94 g/cm^3.

Eight bars of beryllium oxide hot pressed to 95% of theoretical density were fabricated and sent to Atomics International for mechanical properties tests. Three right cylinders 2 in. OD, 1/2 in. ID, and 2 in. long were also fabricated for testing, but they were damaged in machining. The dimensions of four of the bars were 5/16 x 7/16 x 6 in., and the other four were 1/8 x 3/16 x 6 in.

Chemistry - Fuel Research

The ternary compound reported previously to be near the composition corresponding to the formula $6RbF \cdot 4NaF \cdot 5BeF_2$ was recently found to be closer to the composition corresponding to $2NaF \cdot 4RbF \cdot 3BeF_2$ and is tentatively considered to have the latter formula. The compatibility triangle $2NaF \cdot 4RbF \cdot 3BeF_2$-$2RbF \cdot BeF_2$-NaF has a peritectic near 37 mole %

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NaF-30 mole % BeF_2 at 570°C. The alkemade line between the ternary compound and $2NaF \cdot BeF_2$ has a binary eutectic near 51 mole % NaF at 480°C and forms one side of a compatibility triangle with NaF. There is a ternary eutectic in this triangle which melts at about 477°C and lies very close to the binary eutectic at 480°C. The joins $2RbF \cdot BeF_2$-NaF and $3RbF \cdot BeF_2$-NaF are binary systems with eutectics at about 650 and 640°C, respectively, near the midpoints.

Recent results of thermal-gradient quenching experiments with the system NaF-ZrF_4 have shown that the phase formerly termed β_1 $2NaF \cdot ZrF_4$ is the high-temperature modification of $5NaF \cdot 2ZrF_4$, which melts incongruently to $3NaF \cdot ZrF_4$ solid solution and liquid at 640°C. The compound $5NaF \cdot 2ZrF_4$ undergoes a solid transition at 524°C.

A purified batch of LiF-MgF_2-YF_3 (25-21.1-53.9 wt %) prepared for the production of yttrium metal by reduction with lithium, showed a halt on the cooling curve at about 670°C. This indicates that the mixture has a higher solidus temperature than was previously reported (640°C) on the basis of observations in the visual-thermal apparatus with small samples of less pure material. Examination of a portion of this slowly-cooled purified material by x-ray diffraction and microscopic techniques showed that an unidentified phase made up the larger part of the mixture and that LiF and a trace of MgF_2 were also present.

Studies were made of the solubility of NiF_2 at 700°C in NaF-ZrF_4 (53-47 mole %) in which the structural metal fluorides (CrF_2, FeF_2, NiF_2) were present in the approximate ratio occurring in 18-8 stainless steels. A solubility of 0.5 wt % NiF_2 was found in a fluoride mixture containing the following weight percentages of structural metal fluorides: CrF_2, 3.8; FeF_2, 15; and NiF_2, 1.6. The solubility was markedly lower than the 1.3 wt % found for a comparable NiF_2 content but with no CrF_2 or FeF_2 added. The presence of CrF_2 and/or FeF_2 depresses the solubility of NiF_2 to such a large extent that complete solubility of NiF_2 can be accomplished only at very low concentrations of structural metal fluorides. Data obtained for a mixture containing 0.50 wt % CrF_2, 1.8 wt % FeF_2, and 0.20 wt % NiF_2 indicate that these amounts of all three fluorides are completely soluble at 700°C.

The solubility of helium in molten NaF-ZrF_4 (53-47 mole %) was determined at 600, 700, and 800°C in the pressure range from 0 to 2 atm. The solubility behavior of helium in this solvent is very similar to that exhibited in the related solvent NaF-ZrF_4-UF_4 (50-46-4 mole %) studied earlier. Henry's law is followed in both solvents, and the solubility increases with increasing temperature. The numerical value of Henry's law constants in the absence of UF_4 are 2.16, 2.92, and 4.20 x 10^{-7} moles of helium per cubic centimeter of solvent per atmosphere at 600, 700, and 800°C, respectively. The corresponding constants determined

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earlier for the UF_4-bearing solvent were 2.0, 2.7, and 4.1×10^{-7}; the difference may be less than the over-all uncertainty of the experiment.

Chemistry - Fuel and Coolant Production

Fourteen batches totaling approximately 3500 lb of fluorides were processed in the 250-lb capacity purification facility. One week of down time occurred on one of the two rigs because of a furnace failure.

About 150 lb of special fluoride compositions was made up during the month, and some 450 lb of $NaF-KF-LiF-UF_4$ (11.2-41-45.3-2.5 mole %) was prepared.

The filling, draining, and sampling of engineering test units continued at a normal rate.

Chemistry - Analytical Studies

Detection limits of less than 50 parts per billion of sodium in air were obtained after minor modifications were made to the instrument designed for the measurement of the absorbance of sodium resonance radiation by sodium atoms. It is the function of the instrument to detect increments in the concentration of alkali metals in air, and the thermodynamic constants of the reaction

$$Na_2O \rightleftharpoons 2Na + 1/2\ O_2$$

indicate that measurements must be made on samples at temperatures in excess of 900°C.

A sensitive method for the determination of microgram amounts of nickel in alkali metals with 4-isopropyl-1-2-cyclohexanedionedioxime was developed. The coefficient of variation of the method is about 5% for the range 0.1 to 1 ppm of nickel. The substituted dioxime and nickel form a complex that is readily extractable into xylene (partition coefficient, $\sim$5000). Interferences are iron, copper, and cobalt, which are successfully masked with fluoride, sulfide, and cyanide, respectively. The method is also applicable to the determination of nickel in fused fluoride salts.

A method was developed for the colorimetric determination of small amounts of zirconium in moderately strong sulfuric acid solutions. Existing methods for determining zirconium are not applicable in such systems. The reagent used is pyrocatechol violet, which forms a blue-colored complex with zirconium. The method is extremely sensitive, the molar absorbance index of the complex at 650 mμ being 32,600. Zirconium

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in the range 0.1 to 2 μg/ml can be determined in the presence of uranium, lanthanum, cerium, iron, nickel, chromium, and thorium with a coefficient of variation of approximately 5%.

Bulk Shielding Facility (BSF)

A decision was made not to use the present aluminum grid plate for the new UO_2-stainless steel core in the BSF reactor, and a stainless steel grid plate is now being designed. This will permit a square fuel element spacing of minimum size so that the entire reactor assembly can be enclosed in a shield which corresponds to a 25.125-in.-dia sphere. It will also permit the end boxes of the elements to be reduced to 2.896 x 2.896 x 2 in. The stainless steel (17-7 PH) selected for the new grid plate can be hardened to an R_c of 40, which will permit the thickness of the plate to be reduced to 0.85 in. with a 1-in.-thick flange around the perimeter.

It was decided that a major portion of the distortion in the spectra of gamma rays above 1 Mev that are observed with the 10-in.-dia NaI(Tl) spectrometer crystal is due to Compton back-scattering near the surface of the crystal. The Harshaw Chemical Company has agreed to drill a 3/4-in.-dia, 1 1/2-in.-deep well in the conical end of the crystal in an attempt to reduce the observed effects. When the crystal is returned by Harshaw it will again be thoroughly investigated with gamma rays of various energies.

Tower Shielding Facility (TSF)

The Pratt & Whitney J-57 jet engine irradiated at the TSF in January was returned for a second irradiation. The engine was operated continuously while being exposed for 50 hr to radiation from the TSF reactor operating at a power of 500 kw. Flux and dose-rate measurements were made prior to and during the exposure. The oil in the engine was not changed at any time during this exposure, and no deleterious radiation effects on the performance of the engine were observed during the test. (During the previous exposure, the oil was changed at 8-hr intervals.)

Tower Shielding Reactor II (TSR-II)

Mockups of the TSR-II boron-loaded and stainless steel control plates were operated in a 6-in.-square water-filled hole in the center of the BSF reactor. The reactor loading used contained about 2.2% excess reactivity with dummy elements in the hole and about 1.1% with water in the hole. The mockups consisted of eight or four 77-mil-thick solid stainless steel plates, eight or four 78-mil-thick perforated stainless steel plates, or aluminum plates loaded with 50 g of boron each. The effectiveness of the stainless steel plates as a function of distance

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from the fuel was determined. There was insufficient excess reactivity for criticality when more than two of the boron-loaded plates were used, and even with the two it was necessary to position them as close to the center of the test well as possible.

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