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# OAK RIDGE NATIONAL LABORATORY

## STATUS AND PROGRESS REPORT

October, 1952

AEC RESEARCH AND DEVELOPMENT REPORT

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# OAK RIDGE NATIONAL LABORATORY

# STATUS AND PROGRESS REPORT

October, 1952

J. P. Lane

Date Issued: NOV 7 1952

OAK RIDGE NATIONAL LABORATORY
Operated by
CARBIDE AND CARBON CHEMICALS COMPANY
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Post Office Box P
Oak Ridge, Tennessee

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

October, 1952

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

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PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Purex Process (AEC Activity 2803.2)

The operation of the Purex pilot plant will be increased in scope to provide data on processing shorter cooled (60-65 days out of pile) material; previous runs concerned 90 days cooled material. The major new problem to be evaluated is fission product iodine build-up in the solvent. Other problems are concerned with ruthenium contamination in the acid recovery system, crud formation in the solvent recovery system, and changes in the performance of certain columns. The additional data will be useful primarily in the design of the proposed Purex plant at Hanford.

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PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment (AEC Activity 4103.10)

Operation of the HRE was resumed early in October and critical experiments designed to measure the fuel temperature coefficient between 200°C and 230°C and the value of the reflector in excess reactivity at 225°C were carried out. After the completion of the experiments, the power of the reactor was increased to approximately 10 to 25 KW for a short time. At this power level sufficient activity was produced to indicate a very small leak -- undetectable in the pressure and hydrostatic tests -- that allowed fission gases to leak from the low pressure gas system into the cooling water of the fuel off-gas condenser.

The reactor was shutdown until the leak was repaired, and during the down period a filter was installed in the ventilation system between the reactor and the stack. Operation of the HRE will be resumed early in November.

ISHR Design (AEC Activity 4109.1)

Preliminary layouts for a two-core homogeneous reactor system arrangement have been completed and the details of the system are being evaluated. At present the two-core system appears more feasible and attractive than single region homogeneous reactors and, therefore, emphasis is now being placed on the design studies relating to this type of system.

Dynamic Corrosion Studies (AEC Activity 4109.4)

In view of the encouraging corrosion results obtained in 100-gpm circulating loops using 5 g U/l solutions in 347 stainless steel at 250°C, plans are being made to increase the number of loops devoted to this system. The effects of fission products and homogeneous recombination catalysts will be studied in loops that are changed over to the 5 g U/l solutions.

Boiling Reactor Experiment (AEC Activity 4112.1)

The effort devoted to studying corrosion and solution stability in boiling reactor systems is being increased so that the non-nuclear aspects of the feasibility of boiling reactors can be determined before an experimental boiling reactor is constructed. For the same reason the development and testing of components for the systems to be used in the small-scale, "teapot," boiling reactor experiments will receive more attention.

Theoretical and laboratory studies on nuclear stability and power removal will continue. Conceptual design studies of large scale boiling reactors for specific applications will be continued as a means of discovering and evaluating the importance and magnitude of various problems associated with such reactors.

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## AIRCRAFT NUCLEAR PROPULSION PROJECT

### Aircraft Reactor Experiment (AEC Activity 4401.1)

The ARE fabrication and assembly are progressing according to schedule. Particular attention has been given to the design and fabrication of components of the liquid fuel system such as pumps, tanks, and instrumentation. The pressure shell has been received from the vendor and final machining by the Y-12 shops is in progress. Also, the cutting of the BeO moderator blocks is well under way. The control rod cooling blowers have been installed in building 7503 and considerable utility piping and electrical wiring have been completed.

### ANP Experimental Engineering (AEC Activity 4401.1)

Several materials have been tested for their use in packed seals by heating them to 1500°F under compression. Those that showed the most promise of being high temperature dry lubricants are graphite, $Ni_2O_3$, $Ni_2O_3$ + Mo, $Ni_2O_3$ + C, $MoS_2$, $MoS_2$ + Mo, $MoS_2$ + BN, and BN + C.

The gas seal centrifugal pump has operated a total of 1275 hours with (Na-Zr-U)Fx, with maximum temperatures of 1500°F. The rotary graphitar-tool steel gas seal has functioned satisfactorily with only slight gas or fuel leakage. No maintenance was required.

### ANP Critical Experiments (AEC Activity 4401.2)

The low power room-temperature study of the mock-up of the Aircraft Reactor Experiment has been completed. The assembly of a packed powder mixture of $ZrO_2$, NaF, C, and $UF_4$ contained in stainless steel tubes and surrounded by BeO reflector and moderator first became critical with a loading of 5.8 kg U-235. With this loading there was insufficient excess reactivity available for the evaluation of some of the reactor safety components and it was necessary to increase the reactivity by increasing the uranium density in the fuel. After this loading change the critical mass was 5.2 kg U-235, a somewhat lower value due to the redistribution of the fuel in the BeO and the smaller number of stainless steel tubes required. The safety and control rods, containing $B_4C$, which are to be used in the ARE reactor have been evaluated. The reactivity change incurred by motion of each of the control rods agreed with that expected from calculations; the value of the safety rod was somewhat less than that predicted. An extensive series of measurements of neutron flux and fission rate distributions have been completed.

A mock-up array of beryllium, sodium, and enriched uranium has been made of a second ORNL aircraft propulsion reactor, the "Fireball." In this design the fuel is distributed in a shell around a core of beryllium and has an external beryllium reflector.

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ANP Metallurgy (AEC Activity 4401.5)

Seesaw corrosion tests lasting 100 hours have been conducted on Inconel and 300 series stainless steels containing various Na-Pb mixtures. The Inconel was severely attacked, particularly when the amount of sodium was small. Preliminary tests indicate that the attack on stainless steel was small.

In an attempt to study the mass transfer characteristics of metals in high purity lead, a thermal convection loop was fabricated from quartz. Samples of Inconel were placed in the hotter portion of the loop (800°C) and the cooler portion (400°C). The loop plugged after 125 hours when crystals formed in the coldest portion of the loop; the plug was not in contact with Inconel metal.

Tests indicate that the tensile strength of Inconel is not significantly reduced by the high temperature heat treatment (2300°F) involved in brazing Inconel with Ni-Pd.

Corrosion tests were conducted on various brazing alloys. For Inconel-liquid sodium systems, Nicrobraz, Cr-Si-Mn-Ni, Cr-Si-Ni, and Mn-Ni were satisfactory with Nicrobraz being the most promising alloy. For Inconel-liquid lithium systems Cr-Si-Mn-Ni is the best. Other systems and alloys are being investigated.

Heat Transfer and Physical Properties Research (AEC Activity 4401.5)

The thermal conductivity of the proposed fuel carrier 57% NaF: 43% $BeF_2$ (mol basis) has been measured between 1100°F and 1500°F; it averages 2.4 Btu per hr/ft/°F. A preliminary value of the density of this fluoride composition at 1250°F is 2.24 g/cc.

Shielding Research (AEC Activity 4401.7)

An Architect-Engineer has been engaged for the design of the tower for the Tower Shielding Facility. Several preliminary schemes have already been discussed, and it is expected that one of these will be chosen shortly. Complete design is expected by the end of January, with construction due to be completion in November 1953.

The air scattering experiments in the Bulk Shielding Facility have been repeated in part and show that the preliminary measurements reported last Summer were somewhat pessimistic. The divided shield design of the Shielding Board is not yet vindicated, however, although indications are that it may be. The Lid Tank has been engaged in measurements basic to shielding, with particular emphasis on determinations of effective removal cross sections for several interesting elements. In addition, work has continued leading to the design of the submarine and the X-6 airplane.

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## PROGRAM 5000 - PHYSICAL RESEARCH

### REACTOR OPERATIONS

The total accumulated KWH for X-10 pile operations during October were 2,700,401 averaging 3,954 KW per operating hour. Pile down time was 8.2% as compared with 9.7% in September. There were two slug ruptures which were discharged without difficulty.

The total accumulated KWH for LITR operations during October were 1,024,205 averaging 1,488 KW per operating hour. Down time was 7.5% as compared with 10.3% in September.

### ISOTOPE PRODUCTION

Radioisotope Production (AEC Activity 5111)

There were 880 radioisotope shipments during October.

Stable Isotope Production (AEC Activity 5121)

Titanium, sulphur, and lithium were processed during the month of October, yielding eleven isotopes. Overall production innage for the four calutrons was 2,130 hours. Outage time was 17.8% as compared with 27.6% during September. The integrated output was 982,037 ma hours for the Alpha channels and 28,367 ma hours for the Beta channels.

Chemical processing refinement was conducted on isotopes of barium, lithium, germanium, and calcium. Chemical services were supplied to the calutrons for the separation of isotopes of lithium, titanium, and sulphur.

Research and production on the separation of rare eaths by liquid-liquid extraction continued. Division between samarium and europium was made successfully.

There were 16 stable isotope shipments during October.

High Voltage Program (AEC Activity 5211)

The angular distributions in the elastic scattering of neutrons from nitrogen have been determined for the resonances at 1.35, 1.40, 1.60, 1.80, and 2.25 Mev. The 1.35 and the 1.80 Mev resonances show a high probability of forward and backward scattering of neutrons, while the other resonances show a high probability of forward scattering.

The 2 Mev Van de Graaff has been installed in the High Voltage Building and put into operation. The analyzing magnet is being calibrated. The 5 Mev Van de Graaff is being moved from Y-12 to the High Voltage Building.

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86 Inch Cyclotron Nuclear Physics (AEC Activity 5211)

Initial measurements of elastic scattering have been made for protons on Be, Al, Ni, and Ta. The angular distributions showed considerable structure, including three maxima and minima. Deuteron detection was further investigated to eliminate the effects of oxygen impurities in the lead detectors. The angular distribution of deuterons from $Be^9(p,d)Be^8$ (ground state) was measured. The measurement of the angular distribution of tritons from $Be^9(p,t)Be^7$ was completed. Methods of determining proton current on angular distribution targets were developed so that absolute measurements can be made. The scintillation spectrometer was developed to the point where satisfactory Kurie plots can be obtained from beta-emitters.

The 86-Inch Cyclotron (AEC Activity 5261)

A scattering probe for use in measuring excitation functions has been installed through vacuum lock to a point 180° from the target position and 31 inches above the magnetic center of the cyclotron. A target of metallic lithium, for the production of $Be^7$ by the (p,n) reaction, has been tested sucessfully at 13.2 KW (600 μa at 22 Mev). Tracks and turntable for the target dolly and vacuum lock control valves have been installed to facilitate remote-control operation.

The 63-Inch Cyclotron Operation and Physics (AEC Activity 5261)

Fluorine, sulphur, and enriched boron 10 have been bombarded with the internal nitrogen beam, and activities in these targets have been studied. Of particular interest is the possibility of reactions in sulphur, since the coulomb barrier is approximately 3.5 Mev above the energy available in the center-of-mass system.

Neutron Velocity Selector (AEC Activity 5261)

A more detail examination of data reveals a resonance at 5.3 electron volts rather than at 4.4 volts as previously reported.

Stable Isotope Neutron Cross Sections (AEC Activity 5261)

The thermal neutron capture cross section of actinium 227 has been measured as 500 ± 35 barns. A similar measurement on scandium was 23 barns (± 5%).

Mass Spectrometer Laboratory (AEC Activity 5261)

Cracking pattern studies and isotopic analyses were made on samples of uranyl sulphate. The original water solutions were reduced to dryness and ignited to $U_3O_8$ before being placed in the mass spectrometer. Upon heating in the ion source oven, the $U_3O_8$ disproportionated to $UO_3$ and $UO_2$. Adequate thermally produced positive ions of uranium were found for isotopic studies.

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Two samples of enriched samarium 144 were investigated for isotopic distribution. The first sample was starting material and the second sample had been irradiated in the Chalk River reactor for a year. Small amounts of masses 145 and 151 were found but all of the mass 149 had been converted to mass 150.

The high temperature behavior of $Cr_2O_3$ has been investigated. The material disproportionates to CrO and $CrO_2$. Large currents of thermally produced chromium ions were noted.

CHEMISTRY

Hot Laboratory Research (AEC Activity 5361)

A curie xenon source was collected from the off-gas system of the HRE. This material will be useful for preliminary equipment set-ups prior to the measurement of the scattering cross section of a large (1000-2000 curie) amount of fission product xenon in the neutron velocity selector.

Thorex (AEC Activity 5361)

The modification of the Hot Pilot Plant Building #3019 for Thorex operation has been delayed by an extension of the Purex pilot plant operation. Testing and evaluating of pulse columns and design studies of proactinium adsorption on silica gel are in progress. Chemical studies reveal that trace quantities of phsophate ion are required to obtain satisfactory proactinium decontamination.

Chemical Engineering Research (AEC Activity 5361)

The continuous dissolution of aluminum-uranium alloy slugs has continued. Preliminary results indicate that a dissolver of 5 inches i.d. and 12 feet high has sufficient capacity for this service in the Idaho Chemical Processing plant.

Volatility Studies (AEC Activity 5361)

Work is to be initiated at ORNL to continue the development study of the chlorine trifluoride process carried through a 2.5 kg pilot plant at K-25. The main objectives of this study will be to determine the economic feasibility of the process and to develop a continuous fluorination method.

Chemistry of Uranium Raw Materials (AEC Activity 5361)

Seventy-five percent of the uranium has been extracted from lignite ash with acid consumptions of only 200 pounds of $H_2SO_4$ per ton of ash. Acid leaching of the raw sample has given 75% extractions, but the consumption of acid is over 400 pounds per ton of ash. Separations of uranium and the organic material in lignite from the ash by flotation technique have been partly successful.

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The sodium salt of di(2-ethylhexyl) phosphinic acid, soluble in ethyl ether, has been used to extract successfully the uranium from a dilute sulfuric acid liquor. Sodium carbonate can be used as a stripping agent for the solvent without a large reagent loss. Di(2-ethylhexyl) phosphoric acid will also form an ether soluble sodium salt.

A benzene solution of methyldidecylamine is a good extractant for uranium from sulfate solutions. Reagent loss to the aqueous phase is not large.

The solid $UO_2(H_2PO_4)_2.4H_2O$ previously reported has been found to be $UO_2(H_2PO_4)_2.3H_2O$. Preliminary investigation of the crystal structure of this compound has shown the crystals to be monoclinic,

$$a = 10.83A, \quad b = 13.92A, \quad c = 7.48A \quad \text{and } \beta = 105^\circ 45'$$

METALLURGY

Physical Metallurgy of Reactor Materials (AEC Activity 5411)

Preliminary X-ray diffraction measurements of the lattice parameters of thorium at 1000°C and 1500°C have indicated a possible allotropic formation with no change in crystal structure. The lattice parameters are 5.18 angstrom at 1000°C and 5.28 angstrom at 1500°C. The magnitude of this change is too large to be explained by impurity solution effect. Thermal expansion measurements on thorium have, however, shown no discontinuity where a discontinuity was noted in the case of electrical resistivity. More exact lattice parameter and thermal expansion measurements are continuing.

Fundamental Physico-Metallurgical Research (AEC Activity 5411)

The studies of the binary phase diagrams of the Group IVa elements titanium, zirconium, and hafnium have commenced with the systems Ag-Zr and In-Zr which are part of a series, in which the $\beta$-sub group elements Ag, Cd, In, Sn, and Sb are alloyed with the Group IVa element zirconium in the same horizontal row of the Periodic Table. The interesting phenomenon has been found in that silver additions to zirconium depress the $\alpha/\beta$ phase boundaries, thereby increasing the extent of the b.c. cubic phase region at the expense of the c.p. hexagonal phase region, whereas when indium is added, the opposite effect is observed, i.e., a raising the $\alpha/\beta$ boundaries and an increasing the c.p. hexagonal phase region at the expense of the b.c. cubic phase region. In this regard, it appears that Group III b solutes, in general, may stabilize the alpha phase of zirconium and titanium. For example, in addition to In-Zr, the systems Al-Zr and Al-Ti have been reported in the literature to be of this type. Further, a trend may be seen in passing from In-Zr to Sn-Zr, since the latter system also shows elevation of the zirconium $\alpha/\beta$ boundaries with additions of tin. The $\alpha/\beta$ boundaries of such systems are of practical importance since the alpha stabilized alloys do not involve allotropic transitions in fabrication, whereas the beta stabilized alloys on the other hand offer opportunities for hardening effects during heat treatment because of the eutectoid reactions.

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## PROGRAM 6000 - BIOLOGY AND MEDICINE

### BIOLOGY

Cytogenetics (AEC Activity 6400)

It has been possible to determine the concentrations of nucleic acids in individual grasshopper neuroblast. It appears that at energy values at which the rate of mitosis is definitely effected, the concentration of nucleic acids is reduced significantly. This reduction is more pronounced on ribonculeic acid than desoxyribonucleic acid.

Radiation Protection (AEC Activity 6400)

Further studies on factors responsible for low temperature recovery have brought out that the material which activates protection is an acid very resistant to heat and effective in a concentration as little as .01 ug/ml. Attempts are being made to purify this material further.

### BIOPHYSICS

Permissible Internal Dosage for Radioisotopes (AEC Activity 6510)

More than 200 tissues have been analyzed semi-quantitatively for B, Co, Au, Mn, Mo, Pb, Cr, Sn, Si, Ni, Bi, Ba, Al, Be, V, Ti, Cu, Cd, Ag, Zn, and Cb. Some 55 bone and cartilage samples were also analyzed for Fe. Neutron activation analyses will be performed for elements not readily adaptable to spectographic techniques.

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## PROGRAM 9000 - RESEARCH FACILITIES

Gas Decontamination Facilities for Buildings #4500 and #4501

The concrete off-gas duct has been connected with the Radioisotope Processing Area stack. The stainless steel process vessel off-gas line has not yet been connected to the filters nor has the stand-by steam turbine driven blowers been put into operation; however the entire job is nearing completion.

Air Supplies and Hood Installation for Buildings #9733-1 and #9733-2

The installations in these two buildings have been completed. This work extended over several months because as little interference as possible with research in these buildings was desired.

Iodine-131 Plant, Building #3028

ORNL Forces have prepared the site prior to the contractors initiating construction of cells.

Silver Recovery, Buildings #9201-3 and #9204-1

Y-12 Forces have begun the recovery of silver from the coils stripped out of these two buildings.

[redacted]

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## RADIOISOTOPE SALES

| Sales | August | September |
|---|---|---|
| Transfers within AEC | $ 120.10 | $ 2,532.25 |
| Cash Sales | 4,767.85 | 10,241.25 |
| Foreign | 1,105.90 | 1,322.70 |
| Cancer Program (Free) | 19,863.12 | 16,849.56 |
| Technical Cooperation Plant | -0- | -0- |
| Total Sales and Transfers FY 1953 to Date | 151,058.32 | 227,385.17 |
| Total Cancer Program (Free) to Date | 1,453,346.28 | 1,470,195.84 |
| Technical Cooperation Plant (Shipment to Date) | 15,152.55 | 15,152.55 |

## GROSS OPERATING COSTS
(Including X-10 & Y-12)

| | | | |
|---|---|---|---|
| (a) | Actual Cost for September, 1952 | 2,272,175 | |
| | Actual Plant and Equipment Cost | 307,522 | |
| | Construction Program "H" | 24,173 | |
| | Total Operating and Construction Cost for September, 1952 | | 2,603,870 |
| (b) | Estimated Operating Cost for October, 1952 | | 3,000,000 |
| (c) | Actual Accumulative FY 1953 Operating Cost through September, 1952 | 7,023,162 | |
| | Actual Accumulative FY 1953 Plant and Equipment Cost through September, 1952 | 1,034,855 | |
| | Actual Accumulative FY 1953 Construction Program "H" Cost through September, 1952 | 68,396 | |
| | Total Accumulative FY 1953 Operating, Construction, and Plant and Equipment Cost through September, 1952 | | 8,126,413 |
| (d) | Estimated Operating Cost FY 1953 through October, 1952. | | 11,126,413 |

[redacted]

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PERSONNEL SUMMARY

| | Number of Employees October, 1952 | New Hires October | Terminations October |
|---|---|---|---|
| Administration | 76 | 0 | 2 |
| Operations* | 118 | 0 | 1 |
| Engineering, Shops and Mechanical | 912 | 4 | 7 |
| Laboratory and Research | 1485 | 12 | 10 |
| Protection | 180 | 0 | 1 |
| Service | 394 | 2 | 3 |
| Total | 3165 | 18 | 24 |

* Includes Electrical Distribution and Steam Plant as well as the Operations Division.

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