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PHYSICS DIVISION

VISIT TO NRC LABORATORY AT CHALK RIVER

SIDNEY SIEGEL

AEC RESEARCH AND DEVELOPMENT REPORT

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Radiation Effects on
Structural Materials

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VISIT TO NRC LABORATORY AT CHALK RIVER

Sidney Siegel

October 26, 1948

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Radiation Effects on Structural Materials

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October 26, 1948.

Colonel Curtiss Nelson, USAEC, Chalk River, Ontario, Canada,
C/o Frederick T. Hobbs, Technical Cooperation Branch,
Division of Research, USAEC,
Washington, D. C.

IN RE: VISIT TO NRC LABORATORY AT CHALK RIVER

1. On September 23 and 24, 1948, I visited the Chalk River Laboratory and conferred with numerous members of the staff, in the engineering and research groups, on problems concerned with the effects of radiation on solids. The changes observed in uranium metal, Al-U alloys, pure and uranium-impregnated graphite and BeO, numerous alloys not containing fissionable materials, and stress-relaxation were discussed in more or less detail. It was thought that a brief bibliography of reports dealing with these topics would be of value to the Canadian project, and this is appended.

2. The Chalk River reactor is now operating, in a thoroughly satisfactory manner, at 14 MW and is expected to operate soon at 20 MW. At this power level difficulties with warping or blistering of the U rods might be expected. A number of rods have been examined after operation to 300 MWD/ton, and have shown no changes serious from the standpoint of reactor operations. The rods, 10 feet long, have been found to contract about 1", with no observed dilation in diameter. No warping or blistering is evident. The metallurgical history of these rods is not completely known, but they are believed to have been rolled in the α phase. The change of shape observed is consistent with that observed at Hanford on similar material. Dr. Lewis believes that the absence of warping is related to the fact that the Canadian rods are long and are vertically suspended, as contrasted to the short horizontal slugs we use.

I urged that the discharged rods be carefully inspected for dimensional instability, and that small monitor samples of the same material be exposed in the highest flux regions of the reactor. Such samples could be measured in greater detail and with greater accuracy than an entire rod before and after exposure, and could give forewarning of impending changes with longer exposure. Furthermore, their behavior might serve as a check on the hypothesis that the shape and disposition of the long rods have an important bearing on their susceptibility to deformation.

The observations by L. Kelman at Argonne on the effects of thermal cycling alone on the dimensions of uranium were described. An experiment is about to begin at Chalk River in which the thermal conditions within a rod in the reactor are

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simulated by electrical heating of a water-cooled sheathed rod about 1 foot long. This experiment is very similar to one being conducted at ORNL by Messrs. W. S. Pellini and E. Boyle. It is highly desirable that information obtained by these two groups be interchanged at frequent intervals.

3. Some discussion of the effects of irradiation on chemical compounds took place. At Chalk River it has been observed that cans containing K- or Ca- nitrate expanded on irradiation in the reactor for 6×10^6 kwh. The material is partially dissociated after exposure, about 12% nitrate being formed. Presumably the swelling of the cans is due to the release of oxygen gas during bombardment. Similar effects have been noted at ORNL by A. F. Rupp, who reports that the gas evolution and volume increase can be avoided if the original nitrate is anhydrous. The dissociation still occurs, but the gas appears to remain trapped in the lattice, with little volume change, until it is released upon solution.

The effects of pile exposure on LiF observed at Chalk River were briefly mentioned. The lines in the X-ray diffraction pattern are broadened. It has been observed that the diffusion of tritium from the bombarded LiF has an anomalous behavior at 400° to 600°C.

The Chalk River experience with D_2O is markedly different from that at Argonne. As originally received the heavy water had a conductivity of 10^{-5}, was redistilled to a higher purity, with a conductivity now of 3×10^{-6}. The rate of gas evolution while in the pile is about 100 times slower than at Argonne, about 10 c /day. Redistillation reduced the gas evolution by a factor of 20 from its original value. No chemical adjustment of pH is required.

4. The Chalk River reactor now operates regularly at 14 MW, may shortly go to 20 MW. At this power it has the highest flux, 5×10^{13}, available in any experimental reactor and offers attractive possibilities for experiments on the effects of radiation on solids. There are several positions in the active lattice where such work could be done. One of these is the central thimble, about 5" in diameter; several other holes 2" diameter, formerly occupied by shut-off rods, near the center of the reactor, are also available. Dr. W. Watson kindly agreed to calculate the fast neutron spectrum in these holes, which are one lattice space removed from the nearest uranium rods. In addition, three of the 4" side holes, which extend to the surface of the callandria, shortly one to be equipped with water-cooled natural uranium cylinders 9" long, $2\frac{1}{2}$" i.d., 1 cm wall thickness. These will make available regions of enhanced fast neutron flux, exceptionally well suited for work on solids.

With these exceptional facilities available for irradiation, it seems highly desirable that a cooperative program on the effects of radiation on matter, mutually agreeable to the interested U. S. and Canadian people, be initiated. A small beginning has already been made on this; samples of the alloy Cu_3Au, in which it is known that disorder is produced by neutron bombardment, were left with Mr. F. Rainbridge for exposure at Chalk River and subsequent study at ORNL. Further experiments of this type, in which changes produced in the reactor will afterwards be studied in the ORNL hot physics laboratory, are being planned. These will include examples of materials in which phase-changes, precipitation from solid-solution, recovery from or production of strain-hardening, etc., can be studied.

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In addition, the Chalk River facilities are well suited to experiments in which changes in properties of materials are measured while under exposure in the reactor. Some work of this type has already been done, at a much lower flux of 10^{12}, at ORNL. Measurements of electrical resistivity, Hall effect, magnetic properties of soft magnetic materials, elastic modulus and internal damping of mechanical oscillations, thermal conductivity, and creep, can all be carried out by suitable electrical means while the samples are situated in a reactor. Experiments of this type will be particularly useful in giving fundamental information on the nature of the dislocation process, i.e., on the number of atoms displaced in a given flux, and on the type of dislocation produced; the last two properties mentioned would give important practical information on the behavior of specific reactor materials. Experiments of all the above types have already been tried on are about to be in the ORNL reactor, so that their feasibility is fairly well evaluated.

I would propose that the group in the U. S. familiarize itself thoroughly with the conditions and space limitations of the Chalk River reactor. After this we would design, have built, and prove out apparatus here, then ship it to Chalk River for insertion in the reactor at a suitable time. The initiator of a particular experiment would spend a period of several weeks at the beginning of the experiment, supervising its installation and observing its initial operation. In addition, we would like to have permanently resident at Chalk River a U. S. scientist who could carry on the subsequent accumulation of data, insertion of other samples, etc. It would be hoped that ultimately the resident scientist, with the cooperation of the groups in the U. S. and in Canada, could keep several such experiments going in the reactor.

A joint program such as that suggested above would make available to us a unique facility and possibly would be of interest to the Canadians in augmenting their research organization with men experienced in this particular field. I would urge that the necessary steps be taken to set up such a joint effort.

Sidney Siegel

Sidney Siegel

SS:H

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