

PRELIMINARY REPORT ON THE MELTING OF URANIUM POWDER

by

L. Szilard

August 16, 1941

Summary: Methods have been found for protecting uranium metal powder from surface oxidation, and this resulted in the production of ingots which have a density of 18 gm./cc. and melt at about 1300 degrees C.

Uranium metal has been produced in powdered form for a number of years by Metal Hydrides Inc. using a calcium hydride reduction process which had been developed by Dr. P. P. Alexander.

Dr. Alexander and others have, in the past, attempted repeatedly to fuse such uranium powder into a solid ingot. These attempts were partially successful inasmuch as occasionally a considerable fraction of the powder was molten but the results were not reproducible and a smaller or larger fraction of the powder remained unmolten. Dr. Alexander's own experiments appeared however particularly promising inasmuch as they seemed to indicate that the true melting point of uranium might be below 1300 degrees C.

It was generally thought that surface oxidation of the powder might be the sole cause preventing fusion. Such surface oxidation appeared, however, almost unavoidable since the uranium metal powder has to be leached from a uranium calcium oxide mixture by a faintly acid solution.

Surface oxidation was also thought to be responsible for pyroforic phenomena exhibited by certain batches of uranium powder which were produced for us by Metal Hydrides.

Some batches were pyroforic from the start; other batches which were not pyroforic when received became pyroforic after a few weeks of storage. One shipment consigned to the Columbia University went up in flames in transit. Another shipment of uranium metal powder which consisted of a number of sealed cans containing the powder did not appear to be pyroforic. The first cans which we opened appeared to be all right. A few weeks later, however, when we began to open the rest of the cans, we found that the content of the can burst into flames merely upon removing the lid of the can. In the circumstances it did not seem possible to work with this metal powder and believing that surface oxidation was the cause of these phenomena it appeared imperative to devise some methods by which surface oxidation could be controlled.

Upon making inquiries I learned that it is customary to protect tungsten powder from surface oxidation by coating it with 2% of paraffine. This is done by wetting the tungsten powder with carbon tetrachloride in which some paraffine had been dissolved by allowing the carbon tetrachloride to evaporate. It seemed well worth trying to apply this method to our uranium powder. Since the presence of hydrogen would interfere with our experiments I proposed to Dr. Alexander to have uranium powder coated with paraffine in the above-described manner, and to free it from hydrogen by pressing it into a dye and heating it up in a vacuum furnace in order to evaporate the paraffine and sinter the powder.

A conference was arranged with Dr. Alexander and Mr. Davis for July 28, in order to discuss this and other methods for

preventing surface oxidation. At this conference we reviewed all details involved in the production of uranium metal powder and I thus learned that after leeching, the uranium powder was placed into flat trays and allowed to dry in air for a few days before being packed and shipped. This way of drying appeared to me a possible source of trouble and I therefore proposed to Dr. Alexander and Mr. Davis that we dry the uranium after leeching either by washing with alcohol and ether, or alternatively, by placing the uranium powder immediately after leeching into a vacuum tank where the water could be evaporated quickly at room temperature.

A few days later Dr. Alexander and Mr. Davis reported to me the following: They had leached a sample of uranium metal powder and dried it in the above-described manner with alcohol and ether and coated in the above-described manner with paraffine. They pressed this powder in a dye at about 10 tons per sq. in. and placed a sample in an unglazed silimanite boat and finally heated it up in a vacuum furnace evaporating the paraffine at about 1300 degrees C. After allowing the furnace to cool and removing the sample they found a fused uranium ingot having a density of over 18. They further reported that the fused uranium did not appear to attack the silimanite boat at this temperature.

The determination of the hydrogen content of such ingots, which were carried out at our request by Dr. J. C. Rodden, and Dr. Holton at the National Bureau of Standards, showed that these ingots were free from hydrogen. It appears thus to be established that the melting point of pure uranium is at about 1300 degrees C.

In close collaboration with Dr. Alexander a number of other ingots were prepared at Metal Hydrides under varying conditions. The purpose of these experiments is to find a method to prevent surface oxidation which is easily applied on an industrial scale. The first ingots which were successfully obtained were made from uranium powder which was leached in a beaker and the leeching solution had a higher acidity than could be used in the leeching tanks which have to be used in a large scale production process. These experiments are not concluded but the indication is that it will be possible to use the routine procedure of leeching and that it might be unnecessary to wash with alcohol and ether provided the freshly leached uranium powder is at once dried at room temperature in a vacuum tank and upon being removed from the vacuum tank is at once paraffine-coated or otherwise protected from being attacked by oxygen or moisture.

In the circumstances there seems to be a good chance that we shall be able to have fusible uranium powder produced on an industrial scale possibly without any considerable increase in cost. It also appears probable that we shall be able to produce on an industrial scale fused uranium bodies of the size and shape which we require without having to resort to a casting operation. It is hoped that one crucible can be used a number of times for fusing uranium powder into the desired shape either half spheres or cylindrical blocks. Experiments are under way to determine whether it is permissible to fuse in hydrogen. Fusion in helium is certainly permissible.

The use of an induction type furnace does not appear to be necessary and we are at present engaged in designing furnaces which appear to be more practical and which could take care of producing ingots at the rate of 700 pounds per week.

The progress made is essentially due to Dr. P. P. Alexander's unusual willingness to disclose all details of his manufacturing process. The present development has to be attributed to the close collaboration which was made possible by the confidence which Dr. Alexander showed us by giving us access to his factory and to all relevant information.

This work was greatly accelerated by the help extended to us by the National Bureau of Standards and by the speedy and accurate execution of the investigations made there under the direction of Dr. C. J. Rodden.

Professor D. P. Mitchell's kind cooperation greatly facilitated our task of starting the production of the uranium metal powder at Metal Hydrides on an intermediate scale.

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