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**FIRE PROTECTION PRECAUTIONS FOR HANDLING URANIUM
TURNINGS, CHIPS, BORINGS, SAWDUST, AND POWDER**

by

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ABSTRACT

Discusses the fire properties of uranium scrap with emphasis on its pyrophoricity. Suggests safe procedure for storage, laboratory handling, disposal and shipment. Reviews existing Interstate Commerce Commission rules for shipment on common carrier. Describes the effect of various extinguishing agents on burning uranium scrap.

FIRE PROPERTIES

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Uranium metal is pyrophoric which means that in finely divided form it may ignite spontaneously on contact with air. While this reaction may occur regardless of whether the uranium powder is dry or moist, it occurs more readily in the latter state at slightly elevated temperatures. The dried uranium powder can also be ignited by rough handling. Uranium turnings and chips are easily ignited by an outside source of ignition.

The term "uranium scrap" is used in this paper to include uranium turnings, chips, borings, sawdust and powder. Such miscellaneous scrap may include material of all sizes from dust to turnings, in addition to oil, water, and foreign matter such as floor scrapings, organic waste, etc.

STORAGE

The amount of uranium scrap in storage should be kept at a minimum. Protection is increased through isolation and separation of the material on hand into small batches. Fire resistive storage facilities are recommended.

The temperature of a mass of burning uranium approaches 2300° F; accordingly it is necessary to isolate uranium storage from other combustible materials.(1)

Scrap may be stored under a mineral oil or under water. However, in the case of the water, provision must be made for the safe ventilation of the resultant hydrogen gas since the scrap slowly oxidizes in contact with water, releasing free hydrogen. Consequently, storage under a mineral oil is generally preferable to storage under water.(1)

The storage of scrap only partially submerged in oil or water is dangerous. Ignition is very apt to occur at the liquid line. The reaction is particularly severe in the case of water since the water boils off through

the mass of burning metal with the liberation of large quantities of hydrogen. (Remember that hydrogen has an unusually wide explosive range, 4% to 75%). In one such fire, involving an insufficiency of water, holes were burned through a metal drum by the fire and hydrogen flames several feet long shot out in addition to flames ten feet high from the top of the drum. If the liquid is oil, it too will probably ignite and add to the fire. By all means, avoid leaving exposed to air, scrap just moist with oil or water.(1)

When not stored properly, as for example when only partially covered with oil or water, incipient spontaneous ignition can usually be detected by the heating of the container; there is usually a marked increase in temperature which can be detected by the hand for some time prior to ignition.(1)

Automatic sprinkler systems provide satisfactory protection for uranium turnings, chips and borings and for the small quantities of sawdust or powder generally encountered in a machine shop or laboratory; while hydrogen is evolved from the water, it burns off readily under control and the sprinklers prevent the extension of the fire. In the unusual cases where extremely large quantities of uranium dust or powder may be involved, an inerting system utilizing a gas which is non-reactive with uranium, such as argon, may be in order.

(The subject of fire extinguishers is discussed in the final section on "Fire Control").

LABORATORY HANDLING

In handling uranium scrap, every possible source of heat or spark should be eliminated. It is advisable to handle the material wet or under an argon atmosphere. Specially constructed explosion safe argon dry boxes have been

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found very satisfactory where extremely pyrophoric forms are involved. Actually, extremely pyrophoric forms of uranium powder may burn so rapidly as to have the effect of an explosion.

If for some reason ordinary laboratory glassware is used in lieu of such a dry box, safety glass screens and face shields are minimum protection. The work area should be kept clean of flammable liquids and other materials which might cause fires which would spread to the uranium. Quantities exposed at any one time should be kept to a minimum.

SAFE DISPOSAL OF URANIUM SCRAP

Uranium scrap may be disposed of by controlled oxidation, by safe shipping to a recovery facility or by conversion to a compact form to reduce the exposure to air. Specifically, these methods include the following, each of which will be briefly described:

1. Wet burning
2. Dry burning
3. Shipment under oil
4. Nitric acid oxidation
5. Degreasing, briquetting and vacuum casting
6. Shipment under argon

Wet burning - This method requires special equipment in which uranium scrap is oxidized under water by means of steam jets. Hydrogen is liberated. The process is carried out at the boiling point of water. An advantage of this method is that atmospheric contamination is reduced to a minimum. This method is desirable only at locations where fairly large quantities of material must be disposed of on a recurring basis.(2)

Dry burning - The most expeditious and least expensive method for the disposal of uranium scraps by conversion to oxide is by direct dry burning in air.

For a quantity not exceeding 5#, the scrap may be spread out on a steel plate in an open area and burned to oxide by the flame of an oxy-acetylene torch. The worker should be protected by a welders face shield and a metal fume respirator. The scrap should be raked to insure that all the metal goes to oxide.

Where larger quantities are involved, a steel cased incinerator with heavy steel flooring is necessary, equipped with a continuous source of combustion to maintain a satisfactory rate of combustion, a rake to permit turning over the material at frequent intervals, an exhaust system to a suitable flu and dust collection equipment which will withstand hot gases and possible incadescent particles. A muffle furnace has been used successfully with very low loss.

Shipment under oil - In the event that it is impossible for some reason to dispose of uranium scrap by oxidation, the scrap may be shipped under a mineral oil; however, this method should be avoided if at all possible. (Shipment under oil should not be undertaken without prior approval of the Production Division, New York Operations Office.)

Nitric acid oxidation - Small quantities of uranium scrap can be oxidized to uranyl nitrate with nitric acid. The reaction should be performed in a wall ventilated hood, in a container sufficiently large to prevent boil over. The vent is important because of the highly toxic nitric oxide fumes and hydrogen evolution.

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Degreasing, briquetting and vacuum casting - This method requires extensive equipment and involves the complete degreasing of the material, removal of impurities and briquetting at pressures of 15,000 to 20,000 p.s.i. It is practical only for the disposition of large quantities of material on a production basis. Actually, it is concerned with converting the scrap to a readily usable form rather than with simply converting it to oxide for disposal.(1)

Shipment under argon - In unusual cases, it is necessary to ship fine uranium powder as such without conversion to oxide and it is possible to ship small quantities of the powder under an atmosphere of argon and at dry ice temperature. (Shipment under argon should not be undertaken without prior approval of the Production Division, New York Operations Office.) Such shipments, if made, will be by courier rather than common carrier.

INTERSTATE COMMERCE COMMISSION REGULATIONS

The Interstate Commerce Commission regulations concerning radiation are found in Supplement 18 to Freight Tariff #4, Sections 366-369 (Shippers are referred to the appropriate freight tariff, Civil Aeronautics Authority or Postal Regulations for exact packaging and labeling information on radioactive materials). The limitation on the amount of uranium permitted to be shipped by express in one package is set at that amount disintegrating at the rate of 10^{11} atoms per second, which would be approximately 17,000#. This limitation is obviously of little significance with respect to the weight of uranium metal in express shipments. The minimum amount requiring labeling is set at that amount disintegrating at the rate of 50×10^6 atoms per second, which would be approximately 8.5 lbs. ^{for 1235}

4.5 lbs. for 1235

While the regulations of the Interstate Commerce Commission are not presently directed towards the pyrophoric properties of uranium scrap, the general regulations require the shipper of dangerous articles to describe, pack and mark his packages properly and to inform the agent of the carrier of the true character of their contents. Shipments of scrap under oil will be made by courier, rather than by mail or common carrier.

FIRE CONTROL

The best fire protection for uranium scrap is provided by keeping quantities small and separated, by segregating the scrap from other flammable materials and by handling and storing uranium in locations suitable for permitting a fire to burn out.

Fires in machining operations can be avoided by prompt removal of scrap out of the region where glowing turnings fall. Formation of a heavy oxide layer will extinguish the combustion of an isolated metal turning. If a small fire occurs it can be extinguished by a gallon or so of the coolant; for this purpose an open top can of the coolant should be kept at hand.

G-1 powder (a commercial preparation with a graphite base), graphite chips, powdered talc or dry sand are useful in uranium scrap fires for controlling radiant heat, spatters and fumes. A supply of at least one of these agents should be available at all locations where uranium scrap is handled.

Ordinary fire extinguishers are not suitable. Uranium powder can burn in an atmosphere of carbon dioxide (which eliminates carbon dioxide extinguishers) and reacts to nitride in an atmosphere of nitrogen. The reaction with carbon dioxide also precludes dry chemical since such extinguishers depend on the heat of the fire liberating CO₂ from the breakdown

of the bicarbonate of soda. Carbon tetrachloride extinguishers should not be used because of the undesirability of releasing carbon tetrachloride fumes in a confined space and because the hot metal present may possibly cause decomposition of the carbon tetrachloride. Soda-acid and foam extinguishers are not recommended since they may cause scattering of the burning material and at best require extremely skillful handling to have any beneficial effect on burning uranium. Hose streams should be avoided. However, as mentioned in the section on "Storage", automatic sprinklers are satisfactory unless an extremely large quantity of powdered uranium is involved; this would by no means constitute the usual situation.

Inhalation of the fumes from burning uranium metal should be avoided. If the burning occurs under controlled conditions, such as the burning of a small quantity in a laboratory, the hoods ordinarily used in handling the uranium will provide sufficient ventilation. However, if the burning does not take place under controlled conditions, approved breathing apparatus should be worn.

- (1) Based upon Report A-4044 December 1945
- (2) Letter from Mallinckrodt Chemical Works to Manager, St. Louis Area Office, U. S. Atomic Energy Commission, November 23, 1949.