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RECOMMENDED PRACTICES FOR URANIUM FINISHING

By
William B. Harris

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B. Steele
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RECOMMENDED PRACTICES FOR URANIUM FINISHING

by

William B. Harris

ABSTRACT

Because of its pyrophoricity and moderate toxicity, uranium requires special consideration in machine shops. Specific machining practices consistent with the maintenance of acceptable levels of airborne uranium are presented. These include various tools for each type of machining job with recommended tool speeds, coolant flows and ventilation requirements.

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The finishing of metallic uranium is accompanied by several problems which do not usually appear in the finishing of other metals. Because of its moderate toxicity, airborne uranium must be kept to a minimum. This is especially difficult because of the pyrophoricity of the material. When a chip of metal is heated to the extent normally occurring in a machining operation, it spontaneously catches fire, releasing uranium oxide fume into the atmosphere.

In addition to this, the heat created in machining leads to a surface phase change, and the creation of a very hard skin which not only has a tendency to break tools, but when cut, creates some airborne dust.

Because of the unusual nature of the problems involved in finishing uranium metal, it has been thought advisable to set down the consensus of uranium finishing practices, which when followed, tend to minimize the health problems involved. It has been our experience that a finishing shop can in most cases be operated without the need for local exhaust ventilation while maintaining uranium air concentrations below the maximum allowable. It is advisable, however, that general ventilation be employed to maintain safe levels under all circumstances.

At the present time, various methods of attaining finished uranium shapes other than machining are being investigated. Some of these operations, such as extrusion, swaging and drawing, can be accomplished without local ventilation provided clean material is used. Rolling and powder pressing, however, require local ventilation but will not be covered in this report. Various machining operations and subsequent material handling will be covered in detail.

I. Machining

A. End-cutting

1. Abrasive Cut-off Wheel

The use of abrasive cut-off wheels (including "cutamatic") has been attempted in trimming uranium stock. Wheels from 12'-18', operating at from 1800-3600 RPM have been used. The main advantage of this type of tool is the speed of cut. The following disadvantages have been noted:

- a. Cut has tendency to draw.
- b. Wheels break, slowing operation and introducing safety hazard.
- c. Large volumes of coolant necessary with attendant mess. (40 gpm)
- d. Excessive atmospheric dust contamination requiring carefully designed exhaust hood and large quantities of air.
- e. Burning of piece.
- f. No chip recovery.
- g. Careful local ventilation required.

2. Power Hacksaw

The tool of choice for rough cutting operations appears to have been the power hacksaw. This has been used extensively for the cutting of rectangular as well as round shapes. With the tool operating at approximately 48 strokes per minute, using a 6"-8" stroke, cutting speeds of from 1/2 to 1 sq. in. per minute have been accomplished, depending on the sharpness of the saw. The advantages of this tool are:

- a. Relatively infrequent sparking.
- b. Fair chip recovery.
- c. Very low air contamination.
- d. Fairly clean cut.
- e. No burning of piece.
- f. Low coolant flow possible with consequent clean operation.

Disadvantages:

- a. Relatively slow speed.
- b. Some drifting of cut.

3. Parting Tool

Where accurate cutting is desired, the only machine which has been used in production and found satisfactory has been a lathe tool. A speed of 60 to 100 FPM of cut for a 50 thousandths cut has been successfully used.

Advantages:

- a. Excellent scrap recovery - clean turnings.
- b. No sparking or fire.
- c. Close tolerance possible.
- d. Fairly high speed.
- e. Very low air contamination.

Disadvantages:

- a. Comparatively long setup time except in repetitive operations.
- b. Large quantities of coolant, but usually easily applied and controlled.

For typical tool, see Appendix A.

4. Circular Saw

Probably the best all around job of cutting off can be done on such a device. Material up to 5" diameter has been cut with a 2' diameter blade at 15 surface feet per minute. The blade in this case was a quarter inch thick with 30 thousandths side clearance.

Advantages:

- a. Excellent scrap recovery.
- b. No sparking.
- c. Fast.
- d. Very low air contamination.
- e. Moderately close tolerance.
- f. Low setup time.
- g. Any size stock.
- h. Easy coolant application.
- i. No local ventilation required.

Disadvantages:

- a. High initial cost of equipment.
- b. High percent scrap.

B. Turning

1. Lathe

The machining of uranium in a lathe at a rate of about 50-100 peripheral RPM apparently presents no unusual problems, and the normal advantages and disadvantages of such work on other materials would hold with a few exceptions:

- a. Coolant flow should be of the order of 7-10 gpm/tool. (Flows as high as 40 gpm have been used at the higher speeds.)
- b. Cuts should be relatively deep to undercut hardened skin.
- c. Care must be taken to adjust cutting speed to oxidation rate and sparking. It should be possible to operate a lathe with no or very infrequent sparking.
- d. Air contamination rate with proper operation should be low if fires are to be avoided.
- e. Turnings should be kept drowned.

2. Centerless Grinder

This type of machine has been used successfully for achieving close tolerances with a very rapid cut. (Rate - 3600 surface feet).

Advantages:

- a. Speed of operation.
- b. Accuracy.
- c. Low fire loss.

Disadvantages:

- a. Low scrap recovery.
- b. High coolant flow.
- c. Sparking.
- d. Local ventilation required.

C. Surface Cutting

1. Slab cutter

Excellent results have been obtained using this tool at approximately 25 FPM peripheral speed with a 1 1/2" feed, taking about a 100 thousandths cut. Coolant rate should be about 10 gpm. The turnings from this tool are clean and the operation may be expected to proceed with a minimum of burning.

2. Miller

Good results are found for both rough and finish milling with cutters up to 12" diameter. The speed and cutting rate are very important factors governing the quantity of chip burning and rate of air contamination. At tool speeds representing a peripheral velocity of 150 FPM (96 RPM using a 6" cutter) and a 1" feed, enough burning of chips occurs to require the constant attendance of the machinist to daub out the fires and keep the chips under coolant. At velocities of 100 RPM or less, sparking is very occasional with coolant quantities in the neighborhood of 10 gpm. Any increase in peripheral tool speed above 150 RPM, results in almost continual burning of chips and high air contamination.

It appears that from the standpoint of machinability, scrap recovery and air contamination by uranium, a deeper cut taken at a slower speed is preferred. This gives a more massive chip, which will burn less easily, and also undercut the hard case formed by the previous cut.

3. Shaper

Rough cutting by means of a standard shaper follows usual shop procedures, and has few pitfalls. One-eighth inch cuts are common and can be carried on without any noticeable sparking and with low air contamination.

4. Surface Grinder

No surface grinding operations have been seen. It would appear that the disadvantages of the use of this machine would greatly outweigh any advantages and careful study should be given to other procedures before using a surface grinder. Careful local ventilation and large quantities of coolant would be required and in all probability the air contamination would be excessive even under ideal conditions.

D. Drilling

Drilling operations have some inherent technical difficulties which require careful handling. There is apt to be some distortion of the hole which can be overcome by good technique. As far as scrap recovery and air contamination are concerned, vertical drilling may be safely carried out. It would appear that the flooding of the hole with coolant adequately provides for oxidation control. The hole should be kept free of cuttings. The coolant should be of such a viscosity as allows penetration to the bottom of the hole. Holes up to 1" in diameter have been drilled in this manner at speeds of about 100 RPM.

Horizontal boring and reaming present a somewhat different problem, but adequate quantities of coolant (7-10 gpm) can be expected to minimize scrap loss and sparking.

II. Storage

A. Raw Material

The storage of natural uranium in large quantities presents some radiation hazard, and at distances up to 10' from the material, beta-gamma activities in the neighborhood of tolerance may be expected. Any location within such distance should be monitored to determine possible restriction. Storage areas should be posted with a sign designating maximum time allowable within the area.

B. Scrap

All scrap should be stored in a heavy gauge steel drum with a loose fitting lid, to allow escape of hydrogen gas. The cuttings should be free from moisture and completely coated with coolant or oil. If the liquid material is such that complete coverage is not assured, the scrap should be completely immersed in oil. When scrap is to be incinerated before recovery, this should be accomplished in small quantities (up to 10#) and as frequently as practical. Before burning, the material should be completely immersed in oil, and stored in covered steel containers.

C. Stock

Finished and semi-finished parts should be protected from oxidation as the process requires, and should be stored in sufficiently small quantities to prevent excessive radiation. Such stocks should be monitored, and shielding provided if necessary to maintain exposures to below 100 mrep/day (maximum permissible dose rate).

III. Handling

A. Raw Material

In the handling of raw materials in substantial quantities, three possible hazards may arise:

1. Direct radiation,
2. Contact radiation,
3. Airborne dust from oxide scale on the surface.

Monitoring of all areas when raw materials are being handled is necessary to establish time tolerances.

In order to prevent excessive hand irradiation from direct contact with the material, some type of hand covering is necessary. One-sixteenth inch leather gloves have been found to reduce this quantity to just above the maximum permissible dose rate (37 1/2 mr/hr) for full 8 hour contact. Inasmuch as continuous contact is rarely if ever encountered, this amount of shielding has been found to be adequate. The gloves should be changed at least each day.

When the material is coated with an oxide scale, the possibility of airborne dust must be considered. Inasmuch as the quantity of contamination is dependent on such factors as speed of operation, room volume, general ventilation rate, etc., it is necessary to take adequate air samples to determine exposure.

B. Semi-finished and Finished Stock

The handling of machined parts presents the same potential direct contact hazard as does the raw material.

Those jobs which require constant handling of these pieces should be evaluated from a time standpoint, and suitable protection provided. Inspectors and packers are particularly exposed, and if gloves may not be worn, the time of handling should be cut to allow an exposure of not more than 1500 mreps/week (hands only).

C. Scrap

In order to maintain the efficiency of the scrap recovery program, some tentative procedures have been set up. The important factors in this are:

1. Operations should be carried on in such a way as to minimize oxidation of the metal.
2. All chips should be broken with a chip breaker.
3. All bright chips and those with minor oxide film, which are caught in a chip wringer, should be kept with the non-oxidizing film left by the wringer and shipped in not more than 200-250 lb. quantities (a 5 to 10 gallon can full) to

a central location for briquetting and subsequent reprocessing.

4. All scrap machinings, which are not shipped for briquetting, should be carefully incinerated and the resultant oxide shipped for recovery.

IV. Oxidation

Natural uranium is a pyrophoric material. This means that it is capable of taking fire spontaneously when in a form which presents a large surface per unit of mass, such as dust, turnings, shavings, etc. It will also decompose water, oxidizing and releasing hydrogen. The fact that it is so easily oxidizable presents two main difficulties to its handling in addition to the direct hazard from fire.

- A. Oxide or material covered with any appreciable film of oxide in the scrap tends to reduce the value of the product and the scrap reclamation value.
- B. Rapid oxidation releases fume into the atmosphere with its attendant health hazard.

For both of these reasons, every effort should be made to prevent oxidation at any stage of the handling.

V. Prevention of Exposure

A. Radiation Hazards

Exposure to radiation may be prevented by use of one or a combination of the following:

1. Distance from source.
2. Reduction of quantity of source.
3. Shielding from source.
4. Reduction of time of exposure.

In order to determine the necessity for the application of such controls, it is imperative that a thorough radiation survey be made by a competent Health Physicist of all potentially dangerous areas. Continual monitoring to locate hazards arising from process changes is also necessary. When control measures are instituted, frequent periodic rechecks must be made to evaluate degree and continuance of control.

B. Inhalation Hazards

The main hazard arising from the handling of a material like uranium, which is primarily an alpha emitter and a chemical poison, lies in the possibility of the inhalation of finely divided material which deposits in the body and irradiates and poisons the tissue with which it is in direct contact. The present Maximum Allowable Concentration of uranium dust is 50 $\mu\text{g}/\text{m}^3$.

Protection from inhalation of this material resolves itself to the exercise of normal measures for the control of atmospheric contamination, with the added restriction imposed by the minute quantities involved.

Briefly, the general procedures are as follows:

1. Suppression of the dust.
2. Isolation of the process.
3. General ventilation.
4. Local ventilation.
5. Personal respiratory protection.

Control procedures which are believed adequate are the following:

1. All spaces in which uranium is machined and those spaces where metal coated with oxide scale is handled should be supplied with adequate general ventilation. This shall be so designed as to provide a continuous flow of air through the space of the order of 10 to 15 lineal feet per minute. If this type of flow is impractical, sufficient dilution might be possible if adequate distribution of air to the extent of about one complete change of air every 5 minutes is provided. This latter method is not positive, and must be checked with complete area monitoring.
2. All uranium machining should be carried out under a large flow of coolant, preferably between 7-15 gpm for low surface cutting speeds with up to 40 gpm at higher rates.
3. All machining operations must be carefully attended and should any burning of chips start, the fire should be immediately extinguished by daubing with coolant and by immersion. This procedure may be facilitated by providing metal slides and shields to guide the chips toward a single location. This location may then be kept flooded and quickly cleaned out.
4. All operations involving the use of an abrasive wheel, disc or belt should be discouraged. If they are used, however, local exhaust ventilation should be applied by means of a hood providing as complete enclosure as permitted by the operation. Design of such hoods should be referred to competent industrial ventilating specialists and the results carefully checked by air analysis.
5. The speed of all machines should be kept below the fire point, and if possible, no sparks should be observable at the point of cutting. A maximum speed of 100 surface or peripheral feet per minute has been found satisfactory for a variety of machining operations.

6. Provision should be made for isolation of any container which catches fire and the material should be extinguished by total immersion in oil or water or by smothering with G-1 or graphite chips. (Complete fire prevention procedures are presented in Appendix B.) Before approaching any burning material, an approved fume respirator should be put on.
7. In the case of isolated exposures which would require extensive controls, the use of suitable personal respiratory protective equipment may be allowed.
8. The discharge from any local exhaust system used on a source of uranium dust or fume should be to the outside, and should be provided with a dust filter which will reduce the effluent contamination to tolerance level. An electrostatic precipitator is recommended, but any other device which is of proved effectiveness would be allowable. No filter medium which is combustible may be used.
9. Coolant - The following coolants have been found to have satisfactory properties for this work:
 - a. Soluble cutting oil - Hydromite
Texaco - 1 pt. - 4 pts. water
Sincool.
 - b. Lard oil.
 - c. High flash mineral oil (about 400° F).
 - d. Lasupar - gulf 3 pts. - 1 pt. cutting base - Gulf.

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NOTE:

Supplied by Kennametal Tool
Company. C.T. 120

CUT OFF TOOL
C-O-2

APPENDIX

1. At no time should fine scraps be permitted to stand partially covered with oil.
2. When small quantities of cuttings are involved, they may be burned with the approval of the AEC representative. All finely divided particles, dusts, etc. should be burned before large quantities accumulate. Burning may be done on a steel plate in the open in small quantities, such as 5 to 10 lbs. Material must be thoroughly burned. The burning reduces the uranium to black oxide. This should be packaged in a steel drum and shipped for reprocessing. Care should be observed in incinerating and packaging to prevent inhalation of fume or dust.
3. When storing fine parts prior to burning, they should be completely submerged in oil, in a steel drum with lid. There should be no sprinkler systems above or in the immediate area of this storage. Water should never be used in case of fire (water will extinguish a very small uranium fire, but the question of size of fire, relative quantities of water would need to be ascertained and this should not be left up to the average layman). Therefore, it would be much safer to supply a tank of oil to drop metal into in case it ignites. An adequate CO₂ fire extinguisher could be used both on ignited shavings or burning oil.
4. There should be an adequate sized pair of tongs to handle stock being worked on in cases of ignition. Stock should be removed from machine and submerged in a tank of oil which should be very near the machining operations.
5. If at any time the oil ignites, an available CO₂ extinguisher should be used. The oil should be of a very high flash point, so that the fire should be easily controlled.
6. If material or stock cannot be submerged, G-1 powder or graphite chips may be used. An asbestos blanket may also be used.
7. From experience gained at Iowa State College Laboratory a special hand fire truck was built and mounted on four large casters. The truck consists of a wooden cabinet and a platform for a 55 gallon drum. This drum is filled with graphite chips. The cabinet contains asbestos gloves, asbestos blankets, asbestos shields for the front of the body, respirators (necessary in fighting any uranium fire since large volumes of oxide dust are given off), a flashlight, two buckets, two pairs of pliers, two screwdrivers and two hammers. The following items are placed on the outside of the cabinet and on the corners of the platform: a wire noose made from about 30 ft. of No. 10 wire and a crossbar, and a No. 10 scoop, a small hand scoop, long handled shovel, small dust pan with metal scraper, two liquid carbon dioxide extinguishers, fireman's ax, crowbar, and a 10 ft. steel rod with one sharp end, which can be used as a punch. A special barrel-handling hand truck and a very low 4 wheel, all steel, cart are also reserved for moving barrels

or 5 gallon buckets, respectively, which are on fire. Both the truck and cart have sheet metal protection for the operator. The barrel truck is constructed so that a barrel can be picked up without being touched by the operator. This is quite important if the barrel is hot.

The foregoing items of the paragraph listed for use on hand fire truck are used as follows:

Graphite chips - for smothering fires.
Asbestos blankets - for smothering fires or protection of equipment.
Asbestos shields - self-explanatory.
Respirators - self-explanatory.
Buckets for handling very small fires, carrying them to the outside or applying graphite chips to fires.
Pliers - for picking up shavings on fire, etc.
Wire noose - for placing around barrel of chips on fire and removing from area.
10' steel rod for punching holes in barrel that might contain water and chips. This permits water to drain from material.
Isolation of burning material from other material is the prime motive in fighting a fire.

8. If a few precautions are used, most uranium turning fires can be eliminated. Since speed is very important in extinguishing a uranium fire, the operators should be thoroughly trained. A few experimental fires (with highly contaminated turnings destined to be burned) are useful for training purposes. Municipal fireman, inexperienced with such fires, should not be allowed near unless the building is on fire and given up. One experienced man extinguishing a uranium fire in a large body of turnings within 30 seconds after it has started is more effective than a whole fire brigade 10 minutes later.
9. Any turnings fire may be classified as one of three kinds:
 - a. Fire in dry turnings
 - b. Fire in moist turnings or turnings partially submerged in water
 - c. Fire in turnings covered with a coat of cutting oil or partially submerged in cutting oil.

Of these three kinds, the first is the easiest to control and extinguish. Dry turnings may be ignited by any type of flame, by high temperature or by sudden impact or stress, such as striking a turning on a heavy steel surface with a hammer. A match will ignite an isolated turning with about the same speed as it would a pine splinter, and the turning burns rapidly after ignition. However, there is no flame from such a fire. The main danger from a fire of this type is the damage to equipment and the possibility of igniting nearby combustible material. The heat is excessive and if the mass of turnings is large enough, temperatures in excess of 1300°C can result.

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