# OSTROP 11.0 Fuel Element Handling Procedures

TABLE OF CONTENTS

# OSTROP 11.0 FUEL ELEMENT HANDLING PROCEDURES

*Scope:* The OSTROP 11.0 series procedures are given to direct the operator in the approved methods for handling fuel elements.

## A. GENERAL INFORMATION

The following information describes the equipment that will probably be used to handle and inspect fuel elements.

### 1. Fuel-Moderator Elements

The fuel-moderator elements contain a zirconium-hydride moderator, homogeneously combined with partially enriched uranium fuel. As indicated in Fig. 1. 17 (Vol. 1) the active section of this fuel moderator element is 15 in. in length and 1.43 in. in diameter and contains approximately 8.5 wt-% uranium, enriched to 20% in $U^{235}$ (70% in FLIP fuel). The hydrogen-to-zirconium atom ratio of the fuel-moderator material is about 1.7 to 1. To facilitate hydriding, a 0.25-in.-diameter hole is drilled through the center of the active fuel section; a zirconium rod is inserted in this hole after hydriding is complete. Graphite slugs, approximately 3.5 in. in length and 1.4 in. in diameter, act as top and bottom reflectors.

The active fuel section and top and bottom graphite slugs, are contained in a 0.02-in.-thick stainless steel can. The stainless steel can is welded to the top and bottom end fittings. The top end fitting is grooved and specially shaped to fit and lock into the fuel handling tool. The top end fitting also incorporates a triangular spacer block that positions the top of the element in the top grid and yet provides passages for cooling water flow through the grid. The bottom end fitting fits into the countersunk holes of the bottom grid plate and supports the entire weight of the element. The approximate overall weight of the element is 7.5 lbs; the $U^{235}$ content ranges from about 36 to 40 grams (~ 135 grams in FLIP fuel). Serial numbers on the top end fixture or spacer block are used to identify fuel elements. When properly installed in the core, the top of the triangular spacer block is about level with the top of the top grid plate.

### 2. Instrumented Fuel Elements

Some fuel-moderator elements are equipped with three chromelalumel thermocouples embedded in the fuel. As shown in Fig. 1.18 (Vol. 1), the sensing tips of the fuel element thermocouple are located halfway to the vertical centerline at the center of the fuel section and 1 in. above and below the horizontal center.

Each thermocouple consists of two 0.005-in.-diameter wires embedded in MgO insulation and contained in a 0.040-in.-diameter stainless steel sheath. The sheathed thermocouples pass through a soft solder seal which is contained in a 3/4-in.-diameter leadout tube welded to the upper end fixture. This tube projects about 3 in. above the upper end of the element and is extended by two lengths of tubing connected by unions to provide a water-tight conduit extending above the water surface in the reactor pool. Just above the soft solder seal, a transition is made to heavier thermocouple leadout wires and to a ground wire attached to the sheath. The transition joint is sealed in a potting sleeve. The color-coded leadout wires (chromel-yellow is positive, alumel-red is negative) are 20 gauge with a parallel resistance of 59 ohms per 100 ft. at 75°F. Care must be exercised when handling or connecting the wires. In other respects, the instrumented fuel-moderator element is identical to the standard element.

3. Graphite Dummy Elements

Graphite dummy elements occupy the grid positions not filled by fuel-moderator elements and other core components. The graphite dummy elements are canned in aluminum and have aluminum end fixtures and spacer blocks. These elements are of the same dimensions as the fuel-moderator elements, but are filled entirely with graphite. Each graphite dummy element weights 2.8 lbs. and is anodized after assembly. The spacer blocks have a blue anodized finish to make the graphite dummy elements easily distinguishable from fuel-moderator elements. When properly installed in the core, the top of the triangular spacer block is about level with the top of the top grid plate.

4. Fuel-Handling Tool

The fuel-handling tool, shown in Figure 1.66 (Vol. 1) is used for handling the fuel-moderator and graphite dummy elements. It consists of a stainless steel grapple mechanism, a stainless steel weight, a flexible stainless steel control cable with a handle that can be locked in any position, and a reinforced rubber hose that extends between the handle and the weight for transmitting the weight of a fuel element to the handle.

Four stainless steel balls protruding through the inside wall of a cylinder in the grapple mechanism slip into a groove on the aluminum top end-fixture of an element that has been pushed into the cylinder. The cylinder slides with reference to the rest of the grapple mechanism and holds the balls so that they cannot slip out of the groove in the end fixture.

To take apart the grapple assembly for inspection or repair, first remove the small Allen-head locking screw in the side, then, holding the weight in one hand and grapple mechanism in the other, rotate one relative to the other so as to unscrew the lower part of the grapple.

The proper adjustment of the fuel-handling tool is important to assure that fuel elements are not inadvertantly released during handling. Refer to the general notes on the fuel-handling tool drawing for th_ procedures to follow to adjust the tool properly.

5. Fuel-Element Inspection Tool

Description

The fuel-element inspection tool (see Fig. 1.67, Vol.1) is used to accurately inspect a pulsing fuel element for longitudinal growth and for bowing in excess of 0.062 in.

The upper support plate of the tool is mounted with two 1/2-in. bolts on the aluminum channel at the top of the reactor tank and extends downward 12 ft. into the tank, permitting the inspection of an irradiated fuel element and providing approximately 9 ft. of shielding water over the element. All parts of the tool to be in contact with water are either aluminum or stainless steel. The aluminum support-tube structure has a hole at the bottom end and another at the top to allow shield water to fill the interior of the pipe.

The bowing of a fuel element is detected by a carefully machined cylinder (a go/no-go gauge) attached to the bottom of the tool. If a fuel element will slide completely into the cylinder, its bow, if any, is less than 0.062 in. If the element passes through its cylinder, it will come to rest on the plunger of the spring-loaded bellows assembly. The length of the fuel element is measured by pushing downward (approximately 10 lb. of force is required) on the indexing rod until the indexing plug shoulders on the indexing plate. This places the upper surface of the fuel-element triangular spacer at an indexed position common to all fuel elements measured. Pushing the fuel element downward to this position forces the lower plunger downward an amount that varies with the leng of the fuel element being measured. A bellows attached to the plunger extends and displaces a portion of the water confined in the bellows housing. This displaced water pushes through the transmission line to the upper bellows assembly, forcing an identical bellows to contract. The contraction of the upper bellows causes the upper plunger to rise the same distance that the lower plunger was pushed downward. The movement of the upper plunger is measured with a dial indicator.

A standard element is furnished with the inspection tool; it is a solid piece of aluminum with the same dimensions and the same top and bottom end fixtures as those on a regular fuel element. This standard element must be inserted to calibrate the tool. The amount of bellows displacement caused by the standard element is used to zero the dial indicator. Every fuel element in the core can then be measured and its length compared with that of the standard. Careful records should be kept of each fuel element, grid location, and length, compared with the standard element. Instrumented (thermocouple) fuel elements can also be inspected with this tool. (By using a different indexing plate, a longer go/no-go gauge, and a dummy fueled follower standard, a fueled follower control rod can also be inspected.)

Fuel elements that do not pass the elongation and bowing tests should not be used for further pulsing operations. Currently, the United States Nuclear Regulatory Commission requires that elements which have bowing in excess of 0.062 in. and longitudinal growth in excess of 0.10 in. be removed from the core prior to continued pulsing.

6. Fuel-Element Transfer Cask

Description of a Typical Fuel-Element Transfer Cask

A typical fuel-element transfer cask (see Fig. 11.1) is designed to permit the safe transfer of irradiated fuel elements and other radioactive material from the reactor tank to the fuel storage pits or a hot cell facility; it consists of a steel casing filled with lead, and weighs approximately 5700 lbs. The cask is 45 in. long by 20 in. outside diameter with a 2-in.-diameter cavity extending the full length of the cask to hold a single fuel element. Eyebolts are provided on the top for the attachment of lifting cables. The bottom of the cask contains a 5-in.-high, steel-sheathed lead plug that slides horizontally across the end of the fuel element cavity to provide shielding. This plug can be locked in place with a spring loaded locking bolt attached to the cask. The top of the cask is equipped with a removable lead shield plug which is sized to pass through the central fuel element cavity. The plug can be locked in position at the top of the cask with the rotating locking keys attached to the cask.

In order to minimize the possible rusting of the cask and deposition of corrosion products in the water, the cask should be immersed in the reactor tank only during actual fuel transfer operations and removed as soon as possible. The paint on the cask should be carefully maintained.

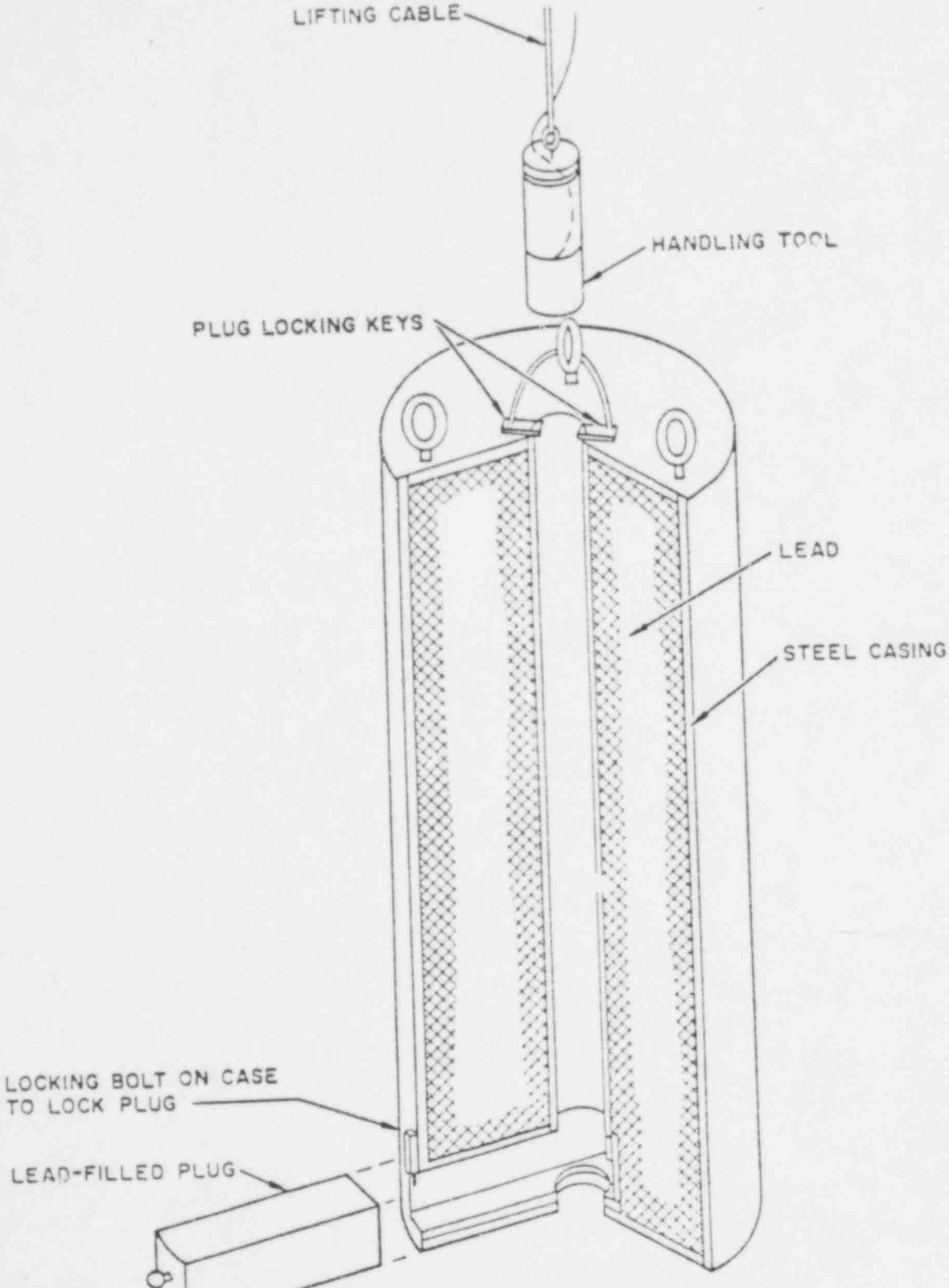



Fig. 11.1 - Typical Fuel Element Transfer Cask

B. GENERAL CONSIDERATIONS AND HAZARDS ASSOCIATED WITH FUEL-ELEMENT HANDLING

1. Irradiated fuel elements are the strongest source of radiation within the reactor. When the reactor is at power, a fuel element is a source of intense gamma and neutron radiation. After shutdown, fission product decay in the fuel continues to make the element a strong beta-gamma source, although the beta radiation is, for the most part, absorbed in the fuel cladding. Calculations indicate that if the reactor is operated at 250 kW for several hours, the equilibrium activity associated with one of these elements is approximately $2.5 \times 10^4$ curies at the time of shutdown. The calculated dose rate in air from a single fuel element after prolonged operation at 250 kW and at a distance of 6 ft. is approximately $2.5 \times 10^3$ roentgens per hour at the time of shutdown. Of course, this dose rate initially decays rapidly, but whenever fuel elements are to be handled, careful surveys with reliable health-physics instruments should first be made.

2. In operating a TRIGA, it may be necessary to transfer fuel from the reactor tank to storage. Because of the radiation level associated with irradiated fuel-moderator elements, elements are normally kept under water for shielding. If an element must be removed from the reactor tank, it should be placed in a shielded transfer cask to reduce radiation levels to tolerable limits.

3. In addition to the external radiation hazards present during fuel transfer operations, loose oxides and other irradiated particulates on the surface of the fuel element cladding constitute a potential contamination hazard. This tactile contamination can be transferred to handling equipment and eventually to personnel, if improper handling techniques are employed. Care must be taken to contain any liquid that drips from the fuel element or the transfer cask; personnel should wear protective clothing; and a continuous air monitor should be used to detect any particulate or gaseous activity that may become airborne. Equipment used in the transfer of a ruptured fuel element must be carefully handled to avoid spreading contamination.

4. Unless great care is exercised, cross contamination of the reactor facility can occur during fuel element transfer between the reactor facility and a hot cell. If the fuel transfer cask is taken into a cell, it will undoubtedly become contaminated. Its return to the reactor facility in a contaminated condition may spread contamination to otherwise clean areas.

C. PROCEDURES

11.1 Fuel Element Handling Procedures

a. The fuel element is engaged to the flexible handling tool by lowering the tool directly over the top of the element end-fixture; the weight of the tool causes engagement. (The fuel element end-fixture is thus locked to the fuel-handling tool.)

b. To release the fuel element it is necessary to first unlock the handle at the operator end of the tool. This is done by rotating the handle about 70 degrees counterclockwise and pulling it out approximately 3 inches. This action moves an internal cylinder relative to the rest of the grapple mechanism, and the tool ball bearings are pushed out of the element end-fixture groove, thus releasing the element.

c. Since the handling tool will slide in and lock automatically, the handle should never be in the unlocked position except momentarily when it is intended that an element should be released.

CAUTION

(1) When inserting or removing elements, be certain the handle is locked and that the tool is securely attached to the element by gently shaking the tool.

(2) When a fuel element is engaged in the grapple mechanism, the handle end of the tool should never be laid on the floor or on the tank covers, where it could be actuated accidentally.

(3) Never force the handle into or out of a locking position. If it does not rotate easily, push or pull the handle slightly, then try again. Forcing the handle will damage the locking grooves of the handle.

(4) When a fuel element is engaged in the tool mechanism, never coil the control cable in a circle of a diameter less than about 2 feet. A tight coil will pull the inner control cable and may release the element even though the handle is locked.

(5) When withdrawing (or inserting) fuel elements, be certain the tool and element are vertical over the grid plate hole before movement is made. Side forces on the fuel element may cause kinking or wrinkling of the fuel cladding.

(6) When inserting fuel elements in the reactor core, be sure each fuel element is seated in its proper lower grid plate position. When properly seated, the top of the tri-flute spacer, which is located on top of the fuel element, will be on a level horizontal plane and very slightly below the level of the upper grid plate. If the tri-flute on the fuel element appears to be above the upper grid plate, the element will be sitting on the lower grid plate, but will not be sitting in its counter-sunk position. If the tri-flute appears to be significantly below the upper grid plate, the element will be angled into the wrong lower grid plate position. The tri-flute position should be determined by using binoculars to look through the water from the top of the reactor tank.

(7) The tri-flute spacers on the 70% enriched FLIP fuel elements are distinctively different from those on the 20% enriched standard TRIGA fuel elements. <u>See Figure 1</u>. This physical features makes it easy to identify the FLIP and standard fuel elements in the core. At the time each newly loaded fuel element is observed for proper seating, <u>verify that the fuel element is of the type intended to be inserted into that specific core position.</u> Furthermore, there are to be <u>no</u> standard TRIGA fuel elements in any grid position except in a specifically approved position in the outer ring of the core. If there are any questions, contact the reactor supervisor.

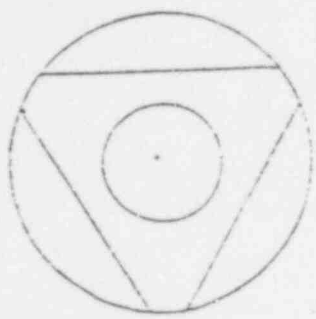
d. Instrumented fuel elements do not require the use of the fuel handling tool. The element can be handled (carefully) using the 3/4 in. tubing that houses the thermocouple leadout wires.

e. Fuel follower control rods do not require the use of the fuel handling tool. The fuel follower control rods can be handled (carefully) by using the long extensions that connect the control rod drives to the control rods.

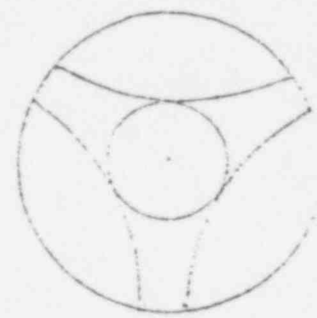
f. The constant air monitor (CAM) will be on at all times during <u>ANY</u> fuel element handling. (This includes storage pit fuel element handling.)

TOP VIEW OF THE OSTR

TRIGA FUEL ELEMENT TRI-FLUTE SPACERS



STANDARD FUEL



FLIP FUEL

Figure 1

## 11.2 Fuel Element Inspection Tool Operation

### a. Preoperational Procedure

Each day the inspection tool is to be used, the following steps must be taken before measuring the length of the fuel elements:

(1) Remove the fill plug and the vent plug at the upper end of the inspection tool and check the water level.

(2) If the water level is low, add demineralized water to the hydraulic system through the fill opening. Continue to add water until all air is purged from the system through the vent hole.

(3) Replace the fill and vent plugs.

(4) Adjust the bezel on the dial indicator to give a zero reading.

(5) As the temperature of the water in the hydraulic system approaches that of the reactor tank water, it will expand or contract causing the pointer of the dial indicator to move. When the pointer of the dial indicator stops moving, remove the fill plug. Add water, if necessary, and replace the plug.

### b. Zeroing the Dial Indicator

Each day the inspection tool is to be used, or after measuring 20 fuel elements, re-zero the dial indicator as follows:

(1) With the fuel-handling tool, lower the standard dummy into the go/no-go gauge so that its bottom end rests on the plunger of the lower bellows assembly.

(2) Remove the fuel-handling tool.

### c. Adjustment of Bellows Travel

(1) At some time it may be necessary to change or readjust the distance the standard element tri-spacer protrudes above the indexing plate. If adjustment is required, unbolt and remove the indexing plate (and go/no-go gauge attached to it). Loosen the 10-32 set screw in the nut which surrounds the lower plunger.

CAUTION

The lower plunger is welded to the lower end of the bellows. Be very careful not to twist the plunger and damage the bellows!

(2) Hold the plunger in a fixed position and rotate the nut. Tightening the nut contracts the bellows and moves the plunger upward. The nut should not be tightened more than is actually necessary since this action reduces the range of bellows travel. Be sure to retighten the 10-32 set screw when adjustments have been completed.

(3) Using the indexing rod, place the indexing plug in one of the six 1-in.-diameter holes in the indexing plate.

(4) Push down (approximately 10 lb. force is required) on the indexing rod until the pointer of the dial indicator stops moving, indicating that the dummy is indexed.

(5) Adjust the dial-indicator bezel to zero the pointer while holding the standard dummy in the index position.

(6) To ensure that the standard dummy is undistorted, repeat steps 3 and 4 twice, using other holes in the indexing plate, 120° apart. These dial-indicator readings should also be zero.

(7) Remove the indexing rod and the standard dummy.

(8) When preparing the fuel measuring tool for measuring fueled follower control rods, the above procedures are also used, except that a special indexing plate and longer go/no-go gauge replace the ones used for fuel elements. The diameter of the longer go/no-go gauge is sized to reject a fueled follower element that has a bow in excess of 0.062 in. in 24 in. of length (the same as the standard element gauge). Unbolt the fuel element indexing plate (and gauge connected to it) from the flange on the support tube and bolt the fueled follower indexing plate and gauge to a like flange on the support tube about 22 in. above. Use the special fueled follower standard dummy and follow the above procedures for zeroing the dial indicator.

d. Inspecting a Fuel Element

Inspect the fuel element for excessive bow and determine its length by the following procedure:

(1) Insert the fuel element into the go/no-go by using the fuel-element handling tool. If the fuel element passes freely through the gauge, it is within allowable straightness tolerance; if not, the element has a bow in excess of 0.062-in.

CAUTION

Never force or drop a fuel element through the go/no-go gauge. To do so may damage the gauge, cause damage to the cladding of the element, or jam the element in the cylinder. To pass the bow test the element should pass through the go/no-go gauge while being lowered slowly through the cylinder.

(2) After the straightness test, remove the fuel-handling tool and insert the indexing rod in one of the indexing holes in the indexing plate adjacent to a corner of the fuel element triangular spacer.

(3) Force the indexing rod down until the element is indexed. Record the dial indicator reading.

(4) Repeat steps 2 and 3 twice, using holes in the indexing plate adjacent to the other two corners of the triangular spacer.

(5) Average the three dial-indicator readings and add this average algebraically to the length of the standard dummy; the result is the length of the fuel element inspected.

(6) Instrumented fuel elements are inspected in the same manner, except that the fuel-handling tool is not required. The element should be handled carefully, using 3/4-in. tubing that houses the thermocouple leadout wires.

(7) With the special indexing plate and go/no-go gauge for fueled follower control rods in place and the measuring tool properly calibrated, fueled follower control rods may also be inspected using the above procedures. With the control extension shafting still attached to the control rod, the fuel element handling tool is not required. (With the extension shafting removed, however, there is a standard fuel element tip on the top of the control rod to which the handling tool will attach.)

11.3 Operation of a Typical Fuel Element Transfer Cask

a. Removing a Fuel Element from the Reactor Tank

(1) Prepare the transfer cask for immersion in the reactor tank by wiping all surfaces with a damp cloth or sponge to remove dust and dirt. Remove dirt and grease from lifting cables and slings. Remove the shielding plugs at the bottom and top of the cask.

(2) With a crane of adequate capacity, raise the transfer cask over the reactor tank so that the bottom of the cask is approximately 3 ft. above the surface of the water. While the cask is kept in this position, lower the fuel-handling tool through the cavity of the cask to the fuel element.

(3) Guiding the flexible tool by hand, engage the fuel element, and remove it from the core (or storage rack) so it is suspenced vertically below the cask, being careful to keep it under sufficient water for adequate shielding.

(4) While ensuring that the element remains engaged, lower the cask until its top is 4 ft. below the surface of the water.

(5) Slowly raise the flexible cable and fuel-handling tool until the element is in the cask.

WARNING

Avoid standing directly over the top of the cask. There will be radiation streaming upward from the cavity of the cask, because there is little shielding on the top of the fuel element; the fuel element is surrounded by lead only on the sides.

(6) Holding the handling-tool cables so as to keep the fuel element within the cask, slowly lift the cask just above the water so that the lower shield plug can be inserted and locked in place. Lower the fuel element onto the shield plug, and remove the fuel-handling tool from the fuel element, keeping clear of the radiation streaming from the top of the cask. Insert and lock the top shield plug in place.

b. Discharging a Fuel Element into the Fuel Storage Pit

CAUTION

A suitable storage area (storage pit) with adequate shielding must be provided for irradiated fuel elements removed from the reactor tank. If water is to be used as a shielding material in the storage pit, it should be changed from time to time, to assure its purity and low conductivity. (See OSU TRIGA Reactor Technical Specifications for fuel storage conditions.)

(1) Set the transfer cask on the floor directly over the fuel storage pit, which should be filled with demineralized water.

(2) Avoiding the radiation streaming from the top of the cask, unlock and remove the top shield plug, and attach the fuel-handling tool to the top of the fuel element.

(3) Withdraw the bottom shield plug only partially (to maintain shielding) to allow the fuel element to pass through. The fuel handling tool now will hold the entire weight of the element. Lower the element to a position near the bottom of the pit.

(4) While ensuring that the element remains near the bottom of the pit, completely remove the bottom shield plug (to be sure it does not fall out) and lift the cask about 3 ft. above the floor to permit visual observation, and install the element in a suitable receptacle at the bottom of the pit.

(5) Disengage the fuel-handling tool from the fuel element, and remove it from the cask.

c. Removing a Fuel Element from the Fuel Storage Pit

(1) Remove the bottom and top shield plug. Insert the fuel handling tool into the transfer cask cavity.

(2) Raise the transfer cask about 3 ft. above the floor, directly over the storage pit, and lower the fuel-handling tool to the bottom of the pit.

(3) Guiding the cables by hand, engage the fuel element.

(4) Lower the cask to the floor directly over the storage pit.

(5) Partially insert the bottom shield plug for shielding, but allow enough clearance for the fuel element to pass into the cask.

(6) Slowly lift the element into the cask. Lock the bottom shield plug in place.

WARNING

Avoid standing directly over the top of the cask. There will be radiation streaming upward from the cavity of the cask, because there is little shielding on the top of the fuel element; the fuel element is surrounded by lead only on the sides.

(7) Remove the fuel-handling tool from the fuel element, keeping clear of the radiation streaming from the top of the cask. Insert and lock the top shield plug in place.

d. Replacing a Fuel Element in the Reactor Tank

(1) Make available a position in the grid or storage rack that is accessible from directly above.

(2) Lower the transfer cask until it is just above the water surface.

(3) Avoiding the radiation streaming from the top of the cask, unlock and remove the top shield-plug, and attach the fuel-handling tool to the top of the fuel element.

(4) Unlock and remove the lower shield plug, holding the weight of the element with the fuel-handling tool.

(5) Lower the transfer cask until the top of the cask is approximately 4 ft. below the surface of the water.

(6) Lower the element to a position about 2 ft. above the core or storage rack.

(7) With the element remaining in this position, raise the cask until it is about 3 ft. above the surface of the water.

(8) Guiding the flexible tool by hand, lower the element to the proper core or storage rack position.

(9) Disengage the fuel-handling tool from the fuel element, and remove it from the cask.

D. Authorization

Proper authorization must be obtained before any fuel elements are handled or any changes in core configuration are made. The Reactor Supervisor or the Reactor Operations Committee must authorize any such core change or fuel element handling.

1. Items that may be authorized by the Reactor Supervisor:

   a. Any movement of a single fuel element out of the core to accommodate an experiment, and the subsequent replacement of this fuel element into the core.

   b. The permanent addition of up to two fuel elements to the core to increase the excess reactivity.

   c. Any movement of new or irradiated fuel elements not in the core.

   d. The removal of fuel elements from the core for maintenance purposes, provided that the reactor remains shutdown during the time that the fuel elements are out of the core, and the subsequent replacement of these fuel elements into the core, such that the core configuration has remained intact.

2. Items that must be authorized by the Reactor Operations Committee: Any fuel element movements except those listed in 1. a., b., and c., above must be authorized by the Reactor Operations Committee. After such authorization has been obtained, the Reactor Supervisor will schedule and supervise the approved fuel movement.