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DESIGN OF CONTAINERS FOR SHIPPING UNIRRADIATED LMFBR ASSEMBLIES

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MASTER

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INTRODUCTION

The fuel assembly for the LMFBR reactor development programs at Hanford (FFTF) and Clinch River (CRBR) consists of a close-packed array of 217 fuel pins in a hexagonal flow tube or housing, which is about 5 inches across flats. Each pin is about 1/4 inch in diameter and has a wire wrapped around it in a spiral with a 1-foot pitch. The wires space the pins from one another in the array, thus providing channels for flow of coolant. The pins are 8 feet long for Hanford and 10 feet long for Clinch River, and the corresponding overall lengths of the assemblies are 12 and 14 feet, respectively. The assembly weight is about 500 pounds.

Major Requirements Affecting General Concepts

Major requirements specified by the users for the design and operation of shipping containers for the unirradiated assemblies include the following:

* Work done under USERDA Contract No. AT(07-2)-1.

- The assembly must be supported at designated points along its length when not in a vertical position.
- The assembly must not experience a shock greater than 6 g acceleration from primary impact if the container is dropped in any orientation from a height of 6 inches.
- The design must be such that the entire package, or an inner container if this is readily removable from an overpack, may be lowered through a 22-inch-diameter floor valve opening and such that the assembly may then be extracted vertically.
- The package must permit removal of a suitably supported assembly in a horizontal position.
- Accelerometers must be provided to indicate the maximum number of g's shock at each end of the assembly and in each of the three principal directions.
- The package must be designed for shipment in a closed trailer with access only through rear doors.
- The weight and dimensions per assembly should be as small as feasible.

The major requirements (Slide 1) determine the general features of design, but details are affected by numerous other requirements relating to cleanliness, protection against physical damage, allowable loads and deflections, allowable radiation levels, limitations of handling devices and facilities, and temperature considerations. The package must, of course, satisfy all applicable regulations, in particular Part 71 of Title 10 of the Code of Federal Regulations.

The regulations require, among other things and in addition to avoidance of criticality, that the package shall not release more than ten millicuries of plutonium if it is dropped from a height of 30 feet onto an essentially unyielding flat surface, then dropped 40 inches onto a 6-inch-diameter penetrator, and then subjected to a 1475°F environment for 30 minutes. The individual fuel pins, without external protection, have been shown to remain leaktight under the specified conditions of impact and fire. There is almost no doubt that the assembly of 217 pins also satisfies the requirement; however, a formal demonstration of this is under way. Thus, the packaging does not have to provide containment under the hypothetical accident conditions of the regulations.

The shipping container is being designed by the Engineering Department of the Du Pont Company as part of a Savannah River Plant program of technical assistance to the ERDA Division of Reactor Development and Demonstration in the area of shipping radioactive materials.

Preliminary evaluation was made for several different designs, including arrangements of two and four assemblies per container. Although some saving in shipping cost could be realized by having more than one assembly per container, consideration of operational difficulties, exposure of personnel to radiation, and risk of damage to an assembly during handling led to selection of a design having one assembly per container.

Unloading Sequence at Hanford

View A of Slide 2 is a bird's-eye view of the entire package. Basically, the package consists of an overpack made up of two concentric pipes with cushioning devices in the annular space, and with a removable cap at each end. Inside the package is a strongback that is split lengthwise into two halves. The strongback has suitable hardware and pads to position and hold the fuel assembly. This slide illustrates the proposed method of unloading at Hanford. View B shows the overpack with end caps removed; C shows the strongback that has been withdrawn from the overpack. In Views D and E, the strongback is raised to a vertical position and attached to an unloading fixture. In View F, a grapple engages the fuel assembly; in G, the strongback is opened; and in H, the assembly is being taken away. With this method of operation, the assembly may be in a plastic bag during shipment.

Unloading Sequence at Clinch River

Slide 3 shows the proposed method of handling at Clinch River. The entire package is oriented vertically and is then lowered into a floor pit as shown in View C. The upper end cap is removed, and the fuel assembly is withdrawn vertically, leaving the strongback in the overpack. Views D and E are merely alternative methods of supporting the package in the floor pit.

Upper End of Fuel Assembly and Container

Slide 4 shows cross sections of the end of the package containing the upper portion of the fuel assembly. Originally a foam-type cushioning material was considered; however, the wire rope devices, suggested by our associates at Hanford and shown at each end in the annular space of the overpack, appear preferable from the standpoints of durability, cleanliness, temperature sensitivity, and fire resistance. Cushioning is provided both radially and axially, and the damping characteristics are good.

An accelerometer is at the left end of the strongback; perhaps more than one accelerometer will be used, depending on the type finally selected, in order to measure in all directions. An accelerometer is also installed at the other end of the strongback. These instruments will have electrical connections to permit readout before the overpack is opened and must be unplugged during the course of unloading operations.

The positioning and holding device at the upper end of the fuel assembly is adjustable to accommodate slight bow and slight variation in length of assemblies.

Between the ends of the inner and outer pipes of the overpack is a diaphragm, primarily for reasons of cleanliness and decontaminability. This diaphragm must be fairly loose, because limiting shock to 6 g's with a 6-inch drop will necessitate about 1.5-inch relative motion between the inner and outer pipes.

Center and Bottom End of Fuel Assembly

Slide 5 shows the central longitudinal section of the package.

Slide 6 shows the bottom end, which is very much like the upper end. However, a pad provides both axial and radial restraint and supports the assembly when the package is in the vertical position. One pad shown is for the Clinch River assembly; the other is for the shorter Hanford assembly.

Aside from the difference in length between the Hanford and Clinch River assemblies, there are minor differences in configuration, and as previously discussed, the proposed methods of handling are different. The strongback is designed to accommodate either type of hardware.

A leg with wheels is attached to the forward end of the overpack for shipment. This leg has a hole to match a pin in a positioning fixture mounted in the trailer. A dolly under the rear end is then used for maneuvering the container into position. The dolly is removed, and the container is then tied down. This method of operation avoids the need for personnel to pass alongside the container during or after loading. As many as six containers will be shipped on a trailer, three abreast and two lengthwise with very little space between containers.

Conclusions

Special shielding is not needed to meet regulatory requirements. The calculated surface radiation level in the region of the active fuel is less than 100 mrem per hour for initial operation. The composition of fuel now forecast after the mid-1980's may result in radiation levels requiring some shielding for handling. The design will accommodate the addition of a moderate amount of either neutron or gamma shield.

Some testing of mockups of the cushioning system is planned as part of the design effort. Whether to fabricate a prototype for dry runs before ordering additional units is being considered. The design appears straightforward so that only minor modification and adjustment might be required.

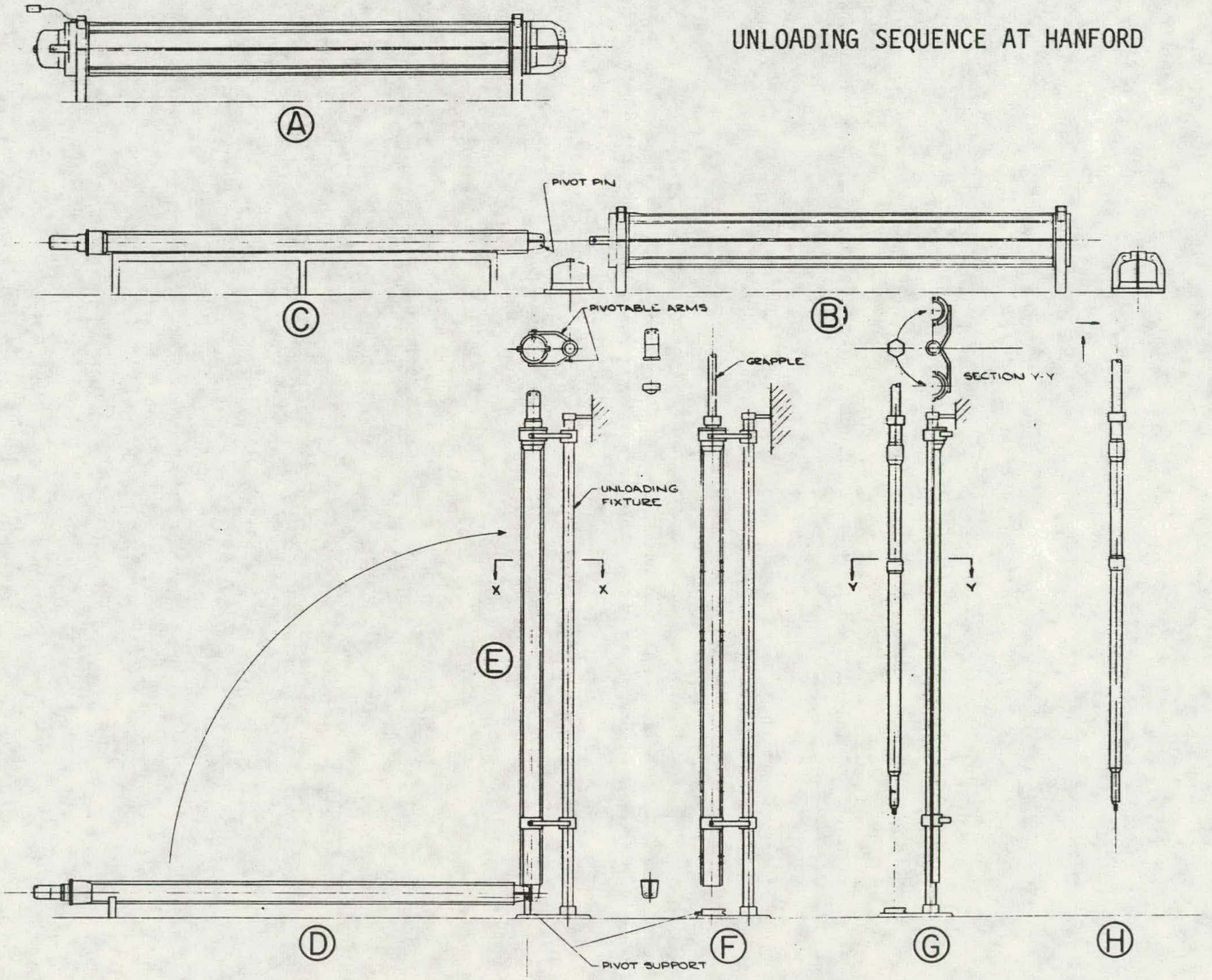
An alternative design being considered has the overpack split lengthwise into two halves. This design would facilitate installation and possible replacement of the cushioning devices and would permit lifting the strongback and fuel assembly out of the opened overpack. Both the inner and outer shells of the overpack would be bolted together for shipment; the inner shell would be bolted through holes in the outer shell, which would then be closed with plugs. Disadvantages of the design are the lesser ease of maintaining cleanliness and the added operating steps. A final decision on the design is expected shortly. Meanwhile, design is continuing with the goal of completing detailed design and safety analysis this calendar year, obtaining a certificate of compliance in 1978, and having containers available for use in 1979.

MAJOR REQUIREMENTS AFFECTING GENERAL CONCEPT

- Support for horizontal assembly
- Maximum 6 g acceleration for 6-inch drop
- Maximum diameter 22 inches
- Vertical or horizontal removal of assembly
- Instrumentation to measure shock
- Shipment in rear-loading trailer
- Minimum size and weight

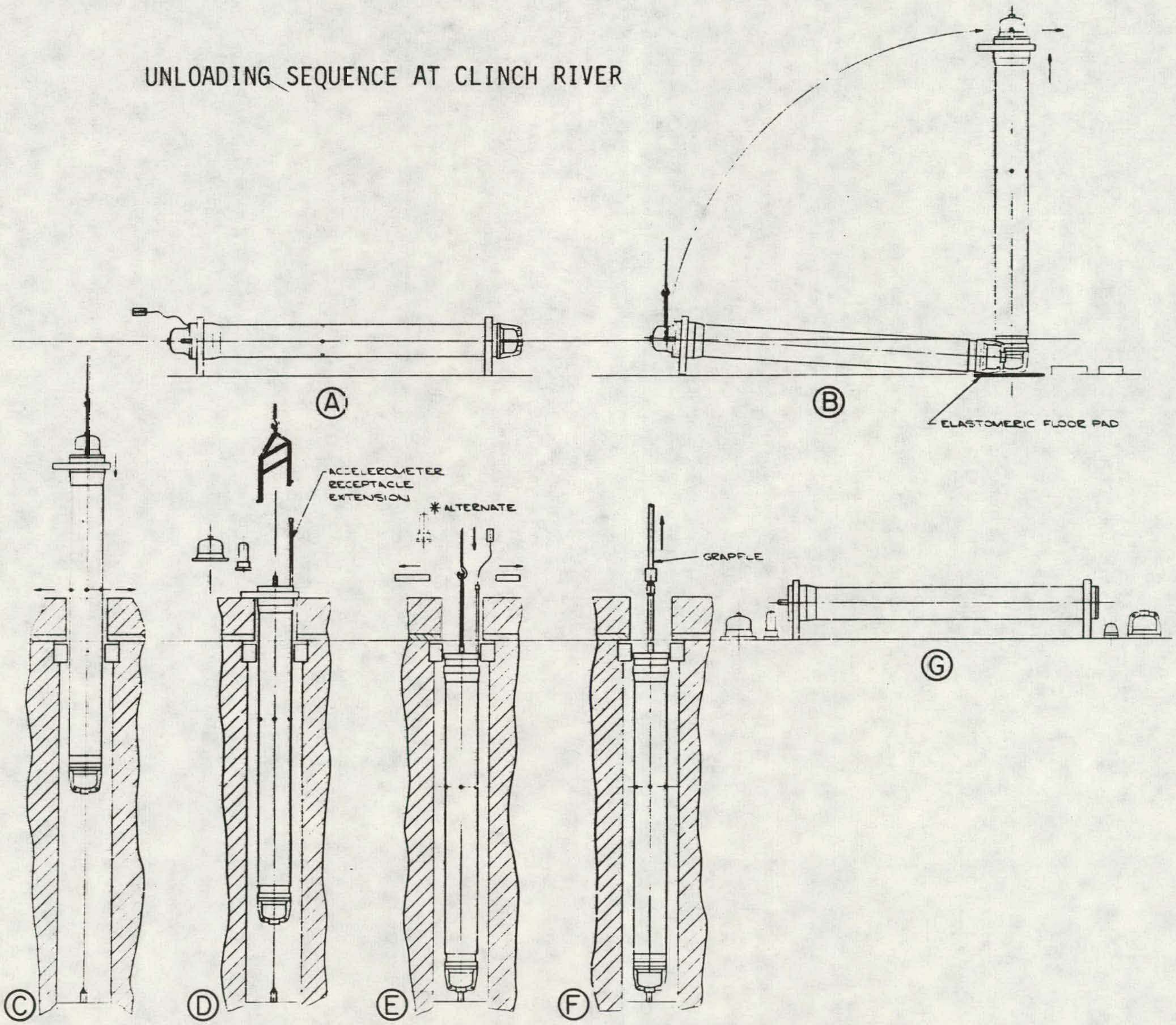
SLIDE 1

UNLOADING SEQUENCE AT HANFORD



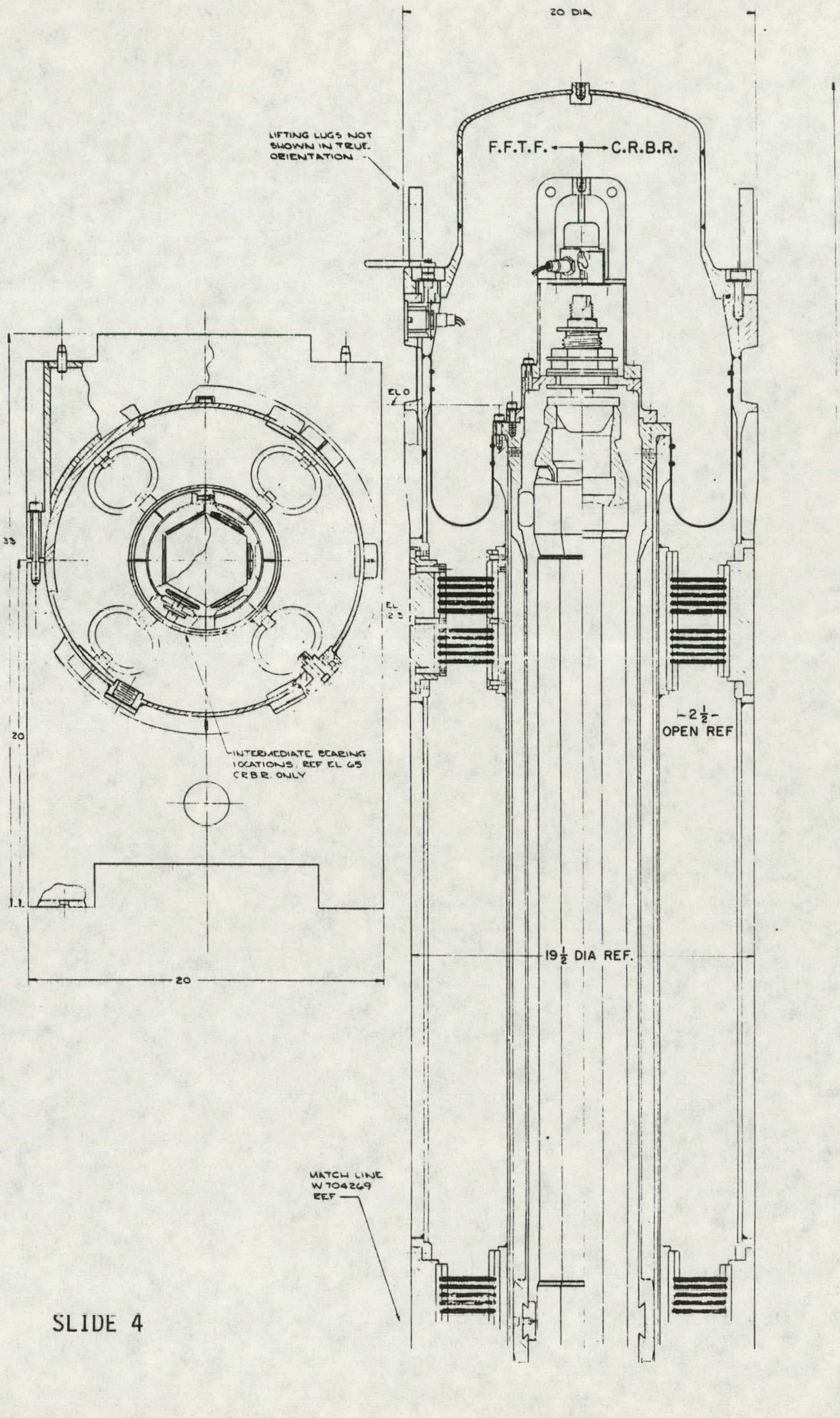
SLIDE 2

UNLOADING SEQUENCE AT CLINCH RIVER



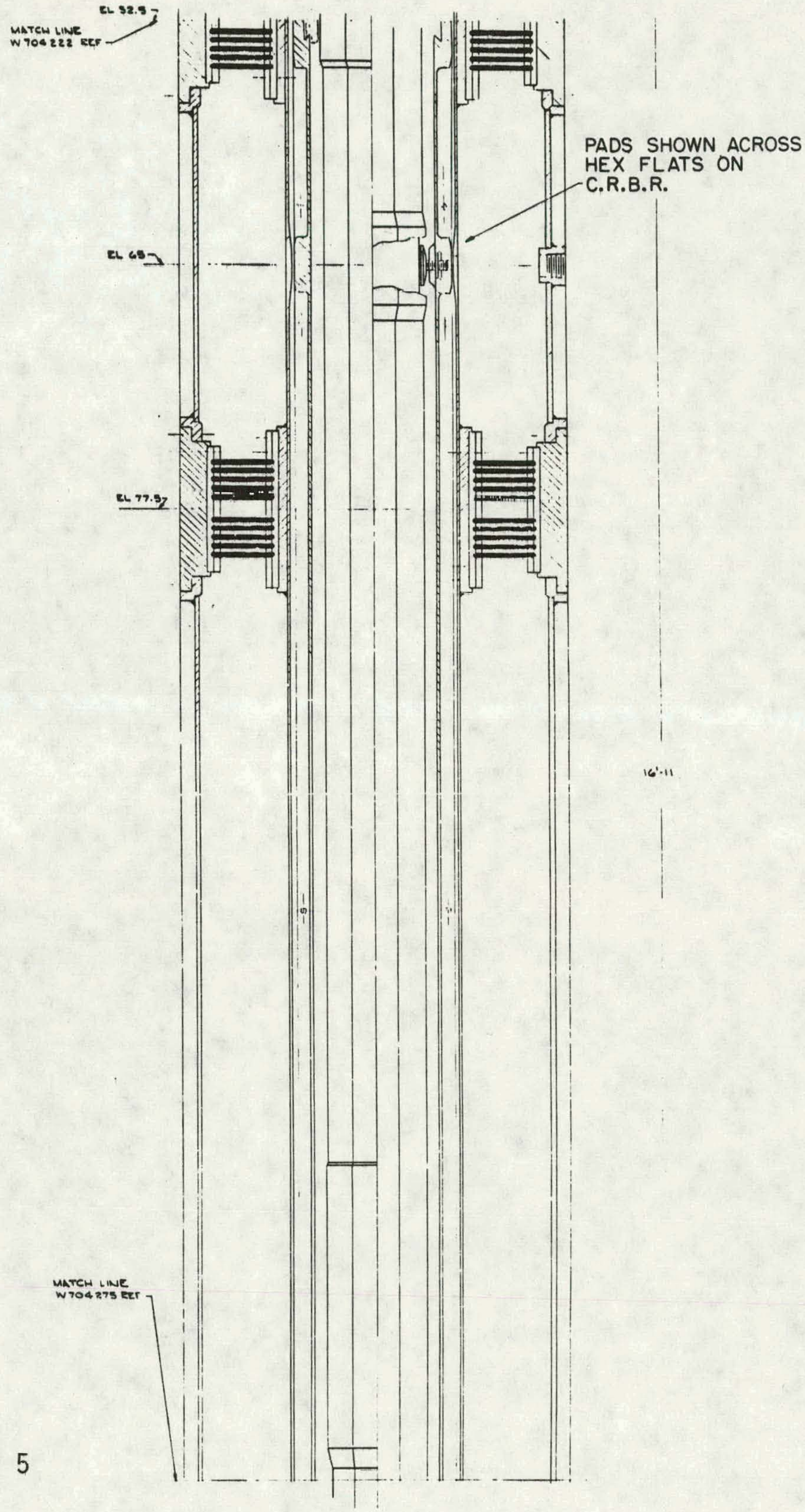
SLIDE 3

UPPER END OF FUEL ASSEMBLY AND CONTAINER



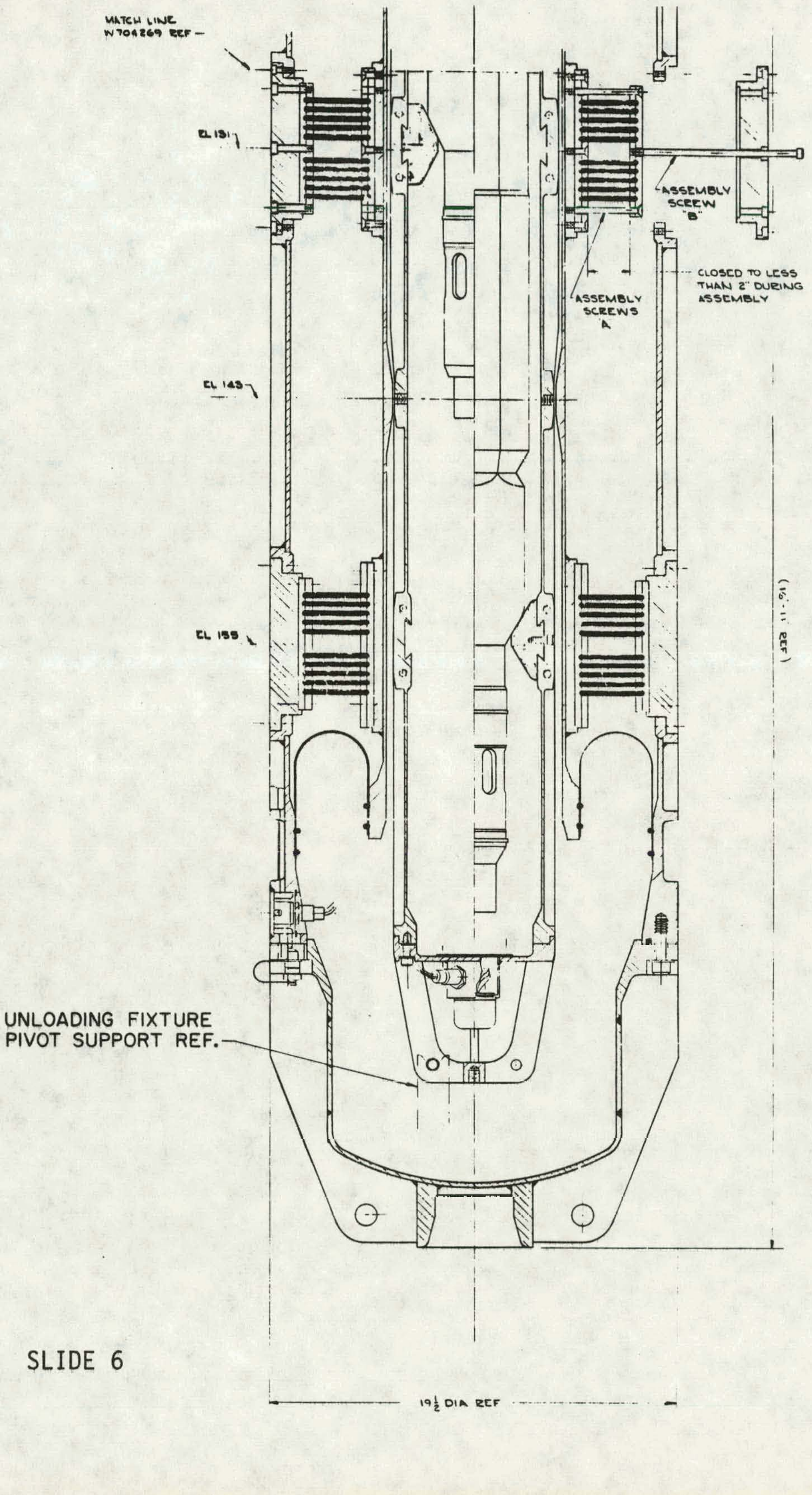
SLIDE 4

CENTER SECTION



SLIDE 5

BOTTOM END OF FUEL ASSEMBLY AND CONTAINER



SLIDE 6