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Revisions history

Rev.	Date	Purpose and record of changes	Prepared by / Checked by
00	04/2012	First issue – Review of document FFDC 04934 revision A – Rod box added for rod type EPR™	
01	See first page	Additional information on characteristics of materials used Modification to Figure 2 illustrating the axial spacer of the EPR™ box Update to table in Paragraph 3 for EPR™ configuration	

1. Purpose

This purpose of this document is to describe the rod boxes that are transported in FCC4 containers. Assembly drawings for these boxes are given in Appendix 1.3-2 of this documentation package. The term "rod channel" is also sometimes used to designate the rod box.

2. General description

2.1. Materials

The components of the rod box, including the axial spacers, are made of type [redacted] stainless steel not sensitive to temperatures between -40 °C and +70 °C and conforming to [redacted] ([redacted] > [redacted] MPa and [redacted] > [redacted] MPa).

The compensating spacers are made of an aluminium alloy [redacted] as per [redacted] or justified equivalent ([redacted] > [redacted] MPa and [redacted] > [redacted] MPa).

The welds of the axial EPR™ spacers are fillet welds with an apothecary of [redacted]mm. A 100% dye penetration test is required during manufacturing.

2.2. Box body

Non-assembled fresh fuel rods are transported by placing the rods in a box which is then inserted into one of the 2 cavities of an FCC4 container.

It is possible to transport 2 fuel rod boxes in the 2 cavities of an FCC container. However, it is not permissible to transport a rod box together with a fuel assembly.

The box body comprises a U-shaped plate closed at both ends and reinforced lengthwise with 2 stringers welded on the upper part of the plate.

Two box body lengths are defined:

- one adapted to the lengths of type EPR™ rods (known hereinafter as an EPR™ rod box),
- the other enabling the transportation of other rods (known hereinafter as an FCC4 rod box).

The arrangements for axial and radial restraint of the fuel rods are described below for these 2 box body lengths.

The horizontal gap between the cavity and the rod box is filled by applying the horizontal pads of the container door against the side of the box.

2.3. Axial restraint of fuel rods for the FCC4 rod box

Where the fuel rods are shorter in length than the box, the gaps are filled with spacers of a length adapted to that of the rods. Axial spacers are thus specified for rods of 12-foot assemblies, 10-foot assemblies or 8-foot assemblies. The rods of 14-foot assemblies are the same length as the FCC4 box and therefore no axial spacers are required.

The rods are loaded in the centre of the box and 2 identical axial spacers are placed at the ends of the box so as to limit the movement of the centre of gravity. The spacers are fixed by means of a screw-and-nut system to the bottom of the box so as not to bear on the rods in the event of an axial drop. The nominal lengths and tolerance intervals of the rods vary according to the design. The screw-and-nut attachment system is therefore adjustable by lock nut so as to limit the axial gap. Figure 1 below shows an axial spacer item 2.

Given the presence of the stringers on the box, the width of the axial spacers cannot be the same as the width occupied by the rods. For this reason an end support plate for rods of greater width is placed between the rods and the spacer (Figure 1 – item 16).

The box is held in position lengthwise in the cavity by means of 2 box spacers (Figure 1 – item 3):

– the one at the bottom end between the container bottom plate and the rod box accommodates the adjustable restraint system of the axial spacer,

– the one at the top end between the container top plate and the rod box also serves to support to the top plate pad, limiting the axial gap between the box and the cavity.

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Proprietary drawing

Figure 1: Axial restraint of rods for the FCC4 rod box

2.4. Axial restraint of rods for the EPR™ rod box

The box is aligned along its axis by adjusting a support plate, which enables the length of the box cavity to be adjusted to the length of the fuel rods.

The rods are loaded and pushed against the base of the box body. At the other end, an end support plate secured to the axial spacer is pushed against the ends of the rods. The spacer is secured using a nut and bolt system holding it in place. This system accommodates the variations in lengths of the rods due to tolerances. Figure 2 below describes the system in question.

Proprietary drawing

Figure 2: AXIAL RESTRAINT OF RODS FOR EPR™ ROD BOX

2.5. Radial restraint of rods

The principle of radial restraint of the rods is the same for the FCC4 rod box and the EPR™ rod box.

The box is filled with full rows of rods. Incomplete rows are completed with inert rods of the same diameter and length.

The minimum spacer height is [redacted] mm (maximum useful height: [redacted] mm).

Loading of [redacted] rows of Ø 10.75 mm rods (maximum load)

Proprietary drawing

The space in the cavity above the fuel rods is filled using a spacer system. This device comprises a principal radial spacer, corresponding to the space above the [redacted] rows of rods (Ø 10.75 mm). Assuming the presence of stringers attached to the box, the width of the radial spacers cannot equal that occupied by the rods. For this reason [redacted] plates are placed side by side between the rods and the radial spacer to cover the width of the rod bundle.

Loading an intermediate number of rows of rods

Proprietary drawing

In the case of filling with rods of diameter less than 10.75 mm or filling with a smaller number of rows, the space is filled by a set of row compensation spacers. This spacer set consists of an upper spacer of the same length as the radial spacer and short intermediate spacers placed at regular intervals between the upper spacer and the radial spacer. These elements are held together by screws of which the heads fit within the thickness of the upper spacer and which are screwed into the radial spacer. The vertical gap between the cavity and the spacer system is filled by applying the vertical pads of the container door.

Loading a small number of rows of rods

Proprietary drawing

In the case of a small number of rows of rods, 2 radial spacers can be stacked together instead of an excessive number of intermediate compensation spacers.

The number of fuel rods transported is limited so as not to exceed the maximum weight per cavity (total weight of box + rods) of 856 kg.

3. Configuration of the rod box

The composition of the rod box for each configuration is defined in the columns of the following table in relation to the type of rods transported. The values are indicated per spacer assembly.

	FCC4 container							
	Fuel rods 17x17 14-foot EPR™	Fuel rods 17x17 14-foot	Fuel rods 16x16 14-foot	Fuel rods 18x18 14-foot	Fuel rods 17x17 12-foot	Fuel rods 15x15 12-foot	Fuel rods 14x14 10-foot	Fuel rods 14x14 8-foot
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

	FCC4 container							
	Fuel rods 17x17 14-foot EPR™	Fuel rods 17x17 14-foot	Fuel rods 16x16 14-foot	Fuel rods 18x18 14-foot	Fuel rods 17x17 12-foot	Fuel rods 15x15 12-foot	Fuel rods 14x14 10-foot	Fuel rods 14x14 8-foot
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	**185**	**185**	**148**	**205**	**185**	**148**	**167**	**222**

***: In the event that a smaller number of rods are transported, [redacted] radial spacers are stacked.**
****: short-handled support plates + long-handled support plates**