ENSA, Equipos Nucleares, S.A. S.M.E.

The ENSA company is recognized among the most important multisystem manufacturers of primary components for nuclear power plants and has the capacity to participate in the manufacture of the primary components of future nuclear power plants of the type that the market and demand require.

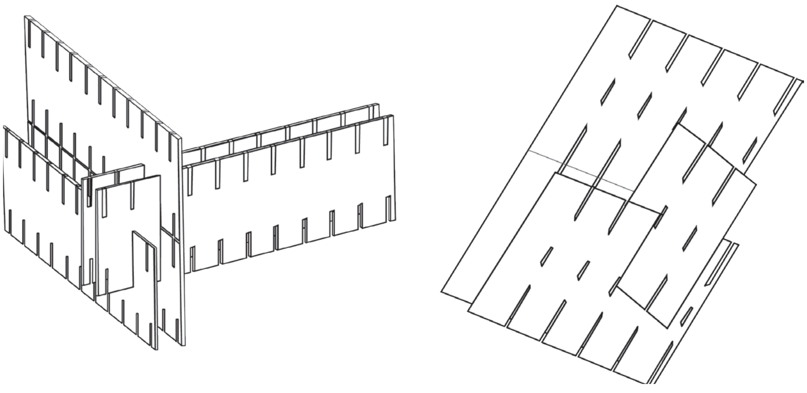
At the same time that it has acquired this global recognition for the supply of primary components, ENSA has been strengthening its commitment and experience in the supply of components for spent fuel storage, be the racks for pools, or storage and transport casks, with own licensed designs for both products.

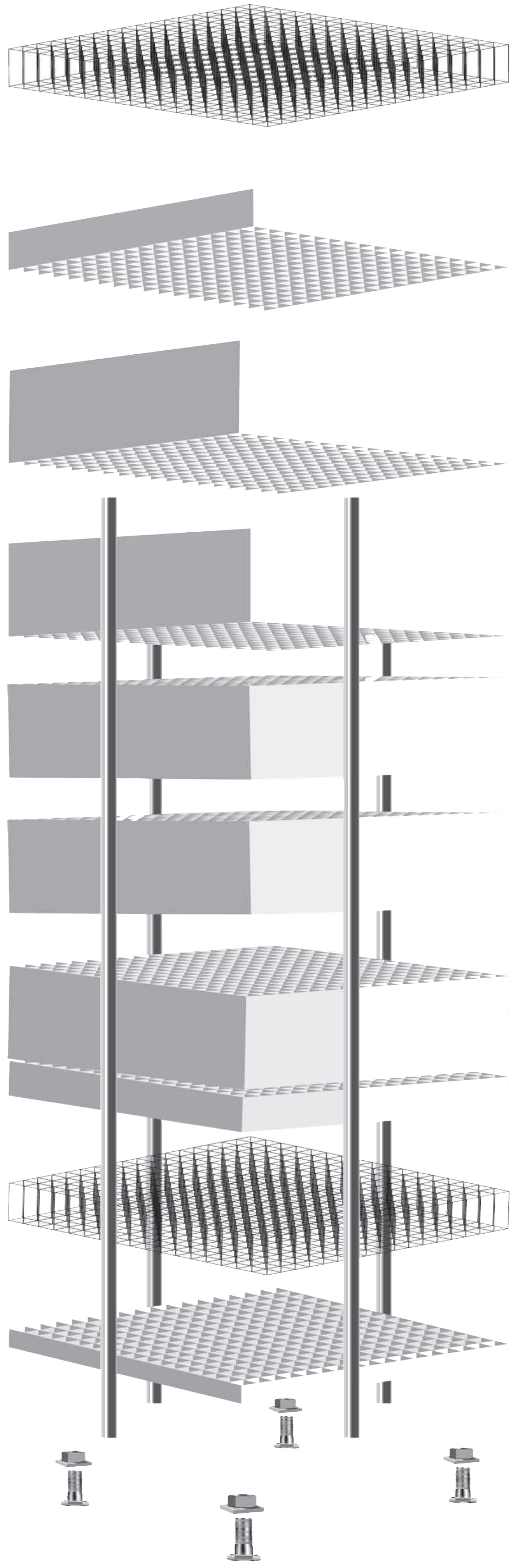
With regard to storage racks in pools, ENSA began its activities in this field at the beginning of the 90s as a manufacturer of racks designed by other systematists, supplying dense racks for the re-racking of the first pools of the Spanish power plants that needed to expand the capacity of their pools. At that time, ENSA had the advantage of a favorable local industrial environment and specifically with the collaboration of ENRESA, which subsequently made it possible to address the international market. In parallel with this “manufacturer” activity, ENSA developed its own design until it reached the current solution, which has patented, and is called “Interlock Cell Matrix”. This design is highly competitive, one of its characteristics being its simplicity of manufacture, and it has undoubtedly contributed to ENSA becoming successful as a designer, manufacturer and installer.

Delivery Year	NPP	NPP Type	Country	Polson Material	Total Qty of Cells	Desing & Licensing	Code
1986	Trillo	PWR	Spain	Welded Borated SS (NO HIGH DENSITY)	592	Others	AS Merk Blatter
	Vandellós 2			SS+Boraflex (AI) (NO HIGH DENSITY)	592		ASME
1992	Sizewell B		United Kingdom		594		
	Almaraz 1		Spain	Welded Borated SS	1.804		
	Almaraz 2				1.804		
1993	Asco 1				1.421		
	Asco 2				1.421		
	Kori 3		South Korea		450		
1996	Philisburg 2 (KKP)		Germany		768		KTA
	Trillo		Spain		533		ASME
1997	Vandellós 2				1.022		
1998	Garoña	BWR			2.600		
	Zorita	PWR			406		
	Ascó I & II				60		
2000	Koeberg 1&2		South Africa	Borated SS	420		
2002	Lungmen 1&2	BWR	R.P.China Taiwan	SS+Borai (AI)	6.152	ENSA	
2003	Olkiluoto I		Finland	Non welded Borated SS	2.610		
2004	Kuosheng		R.P.China Taiwan	SS+Borai (AI)	1.578		
2006	Yonggwang	PWR	South Korea	REGION I: Borated SS	2.604		
				REGION II: Non welded Borated SS			
2008	Ling Ao		R.P.China	Borated SS	1.656		
2007	G.E-ESBWR	ESBWR	USA		*(3504)*		
2009	Cofrentes	BWR	Spain	Non welded Borated SS	3.084		
2014	Olkiluoto II		Finland		1.140		
	Cattenom, Nogent, Penly	PWR	France	Borated SS	1.890		RCCM
2015	Shin Hanul 1&2		South Korea	FRESH: Plain SS	2.270		ASME
				REGION I: Borated SS			
2016				REGION II: Non welded Borated SS			
2017	Olkiluoto I, II	BWR	Finland	Non welded Borated SS	1,470		
2019	Vandellós II	PWR	Spain		780		

Table 1: Ensa’s experience in fuel racks

Figure 1. Construction detail of the Interlock Cell Matrix rack





ENSA has supplied racks in Spain, France, Finland, Taiwan, Korea, China and licensed in the United States, with GE-Hitachi, the spent fuel element storage racks for the ESBWR reactor design. As can be seen in table 1, ENSA has supplied frames for spent fuel elements for 26 different nuclear reactors, of which 9 are in Spain and 17 are in the international market. ENSA has manufactured most (see the same table) of the rack technologies that exist on the market and currently has patented, in most countries, a design called “Interlock Cell Matrix”, whose constructive fundamental characteristics are shown in Figure 1.

The Interlock Cell Matrix design consists of a grid of sheets cut with great precision by laser, which are joined at various heights to form the frame. Those plates are made of stainless steel in their perimeter part, and those of the interior are made of borated stainless steel. The welds that give rigidity to the set are made only in the first height, and in the perimeter plates.

We also want to make a brief review, due to its importance and specific weight in ENSA’s offer of services to the technology it has developed for the assembly of the racks, when a change (re-racking) is required, in the case of pools of nuclear power plants that are in operation.

ENSA, differently from other suppliers, mainly in the United States, has developed a technology that performs the installation by means of remote control without the need for divers. This allows the radiation dosimetry metered to be less than half of that with divers, and an exponential reduction in the amount of waste generated during the operation

Regarding containers (casks) for storage, transport, or dual (storage and transport), ENSA has large experience in both the national and international markets.

Before mentioning ENSA's experience in this sector, it is worth reviewing the two main fuel casks technologies used today:

• Concrete casks ("canister" type system) that mainly consist of a stainless steel capsule with a welded lid and a low thickness wall, which stores spent fuels. In turn, this capsule is surrounded by a thick envelope that is usually composed of carbon steel sheets that contain a special composition concrete (the main shielding element).

• Dual-purpose metal casks, composed of a main body that is generally a metal vessel (ferrule welded to a bottom) that contains the frame with the fuels. It usually has two or more caps bolted to the main body, and also an envelope attached to the body itself that contains a polymer that acts as a shield for the neutrons. (Figure 3 is an example of this type of container).

As can be seen in Table 2, ENSA's experience is dominant in the national casks supply market, where ENSA is the main supplier of the ENRESA company.

ENSA supplies dual-purpose metal casks of its own design to the Trillo, Almaraz, and Santa María de Garoña plants, with the company also being in charge of loading said containers. On the other hand, ENSA manufactures and loads concrete casks designed by third parties for the José Cabrera and Ascó plants.

ENSA began the development of a metal cask for the Trillo plant in 1991, with the help of the North American company NAC (Nuclear Assurance Corporation). In 1992 ENRESA entrusted ENSA with the design and support for the licensing of a cask capable of storing and transporting spent fuel from the Trillo nuclear power plant, based on the NAC-STC design. From this collaboration emerged the DPT cask, of which there are currently 32 units loaded in the Individualized Temporary Storage (ITS) of the nuclear plant. By resolution of the General Directorate of Energy dated October 23, 1997, the dual-purpose cask ENSA-DPT (for the transport and storage of fuel) was approved as a "package" model for type B transport (U) F in accordance with the Spanish transport regulations, that is, radioactive packages of the type B (U) that have to withstand the conditions of accident for fissile contents (F). This was the first time that a metallic cask for the storage and transport of dry irradiated fuel has been licensed in Spain. The DPT cask is essentially composed of two stainless steel ferrules between which there is a layer of lead. Inside, the frame is made up of stainless steel tubes joined by a structure of stainless steel discs and aluminum discs.

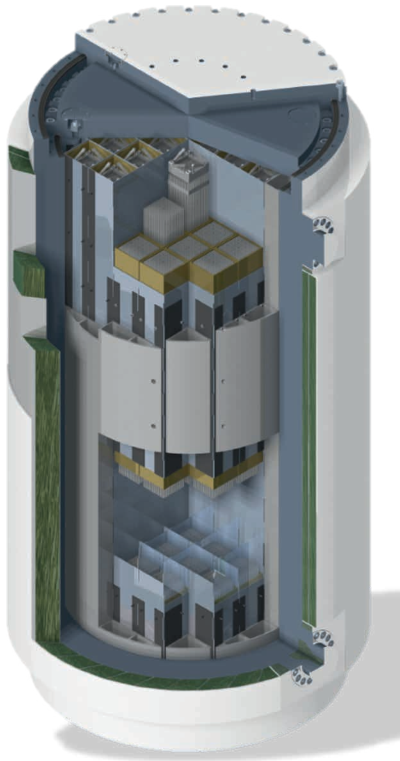


Figure 2. Main components of the ENUN cask

customer	Contract Year	Qty.
ENUSA		15
Nutech		8
NAC International Inc.		1
Vectra		1
NAC International Inc.		5
		1
Nutech		5
ENUSA		3
ENRESA	1990	1
		1
ENUSA	1993	15
ENRESA (Design)	1998	2
Hitachi	2001	1
		1
Transnuclear West	2000	1
NAC International Inc.	2001	2
Transnuclear West		1
Hitachi		1
Transnuclear West	2003	29
ENRESA	2000	6
	2003	4
	2005	4
	2007	6
Transnuclear West		20
Hoitec International	2004	1
		12
		10
	2011	4
ENRESA	2009	6
	2011	4
Hoitec International	2010	10
		10
ENSA		1
ENRESA	2012	5
CGNPC- URC	2013	1
Transnuclear Int.	2014	4
Hoitec International		7
		7
ENRESA	2015	10
Hoitec International	2017	4
		4
	2018	10
		10
ENRESA	2020	24
		44

Subsequently, in the first decade of the 2000s, ENSA developed a new cask design in order to respond to the increasingly demanding requirements of nuclear power plants, an increase

Tabla 2. ENSA's experience in fuel containers

Equipment	Type	Model	NPP	Owner / User	country	Delivery	Fuel	Designer
Cask		MCC4			Spain	1985	Fresh Fuel	Westinghouse
Canister	Dry Shielded	Nuhoms system	H.B. Robinson Nuclear Generating Station	Carolina Power & Light	USA	1987	Spent Fuel	Nutech
Cask			Surry Power Station	Dominion Resources Inc. (VEPCO)	USA	1990		NAC International Inc
	Transfer		Oconee Nuclear Station	Duke Energy	USA	1989		Vectra
	Transport				USA	1990		NAC internacional Inc
					USA	1990		
Canister	Dry Shielded		Oconee Nuclear Station	Duke Energy	USA	1989-1990		Nutech
Cask		MCC4			Spain	1990	Fresh Fuel	Westinghouse
	Scale model 1:4	ENSA-NAC			Spain	1990	Spent Fuel	Ensa
		ST26	Central Nuclear Almaraz I	CNAT	Spain	1992-1997		NAC
		MCC4			Spain	1993	Fresh Fuel	Westinghouse
	Dual Purpose	ENSA-DPT	Central Nuclear Trillo I	CNAT	Spain	1999-2001	Spent Fuel	Ensa
	Scale model 1:3	HIEN 69			Japan	2001		Hitachi- Ensa
Basket	Prototype 1:1				Japan	2001		
Cask	Transfer	NUHOMS OS-197-1	Susquehanna Steam Electric Station	Pennsylvania Power & Light	USA	2002		Transnuclear West
	Dual Purpose	NAC-STC	Daya Bay Nuclear Power Plant	CNNC Everclean	China	2003		NAC International Inc.
	Transfer	HUHOMS OS-197-1	San Onofre Nuclear Generating Station	Southerm California Edison	USA	2002		Transnuclear West
	Prototype 1:1	HIEN 69FA			Japan	2003		Hitachi- Ensa
Failed Fuel Canister	Dry Sorage	For 24PT1 DSC cask	San Onofre Nuclear Generating Station	Southern California Edison	USA	2003	Damaged Fuel	Transnuclear Int.
Cask	Dual Purpose	ENSA-DPT	Central Nuclear Trillo I	CNAT	Spain	2002-2004	Spent Fuel	Ensa
				CNAT	Spain	2004-2005		
				CNAT	Spain	2006-2007		
				CNAT	Spain	2009-2011		
		TN-68	Peach Botton Atomic Power Station	Exelon	USA	2009-2012		Transnuclear Int.
	Transfer	HI-TRAC 100Z	Central Nuclear José Cabrera	Unión Fenosa	Spain	2010		Holtec International
	Overpack	HI-STORM 100Z		Unión Fenosa	Spain	2010		
Canister	Multi Purpose	MPC-32Z		Unión Fenosa	Spain	2010		
Cask	Overpack	HI-SAFE 100Z		Unión Fenosa	Spain	2013		
	Dual Purpose	ENSA-DPT	Central Nuclear Trillo I	CNAT	Spain	2012-2014		Ensa
				CNAT	Spain	2014-2016		
	Overparck	HI-STORM 100S	Central Nuclear Ascó I & II	ANAV	Spain	2012		Holtec International
Canister	Multi Purpose	MPC-32		ANAV	Spain	2012		
Cask	Scale Model 1/3	Ensa ENUN 32P			Spain	2010		Ensa
	Dual Purpose	Ensa ENUN 52B	Central Nuclear Garoña	NUCLENOR	Spain	2014-2017		
		Ensa ENUN 24P	Daya Bay, Ling Ao, Qinshan phase II	CGNPC- URC	China	2016		
		TN-81	Vendellós I	ENRESA	Spain	2016	Vitrified Waste	Transnuclear Int.
Canister	Multi Purpose	MPC 32	Central Nuclear Ascó I & II	ANAV	Spain	2016	Spent Fuel	Holtec Interational
Cask	Overpack	HI-STORM 100		ANAV	Spain	2016		
	Dual Purpose	Ensa ENUN 32P	CN Trillo I, CN Ascó I & II, CN Vandellós II	CNAT / ANAV	Spain	2017-2019		Ensa
Canister	Multi Purpose	MPC 32	Central Nuclear Ascó I & II	ANAV	Spain	2018		Holtec International
		HI-STORM 100		ANAV	Spain	2018		
		MPC 32		ANAV	Spain	2019-2020		
		HI-STORM 100		ANAV	Spain	2019-2020		
Cask	Dual Purpose	Ensa ENUN 32P	Central Nuclear Almaraz	CNAT	Spain	2025		Ensa
		Ensa ENUN 52B	Central Nuclear Garoña	NUCLENOR	Spain	2025		

in container capacity and a search for competitiveness. Out of this effort came the ENUN cask. In addition to the reasons mentioned, the ENUN cask provides an adequate response to the scenario set out in the current waste management plan whereby spent fuels would be transported to the Centralized Temporary Storage Facility (CTSG), to be later transferred to capsules in a hot cell. ENSA has obtained authorization to use (license approval) for three designs of the ENUN casks: the ENUN 32P, the ENUN 52B and the ENUN 24P.

The ENUN cask consists mainly of a ferrule composed of one or two carbon steel forgings that are welded together and welded to the bottom of the container (also carbon steel forging). Inside, a coating is applied to guarantee protection against corrosion when the container is submerged in the water from the power plant pool. In addition, it has two bolted lids (also made of carbon steel forging) whose joint seating surface, as well as that of the container body, are covered by a stainless steel cladding. The body of the container is perimeter surrounded by extruded aluminum profiles into which a polymer containing boron carbide is poured, which has neutron shielding properties. Finally, the set of perimeter profiles is held by a carbon steel sheet casing that is coated with epoxy paint, that is easy to decontaminate.

Inside, the container frame is made of stainless steel sheets that form a grid (similar to that of fuel racks mentioned above) and which is surrounded by screwed extruded aluminum profiles that give the set its cylindrical shape and favor the extraction of heat. In turn, each cell has a square tube made of an aluminum matrix composite material that contains a certain concentration of boron carbide, which ensures that the fuels will be stored in a subcritical condition (without nuclear reaction). Such square tubes are manufactured from sheets joined by welding.

The ENUN cask can be adapted to the needs of each plant. Thus, for example, in the case of Trillo and Almaraz, the ENUN 32P cask has capacity for 32 PWR fuel elements, and at the Santa María de Garoña plant the ENUN 52B container has capacity for 52 BWR elements.

Figure 3. ENUN container body welding

The ENUN container is currently in use at the Trillo and Almaraz plants. Additionally, there are loads planned in 2021 for the Santa María de Garoña plant.

ENSA has contracts for the supply of ENUN casks for these plants: Trillo (14 ENUN 32P casks), Almaraz (20 ENUN 32P casks) and Santa María de Garoña (49 ENUN 52B casks).

In addition to the casks, ENSA also designs and manufactures the auxiliary equipment used for their loading and handling, such as, for example, the transport cradle, the load yoke, the drying and inerting equipment, the impact limiters, etc.

Limiters provide impact defense for the cask and are composed of a stainless steel sheet ("skin"), which contains polyurethane foam and aluminum in a hexagonal structure (honeycomb), and have very good properties of absorption of energy to be deformed.

The cask export market presents great challenges for ENSA. In the United States, the market has evolved to concrete casks, with few exceptions such as the case of the Peach Bottom plant for

Figure 4. Rack assembling

which ENSA was awarded in 2007 the supply to AREVA / TN of 20 TN68 type casks.

In China, ENSA has managed to adapt the design of its ENUN cask to the specific requirements of the Chinese regulator, resulting in the ENUN 24P cask. This container has the particularities that a separation between the fuels has been implemented in the frame that improves the criticality properties and, on the other hand, a management system based on a "female" type trunnion has been used to allow the diameter reduction of the

Figure 5. Image of the ENUN 32P containers.

impact limiter, an additional protection that the cask carries in its transport mode.

In Europe, with some exceptions, metal casks continue to be mainly used, but exporting the ENUN cask is being complicated for ENSA, as it is a mature market in which technological solutions from other designers are already implemented.

In Japan, ENSA started the participation in the design and manufacturability of a double-purpose metal cask for 69 BWR (HIEN) elements, made of carbon steel and single wall, together with the Japanese company Hitachi Ltd in January 2002. This container has been licensed in Japan by Hitachi Ltd.

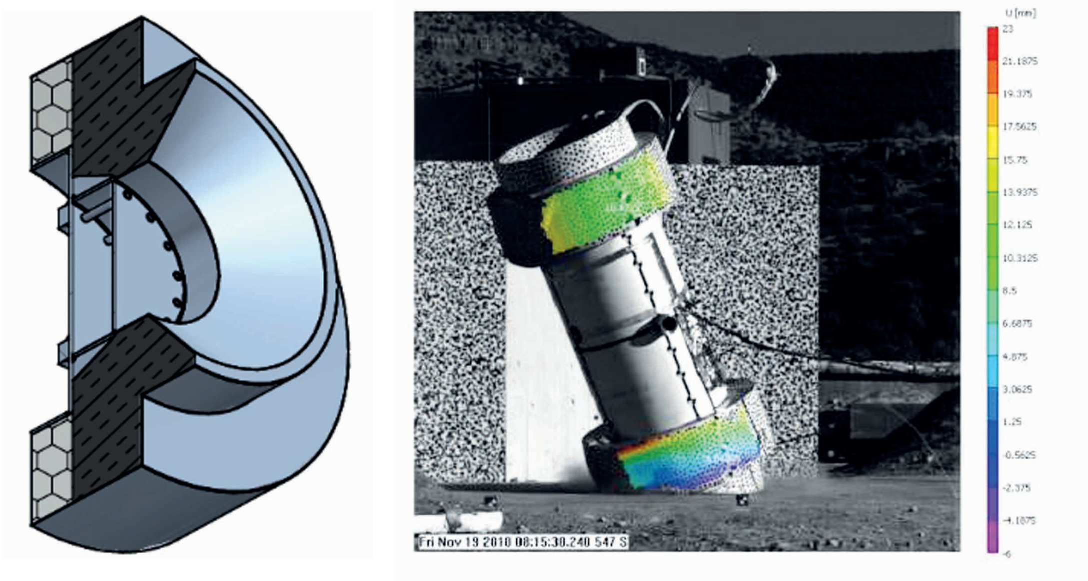


Figure 7. Detail of the impact limiter and drop test of the 1/3 scale model of the ENUN container

ENSA's participation in the design was focused on the contribution of its experience in design, in the preliminary phases of thermal and structural calculations, in the verification of the final mechanical and thermal calculations, as well as in all the design solutions that have been using until reaching their final definition. The development was successful and TEPCO (the Japanese power company) awarded Hitachi the supply of 50 casks from 2011 to 2020. The following table summarizes the characteristics of ENSA's casks

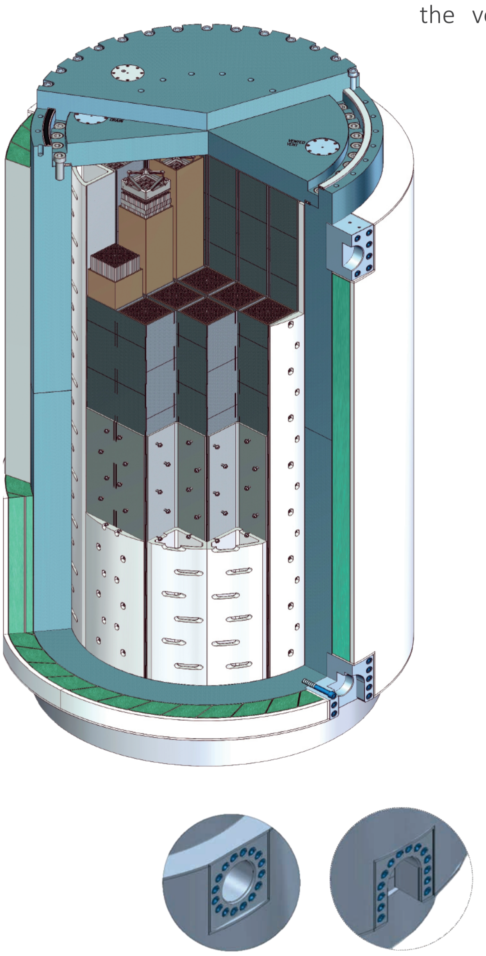


Figure 6. ENUN 24P cask and detail of the "female" type trunnion concept.

Table 3. Characteristics of the casks designed by Ensa

Attribute	HIEN 69	ENSA-DPT	ENUN 32P	ENUN 52B	ENUN 24P
Purpose	Storage Transport	Storage Transport	Storage Transport	Storage Transport	Transport
Capacity (FA)	69	21	32	52	24
Fuel Types	BRW	PRW	PRW + NFH	BWR	PWR
Loaded Weight- Storage Conditions (Tons)	121	105	120	72	-
Overall Length- Storage Condition (m)	5.3	5	5	4.8	-
Overall Cross Section- Storage Condition (m)	2.5	2.4	2.7	2.1	-
Distance between Trunnions (m)	2.8	2.4	2.8	2.2	2.5
Loaded Weight w/Impact Limiters Transport Condition (Tons)	132	113	137	82	121
Overall Length w/Impact limiters Transport Condition (m)	6.8	6.7	8.3	7.6	7.9
Overall Cross Section w/Imact Limiters Transport Condition (m)	3.6	3.2	3.8	3.2	3.3
Heat Rejection (kW)	12.1	27.3	36.2	13	39.3
Maximum Burnup (GWd/MTU)	40	49	65	37.5	57
Maximum Enrichment U-235 (%)	3.1	3.7	49	3	5
Minimum Cooling Time (years)	18	9	7	22	3
Body Material	CS	SS / Lead / SS	CS	CS	CS
Basket Material	BSS + Al	SS + Al + MMC	SS + Al + MMC	SS + Al + MMC	SS + Al + MMC
Gamma and Neutron Shield	CS + Resin	SS/Lead/SS+Resin	CS + Resin	CS + Resin	CS + Resin
Lids	Triple Lid (CS)	Double Lid (SS)	Double Lid (CS)	Double Lid (CS)	Double Lid (CS)
Cask Sealing	Double Metallic O-rings in lids	Two Single Metallic O-rings in lids	Double Metallic O-rings in lids	Double Metallic O-rings in lids	Double Metallic O-rings in lids

CS: Carbon Steel
SS: Stainless Steel
BSS: Borated Stainless Seel
MMC: Metal Matrix Composite

All the information included in this technical report has been provided by ENSA