CASTOR â - Casks to be Used for Interim Dry Storage and Transport of SOGIN Spent Fuel in Italy

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1. Introduction

After shut-down of all Italian, commercial operated NPP´s a large amount of irradiated FA´s spent fuel, which are not covered by existing or future reprocessing contracts, are currently stored at fuel pools of 3 different nuclear installations. The Italian energy group ENEL decided to rely on on-site dry storage waiting for the availability of the National Interim Storage site availability.

In the course of ENEL group privatization the Company SOGIN (**So**cietà **G**estione **I**mpianti **N**ucleari SpA, Rome, Italy) was created in charge of all decommissioning activities.The Company has now

	Type	Designer	MWe	Commercial Operation	Plant Shutdown
Latina	Gas Graphite	TNPG	200	1963	1986
Garigliano	BWR Dual Cycle	General Electric	150	1964	1978
Trino	PWR	Westinghouse	260	1964	1987
Caorso	BWR	AMN - GETSCO	860	1978	1986

been moved out of the ENEL group and is now completely controlled by the Italian Government.

SOGIN has ordered in the year 2000 a total of 30 CASTOR® casks for the on site storage of the spent fuel and a later transport to the national centralized interim storage facility.

The tailored cask design is based on the well established and proven design features of CASTOR® reference casks and is responsive to the needs and requirements of the Italian fuel and handling conditions. In parallel SOGIN is proceeding with the design of the on-site temporary storage facilities.

2. Current Situation in Italy

As a consequence of a national referendum in 1987 the Italian Government decided the definitive closure all NPP's operating in Italy. This decision affected directly and mainly ENEL, as the only Italian utility and owner of all NPP's, but evidently also the Italian industry as well as other nuclear structures and activities, such as ENEA, the National Agency with specific responsibilities in the nuclear R&D, including activities in the field of fuel cycle.

At that date 4 NPP's were officially in operation, i.e. Caorso (BWR, 870 MWe), Trino V. (PWR, 270 MWe), Latina (Magnox, 160 MWe) and Garigliano (BWR, 160 MWe, which, however, was not operating since 1978 for plant modifications). Two other unit construction (Alto Lazio, BWR 1000 MWe) was almost complete (about 70%) and activities for the construction of additional 2 units on the Trino site (standard 1000 MWe PWR) were started. All these plants and activities were immediately suspended and never restarted again.

At that time ENEL's strategy for spent fuel was reprocessing and contracts were in place with BNFL. At the beginning of '90 ENEL decided on the basis of technical and economical evaluations, while honouring the reprocessing contracts already in place, to change the policy and to proceed with the Interim dry storage of the remaining spent fuel.

The current inventory of spent fuel to be considered in Italy is presented in the following table.

Quantities		NPP	Current location	Temporary storage	Final Destination
N° elements	t/HM				
1032	190,4	Caorso	Caorso	Caorso	Centralized SF
47	14,5	Trino	Trino	Trino	Centralized SF
49	15,1	Trino	Avogadro	Trino	Centralized SF
63	12,9	Garigliano	Avogadro	Trino	Centralized SF
262	53	Garigliano	Avogadro	N/A	Reprocessing (BNFL)
252	62	Superfenix	Superfenix	Superfenix	Centralized SF
52	2,0	Trino	Eurex	Eurex	Centralized SF
1	0,063	Garigliano	Eurex	Eurex	Centralized SF
64	1,680	Elk River	ITREC	ITREC	Centralized SF
N/A	0,116	Varied	Casaccia	Casaccia	Reprocessing (UKAEA)

The above table includes also the fraction of Superfenix spent fuel of SOGIN property and some spent fuel held by ENEA (the Italian Governmental Research organization) in its laboratories Eurex, ITREC and Casaccia.

3. SOGIN current policy for the dry storage of nuclear spent fuel

The policy, which has been chosen by ENEL and now endorsed by SOGIN for the disposal of its spent fuel not covered by existing or future reprocessing contracts, includes the following phases:

1. No upgrading of the current handling capacities of the Trino and Caorso cranes and preparation of the storage buildings,
2. Loading the spent fuel into the casks in the spent fuel pools of Avogadro, Trino and Caorso,
3. Transport of the casks from Avogadro (Saluggia) to the Trino NPP site,
4. Temporary storage of those casks at Trino and Caorso plant sites in a protected building, which can assure the avoidance of any interference with the decommissioning activities, for the time strictly necessary to make a National Interim Storage Facility available, according to Governmental schedule,
5. Transfer of the casks to the National Interim Storage Facility, where they will be stored for the time necessary to make a final disposal site available.

4. Cask Concepts

The principle of the Dry Storage Cask Concept is the safe confinement of the spent fuel assemblies in CASTOR® casks with a high inherent safety potential, even against extreme accident conditions such as airplane crash.

Very extensive studies performed in Germany and world-wide and experience have demonstrated the enormous advantages of the CASTOR® dry storage cask concept. The main advantages are:

- very low release of activity during storage,
- splitting of total activity according to the number of casks,
- all safety-related aspects are guaranteed by the casks themselves, including accidents ,
- no water chemistry, no secondary wastes are generated,
- storage of failed fuel assemblies is possible in the casks,
- repeated use of the casks or recycling (e.g. for use in nuclear industry, final disposal casks and others),
- long-term storage of fuel assemblies in inert atmosphere,
- small initial investment, splitting of further investment as required.

The following specific features characterize the cask storage concept:

- The radioactive materials are sealed leak tight in the casks; the release of radioactive materials will occur far under the demanded limits of the storage licensing requirements, even after an unlikely accident such as an impact or severe earthquake;
- The decay-heat is removed by inherently safe natural convection; no exhaust air or other cooling media are necessary;
- No safety-related buildings and equipment are needed, as all safety functions will be accomplished by the cask itself;
- Relatively short manufacturing times for the casks are needed.

The cask design proposed for the specific spent fuel is based upon the same concept as for Germany and the international market, which is described in the following. The CASTOR® casks are designed for transport and storage of spent fuel assemblies and have to fulfill the requirements for handling and storage at the several facilities as well as the IAEA regulations for type B(U)F package designs. The main components and their functions are:

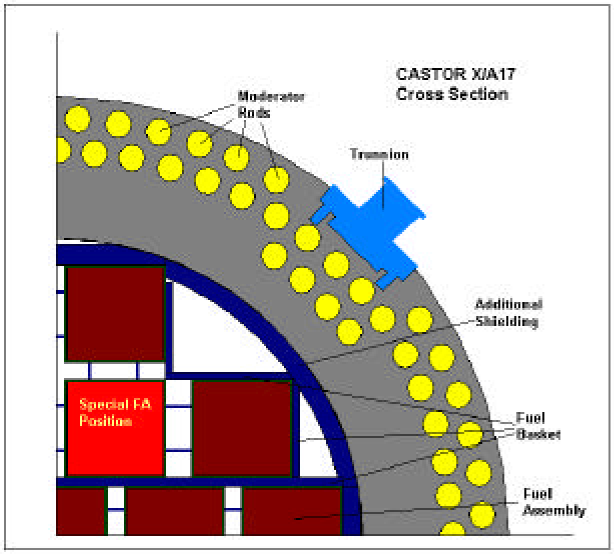
- Cask body made of ductile cast iron
  - gamma and neutron shielding,
  - structural component,
  - heat transfer through wall and from surface to ambient air,
  - part of the confinement system;
- Basket made of stainless steel or aluminium (partially borated)
  - criticality safety under all circumstances,
  - heat transfer from fuel assemblies to cask body,
  - structural component;
- Primary and secondary lids made of stainless steel with bolts and metallic seals
  - gamma and neutron shielding,
  - structural component,
  - part of the confinement system;
- Trunnions made of stainless steel
  - structural component for handling;
- Impact limiters for transportation on public ways only, made of carbon steel and wood
  - structural component to reduce the shock loadings during type B(U) test conditions and under accident conditions.

4.1 CASTOR® X/A17

The CASTOR® X/A17 cask is designed to accommodate up to 17 PWR-FA (uranium and MOX), which were irradiated at the NPP Trino as well as 17 bottled BWR-MOX-FA form NPP Garigliano. The cask is suitable for loading at the "Avogadro"-facility at Saluggia and the NPP Trino, transportation on public ways and storage at the on-site temporary facility at Trino as well as at the National Interim Storage Facility. Due to the handling requirements the mass of the handling configuration is limited to approx. 60 Mg.

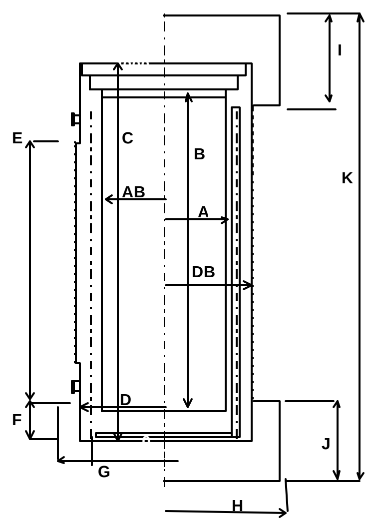
Especially for this cask design it was considered that a portion of the long term stored fuel pins cladding of the BWR Garigliano MOX fuel was defected . For these reasons all Garigliano FA's are placed in the pool within sealed bottles.

Figure 1: Cask Body with Moderator Rods Surrounding the Fuel Basket (the "special FA position" is intended for the four FAs in the cask that are highest in source-term, i.e. consist of high-burn-up or MOX fuel).



The main dimensions and masses are indicated at the following table:

Dimension [mm]		
Cavity diameter	A	1315
Cavity width	AB	1315
Cavity length	B	3350
Total bottom wall thickness		300
Total cask length w/o impact limiter	C	4029
Total side cylindr. wall thickness		305
Total side flat wall thickness		300
Outer diameter	D	1910
Outer width	DB	1925
Trunnion center line distance	E	2850
Distance trunnion / cask bottom	F	570
Excentricity of bottom trunnion		30
Turning radius - bottom side		1155
Width across trunnions	G	2105
Diameter of outer recess of trunnion		120
Length of outer recess of trunnion		10
Diameter of 1. recess of trunnion		100
Length of 1. recess of trunnion		80
Diameter of 2. recess of trunnion		120
Length of 2. recess of trunnion		0
Outer diameter impact limiter	H	2510
Length top impact limiter	I	950
Length bottom impact limiter	J	860
Total length with impact limiter	K	4959
Data Sheet	Var.	Rev.
Transport and Storage Cask	C	6
CASTOR X/A17	Date	16.05.01
	Author	Nöring



Masses kg rsp. Mg	
Number of F/A	17
Number of CB	0
A. Mass of Components [kg]	
Cask body	36862
Basket	7620
Inventory	7633
Primary lid, bolts, moderator	3289
Secondary lid, bolts	1857
Cover plate, bolts	2078
Trunnions, bolts	100
Water during loading	2654
Impact limiter	6522
Bouyancy during loading	7790
Auxilary equipment	1000
B. Handling mass [Mg]	
At the pool[1)]: with Water, PL Aux. Eq., w/o Bouyancy	59,2
loaded, with PL, SL w/o water, Aux. Eq.	57,4
C. Transport configuration [Mg]	
loaded, with impact limiter without sec. lid, cover plate	62,0
loaded, with impact limiter without cover plate	63,9
D. Storage Configuration [Mg]	
loaded with cover plate, without impact limter	59,4
[1)] Saluggia	

In order to minimize the number of casks needed for the decommissioning program the well known data of the existing FA´s were taken to optimize loading patterns:

- Three casks were loaded at the NPP Trino after a decay time of min. 15,3 years at the fuel pool with a total of 47 MOX- (burnup up to 32,5 GWd/t, initial enrichment 4.5 % Pu fiss) and Uranium-PWR-FA´s (low burnup up to 12,5 GWd/t; high initial enrichment 4.5 % U-235) from NPP Trino. Two of these casks were loaded heterogeneously with each 4 MOX-FA´s. After loading these casks will be stored at the on-site temporary facility at Trino.

- Three casks were loaded at the "Avogadro"-facility at Saluggia after a decay time of min. 25,1 years at the fuel pool with a total of 49 Uranium-PWR-FA´s from NPP Trino (burnup up to 30 GWd/t; initial enrichment 4.0 % U-235). After loading it is intended to ship these casks to the NPP Trino and store them their at the on-site temporary facility.

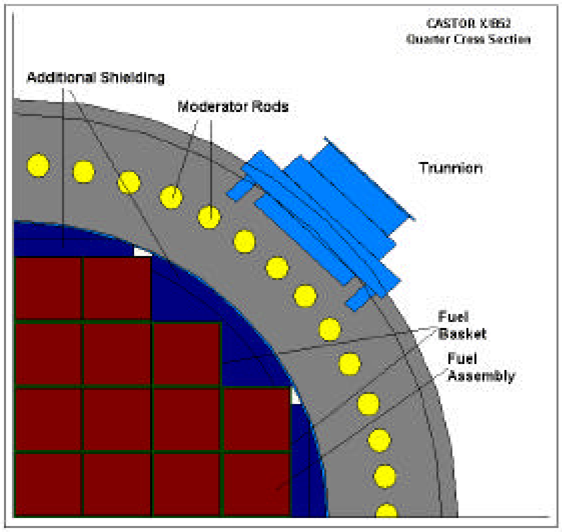
- Four additional casks were loaded at the "Avo -facility at Saluggia after a decay time of min. 23,9 years at the fuel pool with a total of 63 bottled MOX-BWR-FA´s from NPP Garigliano (burnup up to 25 GWd/t; initial enrichment 3.0 % Pu fiss). After loading it is also intended to ship these casks to the NPP Trino and store them their at the on-site temporary facility.

4.2 CASTOR® X/B52

In the frame-work of the decommissioning concept for the NPP Caorso the 1032 irradiated BWR-FA´s, which are currently stored at the fuel pool have to be removed from the plant in order to allow the decommissioning to proceed. For that purpose the CASTOR® X/B52 cask was designed on the basis of the CASTOR® V/52 as a reference cask. It accommodates up to 52 BWR-uranium-FA´s. The cask is suitable for loading at the NPP Caorso, transportation on public ways and storage at the on-site temporary facility at Caorso as well as at the National Interim Storage Facility. Due to the handling requirements the mass of the handling configuration is limited to approx. 85 Mg.

The cask body wall is designed in accordance with the requirements for the gamma and neutron shielding. To improve the neutron moderation, there are axial bore holes distributed on a circle. These are filled with moderator rods made of polyethylene. These rods are installed from the bottom end in the cask body with the necessary free space for thermal expansion and are maintained in their positions with spiral springs and closure plugs. A cross section through the cask, showing the basket and moderator arrangement is given in Fig. 2. The Caorso fuel requires only one row of moderator material in the cask wall.

Figure 2: Cask Body with Moderator Rods Surrounding the Fuel Basket.

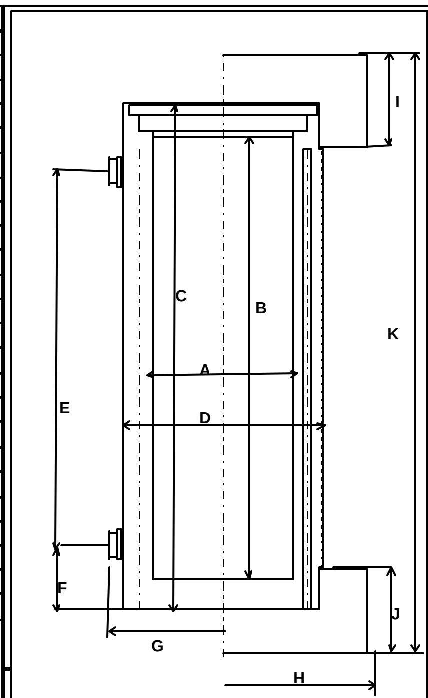


The cask bottom contains, in addition to the cask wall, a moderator plate which covers the whole cavity area. A sealed steel plate is bolted to the cask body over this plate.
The top end of the cask body is designed to accommodate the following components:

- Primary lid with its bolts (cylinder bolts) and its sealing system,
- Secondary lid with its bolts (cylinder bolts) and its sealing system,
- Positioning and attachment of the impact limiters during transport on public roads,
- Positioning and attachment of the protection plate at the interim storage site.

The main dimension and masses are given in the following table:

Dimension [mm]		
Cavity diameter	A	1390
Cavity length	B	4510
Total bottom wall thickness		300
Total cask length w/o impact limiter	C	5152
Total side wall thickness		285
Outer diameter		1960
Trunnion center line distance	E	3800
Distance trunnion / cask bottom	F	660
Excentricity of bottom trunnion		30
Turning radius - bottom side		1194
Width across trunnions	G	2240
Diameter of outer recess of trunnion		280
Length of outer recess of trunnion		10[1)] /5
Diameter of 1. recess of trunnion		250
Length of 1. recess of trunnion		85[1)] /65
Diameter of 2. recess of trunnion		300
Length of 2. recess of trunnion		0[1)] /55
Outer diamter impact limiter	H	2830
Length top impact limiter	I	935
Length bottom impact limiter	J	850
Total length with impact limiter	K	6082
[1)] valid for 4 lid side trunnions		
Data Sheet	Var.	Rev.
Transport and Storage Cask	B	5
CASTOR X/B52	Date	02.02.00
	Author	Hüggenberg



Masses kg rsp. Mg	
Number of F/A	52
Number of CB	52
A. Mass of Components [kg]	
Cask body	49109
Basket	8829
Inventory	16848
Primary lid, bolts, moderator	3672
Secondary lid, bolts	2082
Cover plate, bolts	2173
Trunnions, bolts	775
Water during loading	3899
Impact limiter	8700
Bouyancy during loading	10238
Auxilary equipment	4500
B. Handling mass [Mg]	
At the pool: with Water, PL Aux. Eq., with Bouyancy	77,4
loaded, with PL, SL w/o water, Aux. Eq.	81,3
C. Transport configuration [Mg]	
loaded, with impact limiter without cover plate	87,9
loaded, with impact limiter without cover plate	90,0
D. Storage Configuration [Mg]	
loaded with cover plate, without impact limter	83,5

In order to minimize the number of casks needed for the decommissioning program the well known data of the existing FA´s were taken to find following optimized, heterogeneous loading pattern, which is applied for each cask:

5. Summary

The choice of using dual purpose metallic casks has been taken by SOGIN as the most flexible and most convenient alternative in the given Italian situation. The possibility of moving the casks on public roads using the same "packages" as for temporary storage is extremely convenient in a situation in which there is the need to proceed with decommissioning of the plants, but a centralized storage facility is not yet available.

Also the consideration that the spent fuel should remain in at least two sites for some years and cannot be centralized was a deciding factor in favor of this choice. GNB was chosen after an international open bid as the supplier for the Caorso, Garigliano and Trino spent fuel.

The licensing process shall take advantage of the large GNB experience with this type of casks and of the approval rules and process already in place mainly in Germany, but also in other countries such as USA.

The design of the CASTOR® X/A17 for up to 17 PWR-Trino-FA´s or 17 BWR-Garigliano-FA´s and the CASTOR® X/B52 casks holding up to 52 BWR-Caorso-FA´s is suitable for the following conditions of use :

1 Loading of the casks in the fuel pools of the nuclear installations of Trino, Caorso and Avogadro,
2 No upgrading of the current on-site crane capacities,
3 Transport of the FA´s, which are currently stored at Saluggia facility to the NPP Trino,
4 On-site storage in vertical or horizontal position with the possibility of transfer to another temporary storage or a final repository, even after a number of years,
5 The partial loading of Mixed-Oxide (MOX) and failed fuel,
6 Loading and drying of bottled Garigliano-FA´s.

The design of the CASTOR® X/A17 and X/B52 casks aims at optimizing safety and economics under the given boundary conditions. The long time span of intermediate wet storage of the fuel results in a reduced shielding and thermal-conduction requirement. This is utilized to meet the tight mass and geometry restrictions while allowing for the largest cask capacity possible.