AUTORITÉ DE SÛRETÉ NUCLÉAIRE

DEPARTMENT OF TRANSPORT AND SOURCES

APPROVAL CERTIFICATE
FOR A PACKAGE DESIGN

The French Governing Authority,

Pursuant to the request submitted by the Atomic Energy and Alternative Energies Commission (CEA) by letter CEA MR/DPSN/SSN/2012/177 dated 24 November 2012,

and in light of the safety analysis report CEA DSN/STMR/LEPE/TNBGC1 DSEM 0600 Ed. 02 dated 11 October 2012,

hereby certifies that the package design comprising the **TN-BGC 1** packaging described hereafter in appendix 0 index bb and

- loaded with:
  - uranium oxide powder, as described in appendix 2 index bb; or with
  - uranium metal ingots, as described in appendix 4 index bb; or with
  - uranium oxide fuel rods or fuel rod sections or pellets, as described in appendix 7 index bb; or with
  - solid uranium-bearing materials as described in appendix 11 index bb; or with
  - TRIGA fuel as described in appendix 26 index bb; or with
  - an aqueous solution of uranyl nitrate, as described in appendix 40 index bb; or with
  - U-Zr alloy fuel plates, as described in appendix 41 index bb; or with
  - uranium-bearing materials of diverse forms, as described in appendix 42 index bb;

is compliant, as a type B(U) package loaded with fissile materials, with the requirements of the regulations, agreements or recommendations listed below:

- International Atomic Energy Agency (IAEA) regulations for the safe transport of radioactive material, IAEA Safety Standards series, No. TS-R-1 2009 edition;
- European Agreement on the International Carriage of Dangerous Goods by Road (ADR);
- Technical Instructions for safe air transport of dangerous materials (ICAO-TI);
- Administrative decision of 29 May 2009 amended, on the carriage of dangerous goods by terrestrial routes (TMD decision);
- Instruction of 26 June 2008 pertaining to the technical rules and administrative procedures applicable to commercial air transport and regulation EC 859/2008 dated 20 August 2008 (EU OPS1).

Nonetheless, only contents no. 11 and no. 26 are authorised for air transport.

This certificate does not dispense the consignor from respecting the requirements established by the authorities of the countries across which or to which the package will be transported.

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This certificate is valid until: **30th June 2018**

Record number: **CODEP-DTS-2013-054429**

Montrouge, 10th October 2013

SUMMARY OF CERTIFICATE REVISIONS

Produced	Expired	Type of revision and modifications	Authority	Certificate Ref. No.	Revision index							
					Body	t	0	1	2	3	4	5
		Reserved	DSND		Haj							
25/08/08	15/11/10	Prolongation: contents 2, 4, 7, 11 and 26	ASN	F/313/B(U)F-96	Iak	-	ak	-	ak	-	ak	-
25/08/08	31/08/13	Prolongation: contents 5, 6 and 15	ASN	F/313/B(M)F-96 T	Ial	al	al	-	-	-	-	al
	31/08/13	Reserved	DSND		Iam							
	31/08/13	Reserved	DSND		Ian							
12/02/09	31/08/13	Extension: inclusion of contents 1 and 3	ASN	F/313/B(M)F-96 T	Iao	ao	ao	ao	-	ao	-	-
10/04/09	31/08/13	Extension: modification of contents 1 and 3	ASN	F/313/B(M)F-96 T	Iap	ao	ao	ap	-	ap	-	-
04/11/09	31/08/13	Extension: modification of contents 1, 3, 5, 6 and 15; inclusion of contents 8, 9, 10, 18, 19, 20 and 23	ASN	F/313/B(M)F-96 T	Iaq	aq	aq	aq	-	aq	-	aq
	31/08/13	Reserved	DSND		Iar							
28/04/10	31/08/13	Extension: inclusion of content 39	ASN	F/313/B(M)F-96 T	Ias	as	as	-	-	-	-	-
04/06/10	31/08/13	Extension: cancels and replaces certificate F/313/B(U)F-96 (Iak)	ASN	F/313/B(U)F-96	Iat	-	at	-	at	-	at	-
	31/08/13	Reserved	DSND		Iau							
04/08/10	31/08/13	Extension: inclusion of content 42	ASN	F/313/B(U)F-96	Iav	-	av	-	-	-	-	-
	31/08/13	Reserved	DSND		Iaw							
10/11/10	31/08/13	Extension: inclusion of content 40	ASN	F/313/B(U)F-96	Iax	-	ax	-	-	-	-	-
10/05/11	31/08/13	Extension: modification of content 40	ASN	F/313/B(U)F-96	Iay	-	ay	-	-	-	-	-
17/08/11	31/08/13	Extension: inclusion of CH_2	ASN	F/313/B(U)F-96	Iaz	-	az	-	az	-	az	-
20/04/12	31/08/13	Extension: inclusion of content 46	ASN	F/313/B(M)F-96 T	Iba	ba	ba	-	-	-	-	-
		Prolongation: contents 2, 4, 7, 11, 26, 40, 41 and 42	ASN	F/313/B(U)F-96	Jbb	-	bb	-	bb		bb	-
10/10/13	30/06/18	Prolongation : contents 2, 4, 7, 11, 26, 40, 41 et 42	ASN	F/313/B(U)F-96	Jbb	-	bb	-	bb		bb	-
		Reserved	DSND		Jea							

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Body	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	46
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ANNEXE 0

TN-BGC 1 PACKAGING

1. PACKAGING DEFINITION

The packaging is designed, manufactured, inspected, tested, maintained and used in compliance with Safety Analysis Report CEA DSN/STMR/LEPE/TNBGC1 DSEM 0600 Rev. 02 dated 11 October 2012.

The packaging consists of a parallelepiped cage inside which a generally cylindrical body equipped with a closure system and a shock absorber cover is fixed. The packaging is presented in figure 0.1.

The packaging design drawings are as follows:

- concept drawing - overall : TN 9990-65 (C);
- cage : TN 9990-118 (B);
- fitted plug : TN 9990-117 (B);
- shock absorber cover : EMB TNBGC PBC PDC CA 010001 A.

The main dimensions of the packaging are as follows:

- cage cross-section : 600 x 600 mm²;
- overall height of cage : 1 821 mm;
- diameter of body in centre section : 295 mm;
- diameter of cover : 466 mm;
- overall body length with cover fitted : 1 808 mm.

The maximum admissible mass of the loaded packaging for transport is 396 kg; its mass when empty is 280 kg.

In light of the tolerances on the dimensions and densities of the balsa and poplar wood in the packaging (shock absorber cover and base of body), the total mass of water in these elements is below 1670 grammes.

The packaging comprises the principal sub-assemblies described below.

1.1 Cage

The cage is a structure made of 30 x 30 mm, 2 mm thick aluminium tubes.

Reinforced passages are built in at two heights to enable introduction of the forks of a forklift truck, in order to handle the packaging.

Frames are provided inside the cage to connect the cage to the body. They are welded to the vertical struts of the cage and drilled to allow the passage of the body mounting bolts.

1.2 Body

The cavity has a useful diameter of 178 mm and useful length of 1,475 mm. It is formed from a 6 mm stainless steel shell (that provides most of the radial gamma shielding) and an 8 mm base also made of stainless steel.

A second 1.5 mm stainless steel shell with an internal diameter of 292 mm cooperates with the first shell to delimit a space filled with resin (minimum thickness 48 mm), which acts as a neutron absorber and an active thermal insulation.

From the inside of the packaging towards the outside, the base also features a 25 mm thick steel diffuser plate made of high-strength steel, a 24 mm layer of resin, a false bottom, a wooden shock-absorbing disk and a stainless steel plate.

In the upper part, a stainless steel machined flange is welded to the two shells to receive the closure system described below.

1.3 Closure system

The body cavity is closed using a system composed of 3 main parts: a plug, a compression ring and a bayonet ring.

The plug is held against the body by the compression ring. This component is screwed into the bayonet ring, which itself is compressed against the body flange.

In the centre of the plug, a hole fitted with a quick-connect coupling allows the package to be de-pressurised before dispatch and re-pressurised to atmospheric pressure upon arrival before unloading. This hole is closed with a cap.

The leaktight seal between the plug and body and the quick-connect cap is formed by two pairs of O-ring seals. The spaces between the seals both communicate with the same inspection port used to verify the leaktight properties of the closure system.

The two O-ring seals defining the limit of the containment system are made of THT silicone, with a hardness rating of shore 65. These seals are numbered 11 and 13 on the TN 9990-65 (C) plan. The other two seals (12 and 14) are Viton seals.

1.4 Shock absorption system

A leaktight shock absorber cover is placed over the top of the body and the closure system.

It is composed of two steel plate compartments, that closer to the body is filled with resin, the other is filled with wood.

The cover is attached to the body using two bent rods that fit into the lugs on the body, and with two clamping pins, the ends of which are bolted onto the cover and welded to the packaging body.

1.5 Handling and tie-down components

The cage is used to handle and secure the packaging.

The packaging can be handled either in a horizontal or a vertical position.

The packaging is transported in horizontal or vertical position, according to the principles set out in the instructions for use of the package model and in the safety file of the package model:

- in horizontal position: the packaging is stowed on the floor and tied down around the cage by strapping. Only one stacking level is allowed. Wooden structures can be used between two packagings and around the cages.

- in vertical position: the packagings are grouped in batches and held by straps which are arranged above the cage and at mid-height. The leg is stowed. Stowing devices (for example corner beams) are added in the upper section. The packagings can be grouped in rows of 2.

Stowing and tie-down must be performed on the basis of a pre-set procedure checked according to the provisions of the quality management system.

1.6 Safety functions and elements important for safety

The main safety functions and elements important to safety are:

- the **containment** function offered by the packaging containment system, represented by the inner shell, the base of the body and their circumferential welds, the plug and the quick-connect cap, which are fitted with silicone internal seals;
- **radiological protection**, mainly provided by:
  - lateral shielding represented by the stainless steel of the inner shell and the outer shell for the main part of the shielding against gamma radiation, and by the resin (48 mm minimum) for the shielding against neutron radiation;
  - base shielding represented by the stainless steel of the base of the cavity and the two closure plates as well as the carbon steel in the distribution baffle for the main part of the shielding against gamma radiation, and by the resin (24 mm minimum) and wood for the shielding against neutron radiation;
  - top shielding represented by the stainless steel of the plug and the sheet metal cover for the gamma protection, and by the resin (min. 24 mm) and wood contained in the cover for the neutron protection;
- **criticality safety** provided by the confinement system which comprises the elements described in the content appendix and:
  - the packaging: geometry (maximum diameter of the packaging to favour interactions, cage), the materials used, the composition and thickness of the neutron-absorbing resin (hydrogen and boron content, thickness of burnt resin);
  - the internal fittings: geometry of shims, constituent materials of shims (aluminium), geometry (diameter, thickness) of container, material used for container;

For the internal fittings, the parameters important to safety are indicated in the table below.

Internal fitting	Internal diameter (mm)	Thickness (mm)	Material
TN90	≤ 120	≥ 2	Z2 CN 18-10
AA-41 - AA203 - AA204	≤ 115	≥ 2	Z2 CN 18-10
TN90 type 2	≤ 130	$4 \leq e \leq 5$	Z2 CN 18-10
E7	≤ 60	≥ 2	UA4G

- the **dissipation of internal thermal power** via radiation between the radioactive materials and the inner shell within the body, by conduction in the body and heat exchange between the body and the ambient air;
- **impact protection**, provided by the shock absorber cover and the cage;
- **fire protection**, provided by the radiological protection and the cover. The body and the cover are fitted with fuse plugs that prevent the risk of overpressure due to the accumulation of steam.

2. MEASURES TO BE TAKEN BY THE CONSIGNOR PRIOR TO SHIPPING THE PACKAGE

The packaging must be used according to procedures that comply with the instructions for use in chapter 10 of the safety analysis report CEA DSN/STMR/EMBAL/LEPE/DSEM 0610 Rev. 02 dated 11 October 2012.
Furthermore, for the leakage test of the closure system via the inspection port, the leakage rate must remain below 6.65 x 10^{-4} $Pa.m^3.s^{-1}$ SLR.

3. MAINTENANCE PROGRAMME

The packaging must be used according to procedures that comply with the instructions for use in chapter 10 of the safety analysis report CEA DSN/STMR/EMBAL/LEPE/DSEM 0610 Rev. 02 dated 11 October 2012.

4. NOTIFICATION AND REGISTRATION OF SERIAL NUMBERS

The applicable authorities must be kept informed of any packaging that is taken out of service or transferred to another owner. With this in mind, it is the ceding owner who is responsible for providing the name of the acquiring owner.

5. QUALITY ASSURANCE

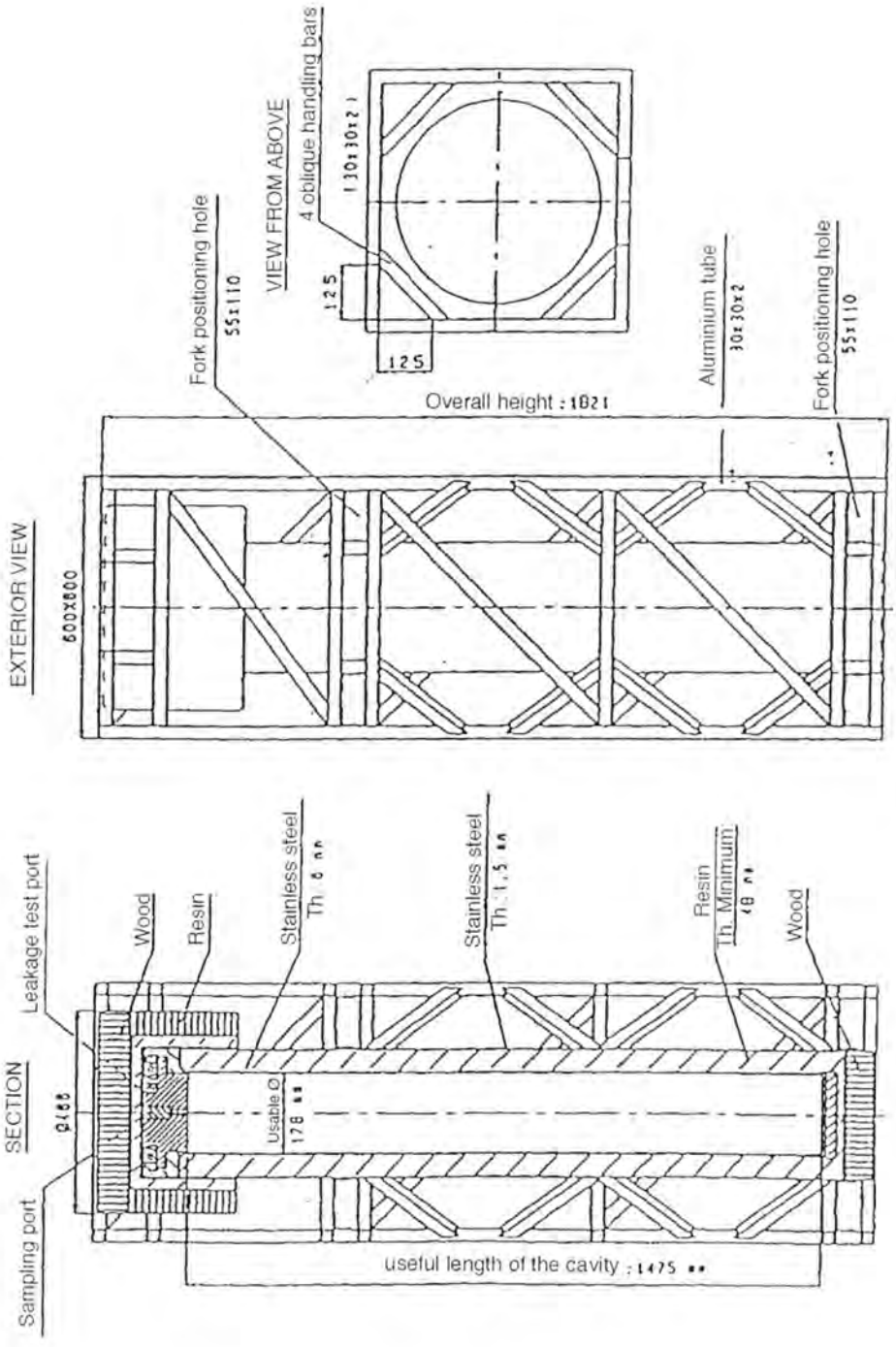
The quality assurance principles applied during the design, manufacturing, inspection, testing, maintenance and use of the package must comply with those described in chapter 11 of the safety analysis report CEA DSN/STMR/EMBAL/LEPE/DSEM 0611 Rev. 01 dated 17 July 2012.

6. ADDITIONAL REQUIREMENTS IN THE EVENT OF CONFINED TRANSPORT

If packages are shipped inside a type CB9 transport crate, the heat dissipation conditions may be modified. The thermal power must therefore be below 4W per package and 48W for all packages transported.

FIGURE 0.1

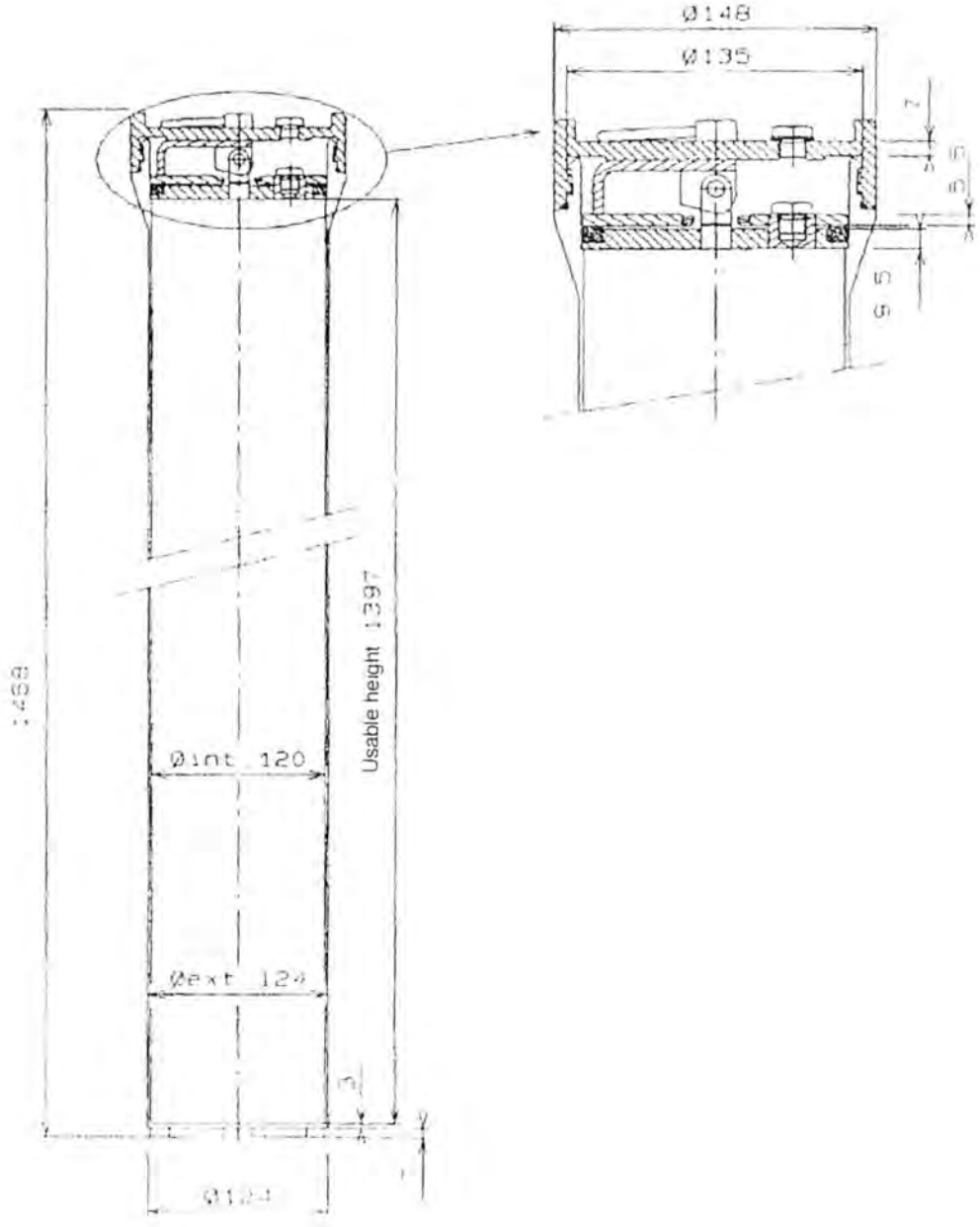
SCHEMATIC VIEW OF PACKAGING



Note: dimensions are in millimetres.

FIGURE 0.2

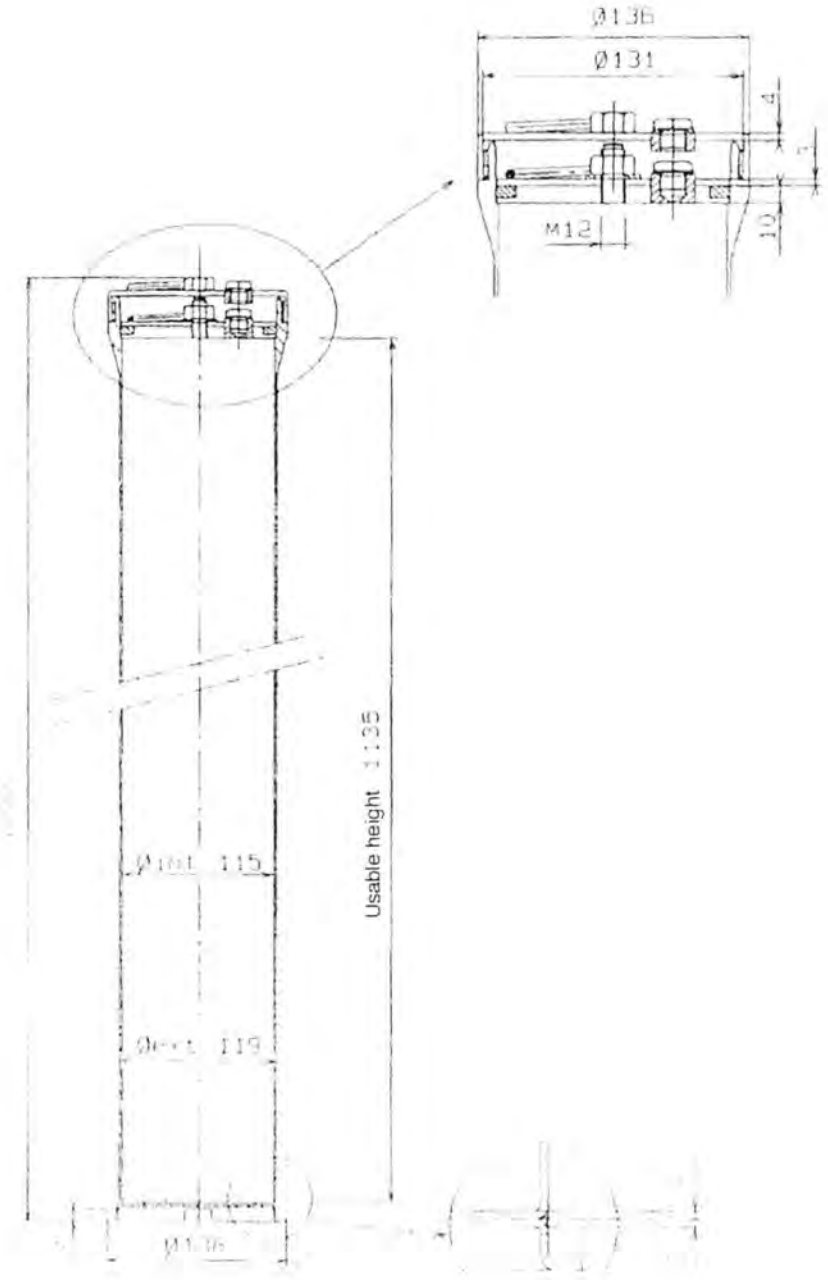
SCHEMATIC VIEW OF TN 90 CONTAINER



Note: dimensions are in millimetres.

FIGURE 0.3

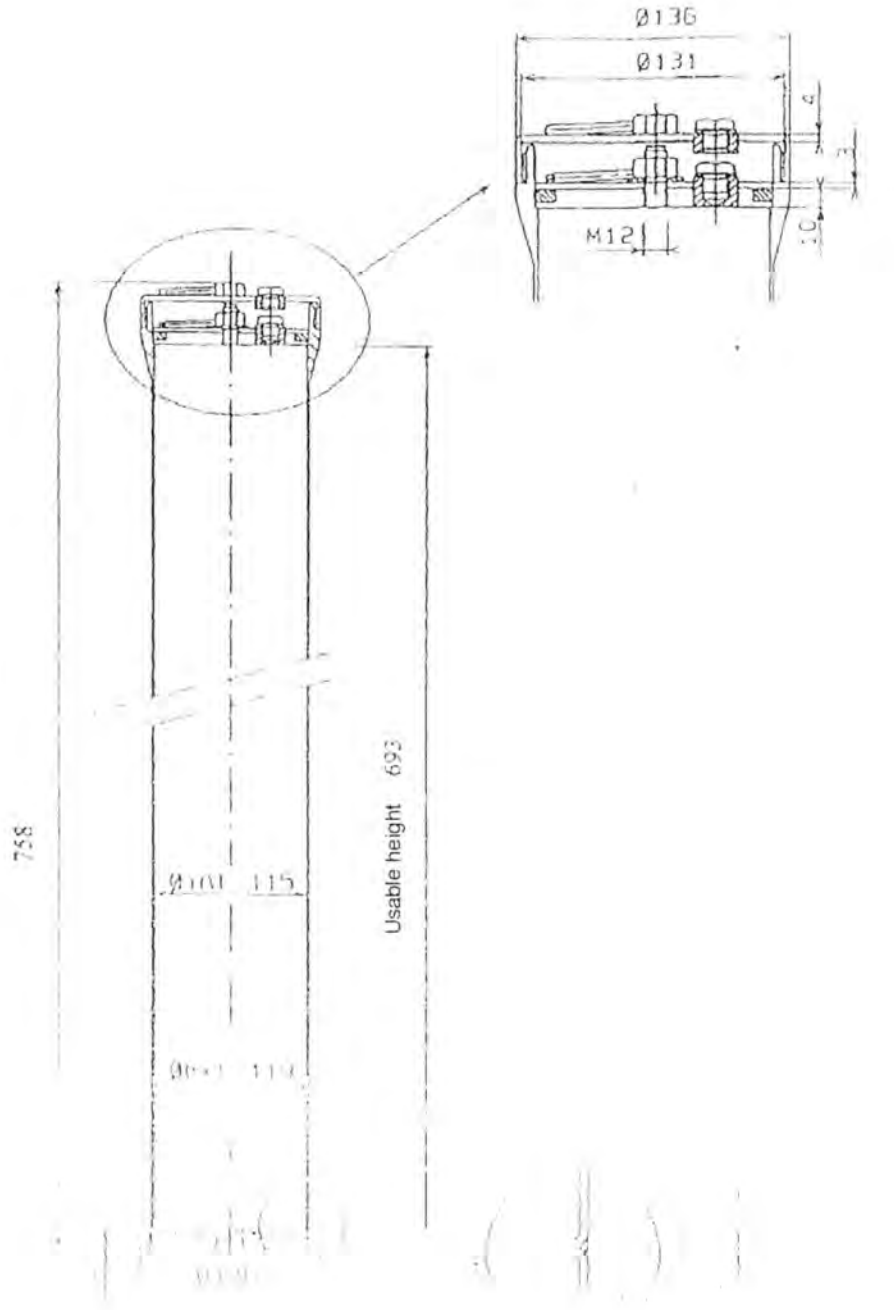
SCHEMATIC VIEW OF AA 204 CONTAINER



Note: dimensions are in millimetres.

FIGURE 0.4

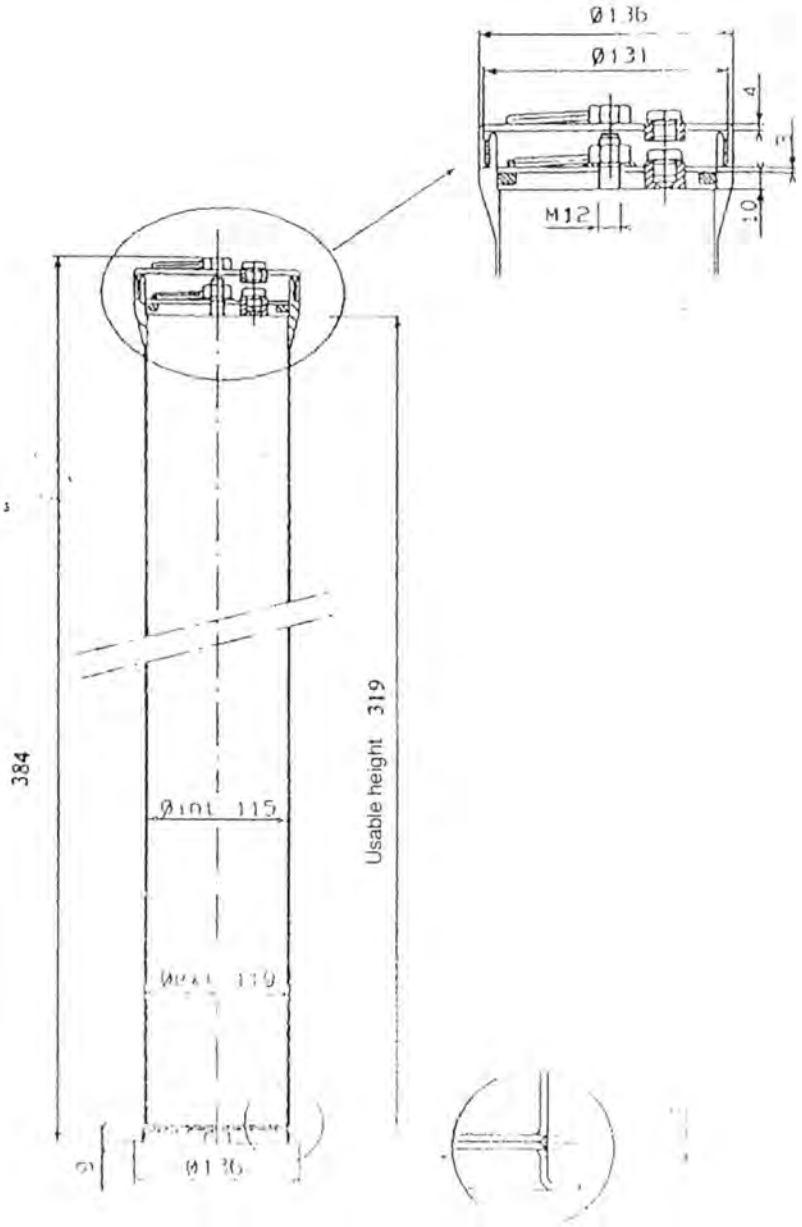
SCHEMATIC VIEW OF AA 203 CONTAINER



Note: dimensions are in millimetres.

FIGURE 0.5

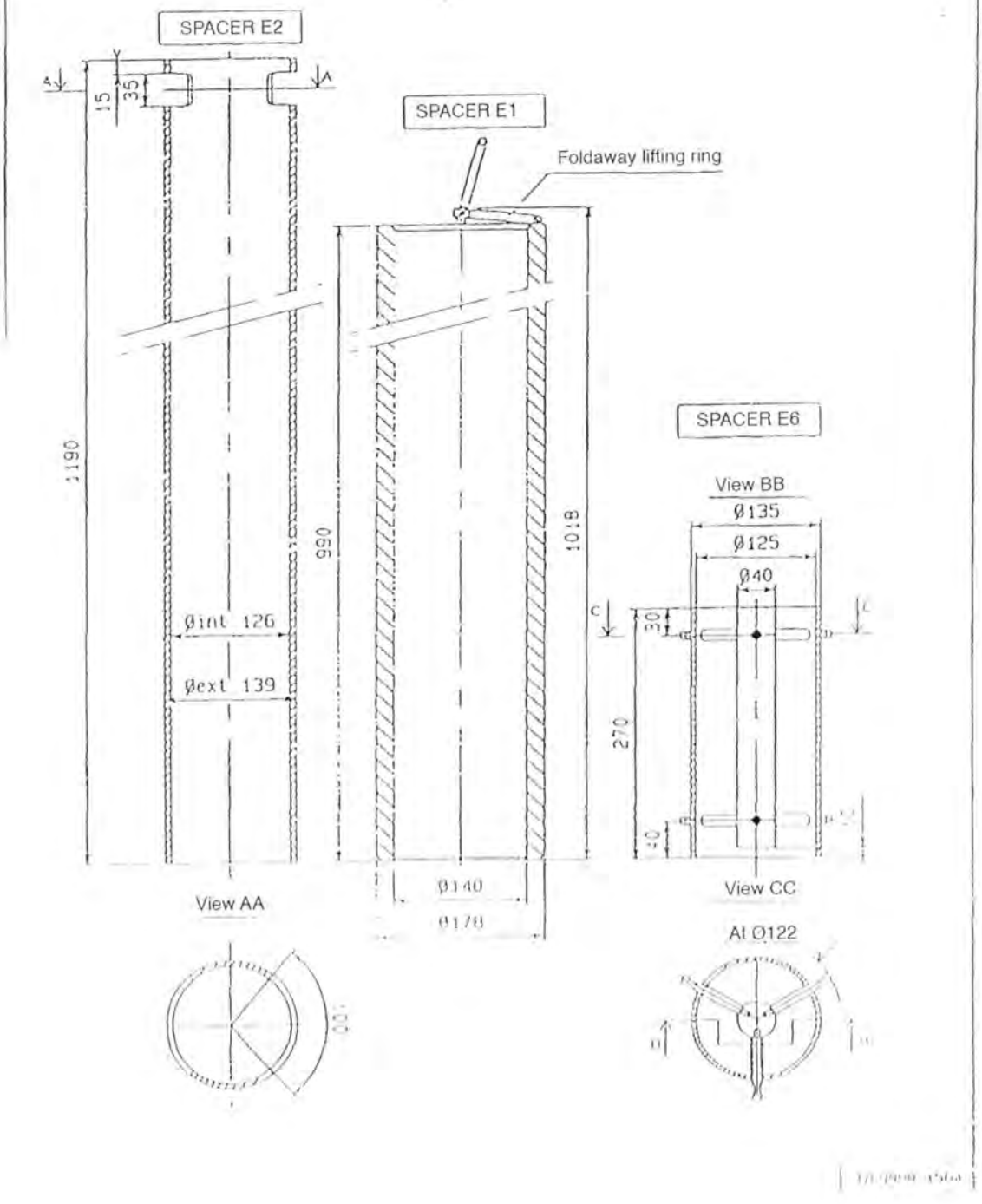
SCHEMATIC VIEW OF AA 41 CONTAINER



Note: dimensions are in millimetres.

FIGURE 0.6

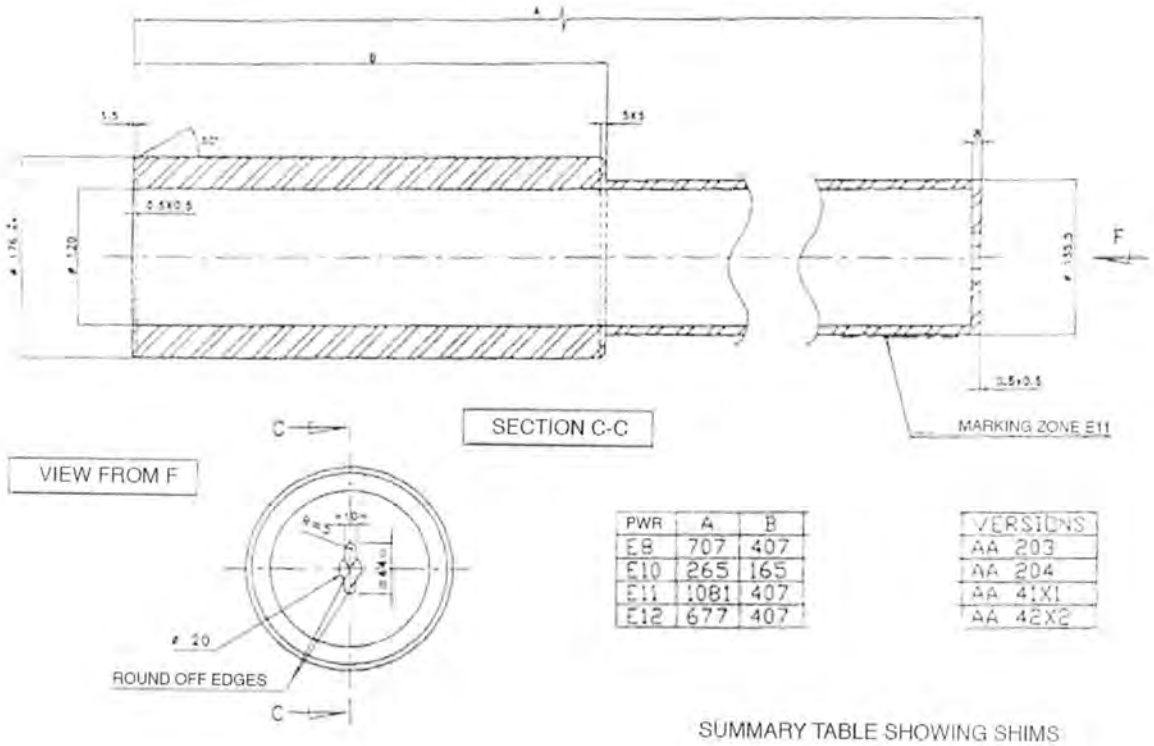
SCHEMATIC VIEW OF SPACERS E1, E2, E6



Note: dimensions are in millimetres.

FIGURE 0.7

SCHEMATIC VIEW OF SPACERS E8, E10, E11, E12



PWR	A	B
E8	707	407
E10	265	165
E11	1081	407
E12	677	407

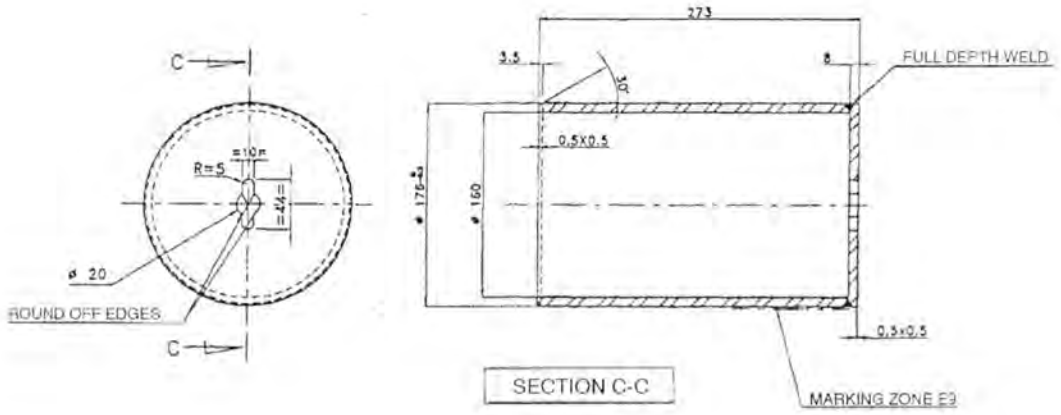
VERSIONS
AA 203
AA 204
AA 41X1
AA 42X2

SUMMARY TABLE SHOWING SHIMS

Note: dimensions are in millimetres.

FIGURE 0.8

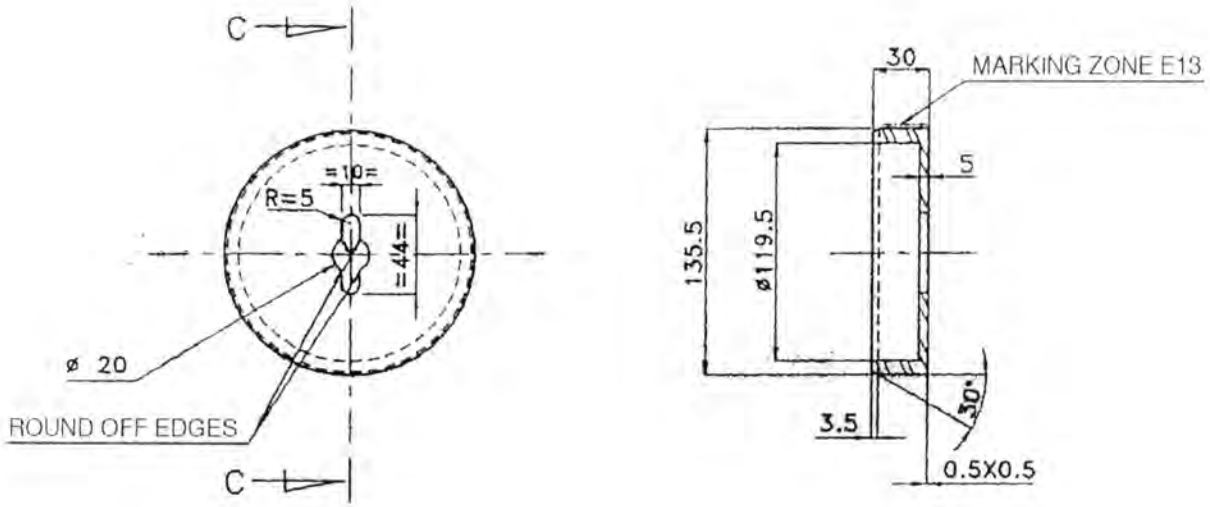
SCHEMATIC VIEW OF SPACER E9



Note: dimensions are in millimetres.

FIGURE 0.9

SCHEMATIC VIEW OF E13 SPACER FOR AA 41



Note: dimensions are in millimetres.

ANNEXE 2

CONTENT NO. 2

NON-IRRADIATED URANIUM OXIDE POWDER

1. DEFINITION OF AUTHORISED CONTENT

This content comprises powdered uranium in the form of UO_2 or U_3O_8.

The powder may be a result of reprocessing but must not have been irradiated after this reprocessing.

The presence of other materials than those defined in this appendix (content and internal fittings) is excluded.

Isotropic composition and maximum admissible mass

The authorised masses are given in the table below:

Content No.	Guaranteed containment diameter (mm)	Presence of hydrogen-bearing materials with higher hydrogen content than water authorised	Enrichment in ^{235}U	Mass Maximum of U	Number of packages
2a	≤ 120 mm	Yes	any	2,2 kg	4
2b			any	2,4 kg	3
2c	≤ 115 mm		< 30 %	40 kg	25
2d	≤ 120 mm	No	any	20 kg	25

The hydrogen-bearing materials authorised for transport are polyethylene, polyurethane and PVC. The presence of polyethylene in content 2d is not permitted. In other contents, its maximum mass is limited to 500g.

Physical characteristics

Maximum powder density: any

Chemical form

Oxide

Special form

The material is not in a special form.

Specific

The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

2. INTERNAL FITTINGS AND CONTAINERS

The content is placed in primary containers, which may be metal boxes, plastic flasks or double-skin plastic casings. These boxes are positioned in a secondary container with a maximum internal diameter of 120 mm or 115 mm (content 2c) and thickness of 2mm: types TN 90, AA 204, AA 203 or AA 41 (see figures 0.2 to 0.5).

The following spacers should be used to position and secure the secondary container in the packaging cavity:

- for the TN 90: Spacers E1 and E2,
- for the AA 204: Spacers E1 and E10 or E6,
- for the AA 203: Spacers E1 and E8,
- for 1 x AA 41: Spacers E1 and E11,
- for 2 x AA 41: Spacers E1, E12 and E13,
- for 3 x AA 41: Spacers E1, E9 and 2 × E13.

The total mass of the loaded internal fittings (AA41, AA203, AA204 and TN90 (materials + primary container) must not exceed 60 kg.

The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 package (material transported, primary/secondary containers & shims) is 116 kg.

Special provisions

If the primary container has been in storage for over a month, the crown must be renewed before loading into the secondary container then into the packaging.

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

3. CRITICALITY STUDY

This is covered by attachments 1, 10 and 12 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

For contents 2a, 2b and 2c, it permits the presence of **hydrogenated materials with a hydrogen concentration greater than that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

For content 2d, it permits the presence of **hydrogenated materials with a hydrogen concentration less than or equal to that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

Criticality Safety Index:

For content 2a: CSI = 12.5 (number "N" : 4).
For content 2b: CSI = 16.7 (number "N" : 3).
For contents 2c and 2d: CSI = 2 (number "N" : 25).

ANNEXE 4

CONTENT NO.4

NON-IRRADIATED URANIUM METAL INGOTS

1. DEFINITION OF AUTHORISED CONTENT

This content comprises uranium metal ingots. The uranium does not come from reprocessing.

The presence of other materials than those defined in this appendix (content and internal fittings) is excluded.

The presence of hydrogen-bearing materials with a hydrogen content greater than that of water is not permitted.

The hydrogen-bearing materials authorised for transport are polyurethane and PVC.

The content must be free of all traces of humidity.

Isotopic composition and masses

The isotopic composition of the uranium is unimportant.

The maximum admissible mass corresponds to 9 ingots of non-irradiated uranium metal each weighing 5 kg (i.e. a maximum total mass of 45 kg of uranium metal loaded into the packaging).

Physical characteristics

Any density

Chemical form

Metal

Special form

The material is not in a special form.

Specific

The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

Special provisions

Particular attention should be paid to the surface condition of the content when loading into their packaging. The surface of the content should be free of scoring or hydrides.

2. INTERNAL FITTINGS AND CONTAINERS

The secondary container must be type TN 90 (see figure 0.2).

A full E4 type spacer must be placed between each ingot under normal and accident conditions of transport, with a minimum edge-to-edge distance of 90 mm between the ingots (see figures 4.1 and 4.2 below).
In addition, all spacers to be used for a maximum load must be stacked within the container cavity, even if the number of ingots actually loaded into the container has not reached the admissible maximum.

Spacers E1 & E2 should be used to position and secure the TN 90 internal fitting in the packaging cavity:

The total mass of the whole load including internal fitting TN 90 is restricted to 60 kg.

The maximum admissible mass of the whole load within the cavity of the package (spacers + TN 90 container + shims) is 116 kg.

Special provisions

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

3. CRITICALITY STUDY

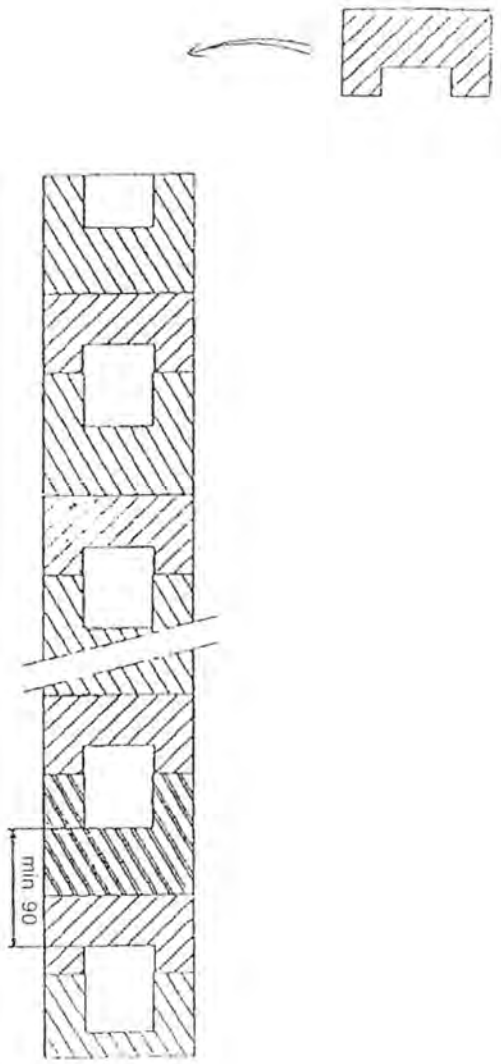
This is covered in note EMB TNBGC PBC DJS CA 0000357 A provided in appendix 4 of chapter 9 of the safety analysis report EMB TNBGC PBC DS- CA 000001 B dated 20 August 2003.

It permits the presence of hydrogenated materials with a hydrogen concentration less than that of water and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

Criticality Safety Index: CSI = 1 (number "N" : 50).

FIGURE 4.1

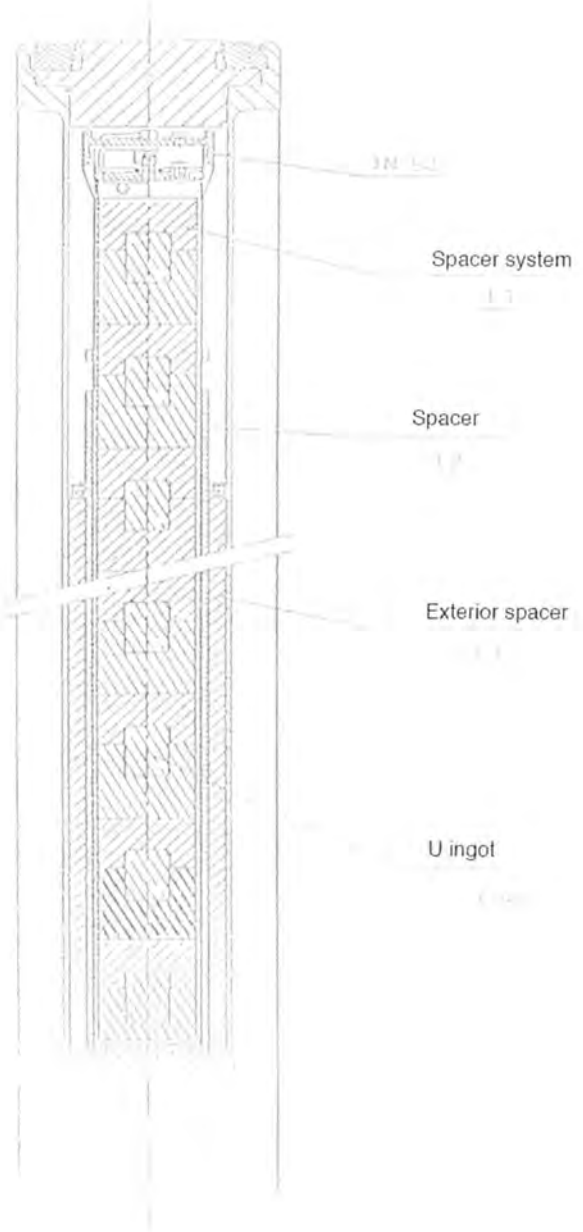
SCHEMATIC VIEW OF E4 SPACER



Note: dimensions are in millimetres.

FIGURE 4.2

EXAMPLE OF INGOT LAYOUT IN TN 90 CONTAINER



ANNEXE 7

CONTENT NO.7

NON-IRRADIATED URANIUM OXIDE FUEL RODS OR SECTIONS OR PELLETS

1. DEFINITION OF AUTHORISED CONTENT

This content comprises uranium oxide (UO_2 only), which can be in the form of pellets, fuel rod sections or complete fuel rods. The uranium is non-irradiated.

In the event that the uranium is reprocessed, the material should not have been irradiated at any moment post-reprocessing.

The presence of other materials than those defined in this appendix (content and internal fittings) is excluded.

The content must be free of all traces of humidity.

Masses & isotopic composition

The authorised masses are given in the table below:

content No.	Guaranteed containment diameter (mm)	Presence of hydrogen-bearing materials with higher hydrogen quantity than water authorised	Enrichment in ^{235}U	Total mass of U	Number of packages
7a	≤ 120 mm	Yes	any	2,2 kg	4
7b			any	2,4 kg	3
7c	≤ 115 mm		< 30 %	40 kg	25
7d	≤ 120 mm	No	any	20 kg	25

The hydrogen-bearing materials authorised for transport are polyethylene, polyurethane and PVC. The presence of polyethylene in content 7d is not permitted. In other contents, its maximum mass is limited to 500 g.

Physical characteristics

The density of the pellets is, as a maximum, equal to 100 % of the maximum theoretical density (d=10.96).

The maximum internal pressure of the rods is 3 bar (abs) at 20°C.

The pellets may be damaged and therefore potentially in the form of debris.

Chemical form

Oxide

Special form

The material is not in a special form.

Specific

The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

2. INTERNAL FITTINGS AND CONTAINERS

The uranium oxide pellets are placed in a primary containment, which may be metal boxes, plastic flasks or double plastic envelopes. The whole assembly is then placed within a container representing the secondary containment.

Sections of rod may be inserted into sleeving tubes. The rods or sleeving tubes can then be placed in a rack. The tubes, sleeves and racks are made of metal and represent the first container.

The secondary containers that may be used must have a maximum internal diameter of 120 mm or 115 mm (content 7c) and a thickness of 2mm. They may be TN 90, AA 204, AA 203 or AA 41 containers (see figures 0.2 to 0.5).

The following spacers (figures 0.6 to 0.9) should be used to position and secure the secondary container in the packaging cavity:

- for the TN 90: Spacers E1 and E2,
- for the AA 204: Spacers E1 and E10 or E6,
- for the AA 203: Spacers E1 and E8,
- for 1 x AA 41: Spacers E1 and E11,
- for 2 x AA 41: Spacers E1, E12 and E13,
- for 3 x AA 41: Spacers E1, E9 and 2 × E13.

The total mass of the secondary container load (material + primary container) must not exceed 60 kg.

The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 package (material transported, primary/secondary containments & shims) is 116 kg.

Special provisions

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

3. CRITICALITY STUDY

This is covered by attachments 1, 10 and 12 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

For contents 7a, 7b and 7c, it permits the presence of **hydrogenated materials with a hydrogen concentration greater than that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

For content 7d, it permits the presence of **hydrogenated materials with a hydrogen concentration less than or equal to that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

Criticality Safety Index:
For content 7a: CSI = 12.5 (number "N" : 4)
For content 7b: CSI = 16.7 (number "N" : 3)
For contents 7c and 7d: CSI = 2 (number "N" : 25).

ANNEXE 11

CONTENT NO.11

NON-IRRADIATED SOLID URANIUM-BEARING MATERIAL

1. DEFINITION OF AUTHORISED CONTENT

This content comprises uranium-based solids. The presence of traces of plutonium, in the order of grammes, is permitted.

The uranium is non-irradiated. In the event that the uranium is reprocessed, the material should not have been irradiated at any moment post-reprocessing.

The presence of other materials than those defined in this appendix (content and internal fittings) is excluded.

Isotopic composition and masses

The Uranium 235 enrichment level is unimportant, but authorisation is granted for a single type of uranium material per package (single isotopic composition).

For transport by air: the maximum quantity of uranium 235 transported in a TN-BGC 1 package is 7 kg. In this case a quantity of 400 g of materials with a greater hydrogen content than water is authorised.

For transport other than by air: the maximum admissible masses are specified in the following table:

Content No.	Presence of hydrogen-bearing materials with higher hydrogen content than water authorised	Guaranteed containment diameter (mm)	Enrichment in ^{235}U	Maximum mass of U (kg)	Number of packages
11a	Yes	$\varnothing \leq 120$	any	2	10
11b		$\varnothing \leq 100$	any	19,5	5
11c		$\varnothing \leq 120$	≤ 20 %	40	10
11d	No	$100 < \varnothing \leq 120$	any	7	50
11e		$60 < \varnothing \leq 100$	any	15	16
11f		$\varnothing \leq 60$	any	40	50
11g		$\varnothing \leq 120$	≤ 20 %	40	50
11h		$\varnothing \leq 115$	≤ 30 %	40	25

The hydrogen-bearing materials authorised for transport are polyethylene, polyurethane and PVC. The presence of polyethylene in sub-contents 11d, 11e, 11f, 11g and 11h is not permitted. In other sub-contents, its maximum mass is limited to 500g.

In the event it proves impossible to guarantee a single isotopic composition per package, the mass limitations are as follows:

- If the uranium is enriched to more than 20 %, the maximum transportable mass of uranium is 7 kg in the absence of materials with a higher hydrogen content than water and 2 kg in the presence of such materials;

- If the various uranium products are enriched to less than or equal to 20 % the maximum transportable mass of uranium is 40 kg in the absence or presence of materials with a higher hydrogen content than water.

Physical characteristics

Any density

Chemical form

The material is exclusively in one of the following chemical forms (or in the form of a mixture of these forms):

- Metallic Uranium,
- Uranium oxides: UO_2, UO_3, U_3O_8,
- Uranium tetrafluoride: UF_4
- Uranium nitrides: UN, U_2N_3, UN_2,
- Uranium carbides: UC, UC_2 and U_2C_3
- Uranium alloyed with the following metals: aluminium (Al), Molybdenum (Mo), Silicon (Si), Zirconium (Zr).

Special form

The material is not in a special form.

Specific

The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

2. INTERNAL FITTINGS AND CONTAINERS

The metallic uranium powder is placed in a primary container, which may be metal boxes, flasks or polymer casings. The whole assembly is then placed within a container representing the secondary containment.

The secondary containers must have a maximum internal diameter of 120 mm and a thickness of 2 mm. They may be TN 90, AA 204, AA 203 or AA 41 containers (see figures 0.2 to 0.5).

In the event that the required internal diameter is less than 120 mm, the secondary container used must be a TN 90 type; the positioning and radial securing inside the TN 90 container must feature E7 type spacers.

The following spacers (figures 0.6 to 0.9) should be used to position and secure the secondary container in the packaging cavity:

- for the TN 90: Spacers E1 and E2,
- for the AA 204: Spacers E1 and E10 or E6,
- for the AA 203: Spacers E1 and E8,
- for 1 x AA 41: Spacers E1 and E11,
- for 2 x AA 41: Spacers E1, E12 and E13,
- for 3 x AA 41: Spacers E1, E9 and 2 × E13.

The total mass of the loaded internal fittings (AA41, AA203, AA204 and TN90 (materials + primary containment) must not exceed 60 kg.

The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 package (material transported, primary/secondary containments & shims) is 116 kg.

Special provisions

When the content is in powder form and if the primary container has been in storage for over a month, the crown must be renewed before loading into the secondary container then into the packaging.

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

3. CRITICALITY STUDY

This is covered by attachments 1, 10 and 12 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012 and note CEA/SEC/T n°89-18 dated 20 January 1989.

Their sub-criticality related characteristics are listed below:

For contents 11a, 11b and 11c, it permits the presence of **hydrogenated materials with a hydrogen concentration greater than that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

For contents 11d, 11e, 11f and 11g, it permits the presence of **hydrogenated materials with a hydrogen concentration less than or equal to that of water** and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

Criticality Safety Index:

For contents 11a and 11c: CSI = 5 (number "N" : 10).
For content 11b: CSI = 10 (number "N" : 5).
For content 11e: CSI = 3.125 (number "N" : 16).
For contents 11d, 11f and 11g: CSI = 1 (number "N" : 50).
For content 11h : CSI = 2 (number "N" : 25)

4. SPECIAL PROVISIONS

When the material is in a metallic form, particular attention should be paid to the surface condition of the content when loading into their packaging. The surface of the content should be free of scoring or hydrides.

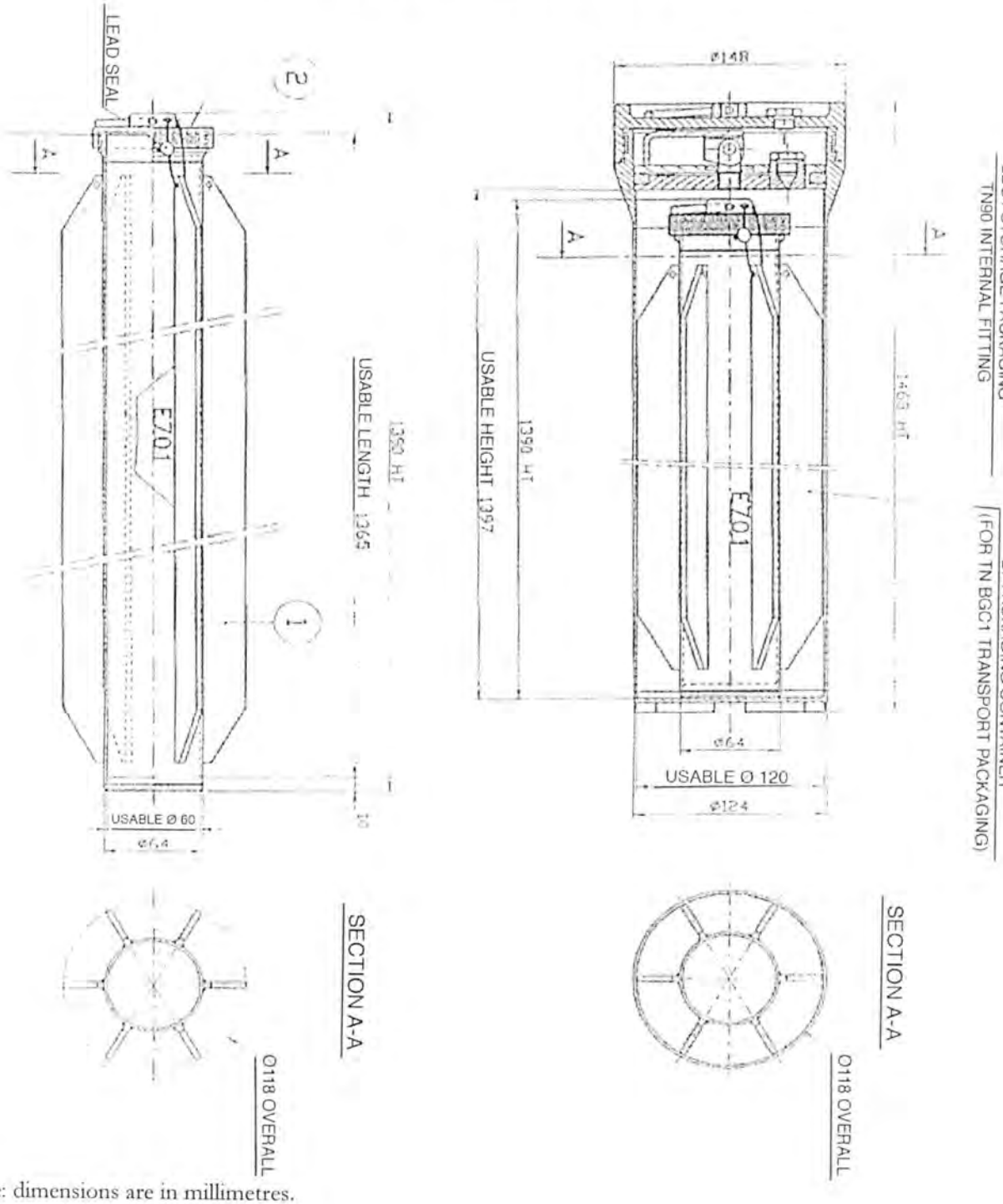
In the event that metallic powders are transported, the containers, the secondary containment and the TN-BGC1 cavity itself must all be inerted at ambient pressure, and a leak test must be carried out on the secondary container (leakage rate below 1.33×10^{-5} Pa.m^{3}s^{-1}).

FIGURE 11.1

SCHEMATIC VIEW OF E7 TYPE CONTAINER

AND

PACKING OF URANIUM-BEARING MATERIALS



Note: dimensions are in millimetres.

ANNEXE 26

CONTENT NO. 26

TRIGA FUEL

1. DEFINITION OF AUTHORISED CONTENT

This content comprises non-irradiated bars of TRIGA fuel elements.

These bars are based upon U ZrHx (where x is between 0 and 2); they are in cylindrical form and are of one of two types- standard or thin, with the following geometric characteristics:

- Standard: diameter = 3.63 cm; length = 12.7 cm,
- Thin: diameter = 1.29 cm; length = 18.6 cm.

The uranium does not come from reprocessing.

The standard bars are drilled, hydrogenated by the centre, the diameter of the hole is 6.35 mm.

The schematic view of standard and thin TRIGA fuel elements is presented in figure 26.1.

The hydrogen-bearing materials authorised for transport are polyethylene and polyurethane. The presence of hydrogen-bearing materials with a hydrogen concentration greater than that of water is not permitted.

The content must be free of all traces of humidity.

The presence of materials other than those defined in the approval certificate is excluded.

Isotopic composition and masses

The maximum 235U enrichment level is 20%. The mass content of U varies between 8 and 47% depending on the type of element:

TYPE	U (% by mass)	ZrH_X (% by mass)	U-Zr (g/cm^3)	U-ZrH_2 (g/cm^3)
Composition of standard TRIGA fuel elements				
103	8	92	6,9	6,04
105	12	88	7,1	6,22
107	12	88	7,1	6,22
117	21	79	7,4	6,64
119	31	69	8,1	7,24
Composition of thin TRIGA fuel elements				
424	47	53	9,3	8,40

Maximum transportable quantities

The maximum transportable quantities are given in the tables below.

- For **transport by air**: the maximum mass of uranium transportable in a TN-BGC 1 package is dependent on the type of fuel element as shown by the table below:

TYPE	Total mass of U (kg)
103	1,1
105	1,7
107	1,7
117	3,3
119	5,3
424	6,6

- For **other modes of transport**: the maximum mass of uranium transportable in a TN-BGC 1 package is dependent on the type of fuel element as shown by the table below, however, the maximum masses defined in Paragraph 2 for the loads applicable to internal fittings and packagings must be respected:

TYPE	Total mass of U (kg)
103	9
105	14
107	14
117	27
119	43
424	76

Special form

The material is not in a special form.

Specific

The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

Special provisions

For transport by air, the mass of water present with the fissile materials, independently of the hydrogen-bearing materials of the package, is less than 1,200 g, or 1,950 g, depending on whether they are standard or thin fuel elements.

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

2. INTERNAL FITTINGS AND CONTAINERS

The TRIGA bars are placed inside cardboard protective tubes, which in turn are placed in a secondary container.

The secondary containers that may be used must have a maximum internal diameter of 120 mm and a thickness of 2 mm. They may be TN 90, AA 204, AA 203 or AA 41 containers (see figures 0.2 to 0.5).

A primary container (Type E7) (see figure 26.2) can be used with the TN 90 for uranium-bearing materials.

The following spacers (figures 0.6 to 0.9) should be used to position and secure the container in the packaging cavity:

- for the TN 90 : Spacers E1 and E2;
- for the AA 203 : Spacers E1 and E8;
- for the AA 204 : Spacers E1 and E10;
- for 1 x AA 41 : Spacers E1 and E11;
- for 2 x AA 41 : Spacers E1, E12 and E13;
- for 3 x AA 41 : Spacers E1, E9 and 2 x E13.

The total mass of the loaded internal fittings (AA41, AA203, AA204 and TN90 (materials + primary containment) must not exceed 60 kg.

The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 package (material transported, primary/secondary containments & shims) is 116 kg.

3. CRITICALITY STUDY

This is covered by attachments 9 and 11 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

It permits the presence of hydrogenated materials with a hydrogen concentration less than or equal to that of water and/or water penetration in all the unoccupied space in the packaging, including in the containment system.

Criticality Safety Index: CSI = 0 ("N" : infinity).

FIGURE 26.1
SCHEMATIC VIEW OF TRIGA ELEMENTS

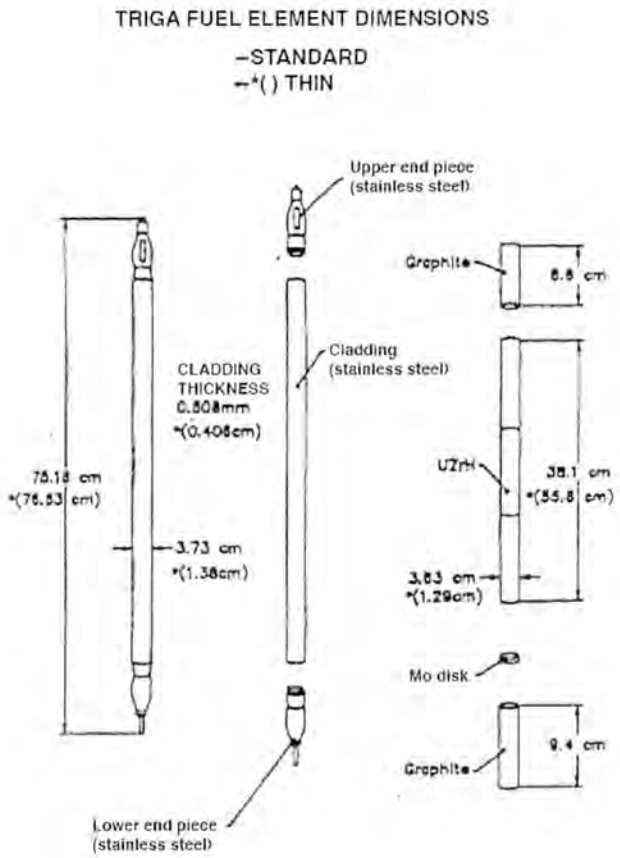
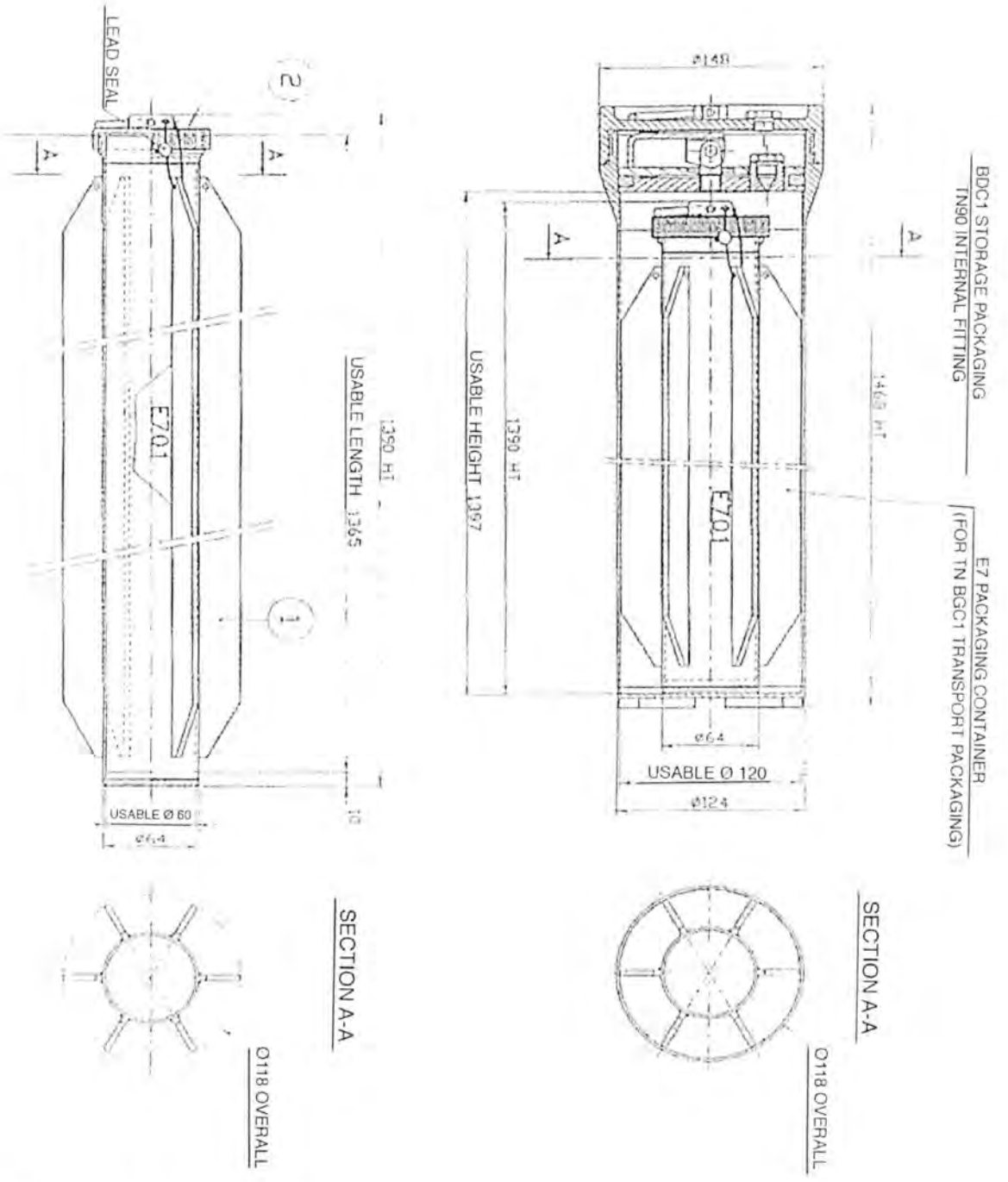


FIGURE 26.2
SCHEMATIC VIEW OF E7 TYPE CONTAINER



Note: dimensions are in millimetres.

ANNEXE 40

CONTENT NO. 40

URANYL NITRATE SOLUTIONS

1. DEFINITION OF AUTHORISED CONTENT

The content is an aqueous solution of uranyl nitrate.

The aqueous solution has not been irradiated.

In order to avoid the production of excess hydrogen within the packaging and its internal fittings, the uranyl nitrate solutions must not have been stored for more than 35 years in an AA 203 or TN 90 container prior to transport.

The presence of hydrogen-bearing materials (other than the flask containing the solution) with a hydrogen content greater than that of water is not permitted.

Isotopic composition

The enrichment in ^{235}U (by mass) is less than or equal to 95%

The presence of the following impurities:
- Pu (*) limited to 0.010 g,
- ^{237}Np limited to 0.015 g,

is permitted.

A quantity of 900 g of ^{232}Th is permitted.

(*) *The quantity of ^{238}Pu must be below 150 µg.*

Maximum quantities

The maximum content quantity authorised for transport is 5 litres of aqueous solution (uranyl nitrate) for a total mass of uranium of less than or equal to 1,800 g.

Specific Activity

The specific activity of the solution is less than or equal to 64 A_2/m^3.

Thermal power

The thermal power of the content is less than or equal to 2.0×10^{-3} W.

2. INTERNAL FITTINGS AND CONTAINERS

The flasks containing the uranyl nitrate solution must be packaged inside cylindrical internal fittings with a maximum diameter of 120 mm and a minimum thickness of 2 mm. The packaging principals are as follows:
- The uranyl nitrate solution must be placed within a flask (primary container) in polyethylene, with a mass of less than or equal to 900 g, then, it may be packaged in a double-skinned polymer cover with a lower hydrogen content than water (PVC or polyurethane). The maximum weight of these covers is 350 g.

- The primary container must be placed in an AA 203 (figure 0.4) or TN90 (figure 0.2) internal fitting (secondary container), where the lid is bolted and fitted with silicone leaktight seals;
- The E3 (figure 40.1) and E3-203 (figure 40.2) metal insulating spacers must respectively be used to position the TN 90 and AA 203 secondary containers in the packaging cavity.

Prior to transport, it must be verified that when polyurethane is used for the double-skin cover, it contains less hydrogen than water.

Note: The primary containment flask may be inserted into a metal basket.

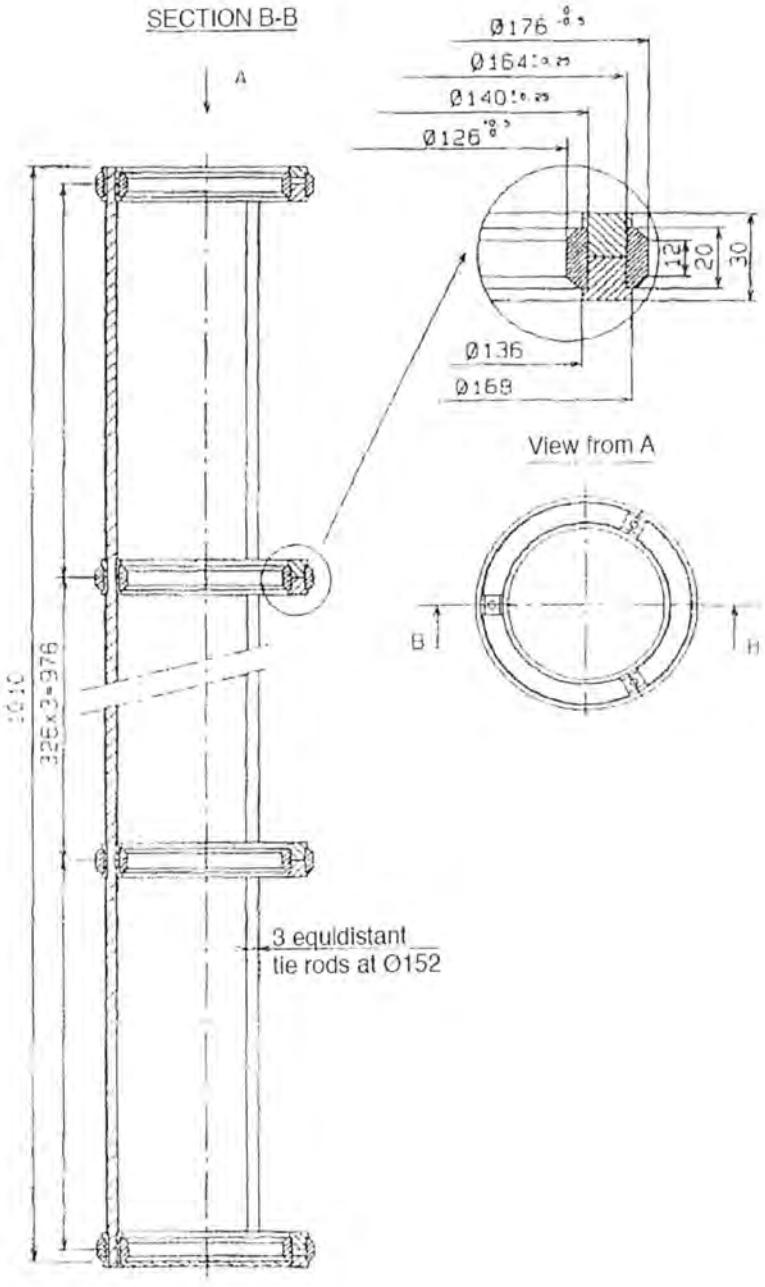
The total mass of the whole load including internal fitting is restricted to 60 kg. The maximum permissible mas of the whole load within the cavity of the TN-BGC 1 package (shims + containers + cargo transported) is 116 kg.

3. CRITICALITY STUDY

This is covered by attachment 7 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

Criticality Safety Index: CSI = 10 ("N" = 5). The presence of hydrogen-bearing materials with a hydrogen content greater than that of water must be less than or equal to 900 g.

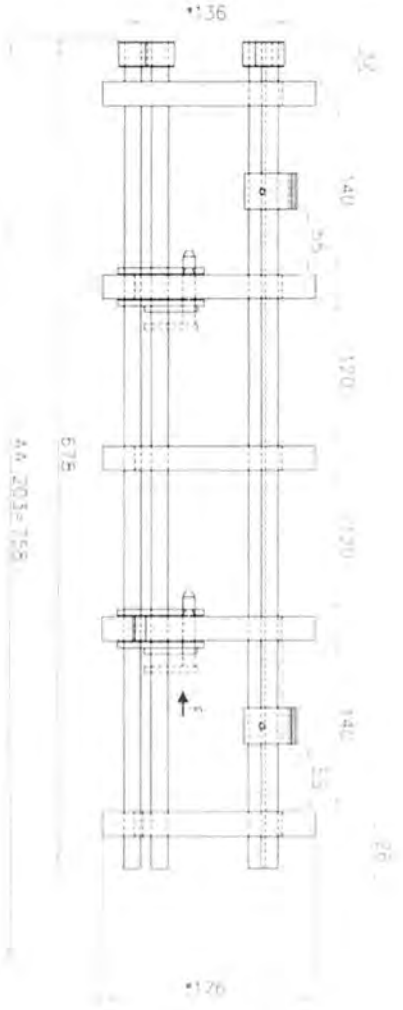
FIGURE 40.1
SCHEMATIC VIEW OF SPACER E3 FOR TN90 CONTAINER



Note: Dimensions are given in mm

FIGURE 40.2

SCHEMATIC VIEW OF SPACER E3-203 FOR AA 203 CONTAINER



Note: Dimensions are given in mm

ANNEXE 41

CONTENT NO. 41
U-ZR FUEL PLATES

1. DEFINITION OF AUTHORISED CONTENT

The plates are metallic fuel plates made of an U-Zr alloy, whose principal characteristics given in the table below:

Principal characteristics	
Form	U-Zr metal alloy
Max. uranium content by mass (U/(U+Zr))	8 %
Max. ^{235}U enrichment	91 %

The total mass of uranium in content 41 is 1680 g.
The presence of materials other than those defined in the approval certificate is excluded.

Thermal power

The thermal power of the content is less than or equal to 10^{-3} W.

Hydrogen-bearing materials

The presence of hydrogen-bearing materials with a hydrogen content greater than that of water is not permitted.

1.1 content 41a

This content features a maximum of 60 U-Zr metal allot fuel plates called "short AZUR plates", packed as specified in paragraph 2. These plates have been subjected to low level irradiation. For information, the activity is in the order of 10^7 Bq per plate.

The dimensions of each short AZUR plate are: 74 x 1.5 x 500 mm and its total mass is 330 ± 10 g.

1.2 Content 41b

This content features 1 U-Zr alloy plate with any dimensions. Its total mass is limited to 60 kg.

2. INTERNAL FITTINGS AND CONTAINERS

For content 41a, the plates are packed in a stainless steel sleeve. The maximum number of plates per sleeve is 30. One or two sleeves are inserted in a TN 90 internal fitting (see figure 0.2), itself secured inside the TN-BGC 1 cavity using spacers E1 and E2 (figure 0.6).

For content 41b, the plate is packed directly in the TN90 internal fitting (see figure 0.2), itself secured inside the TN-BGC 1 cavity using spacers E1 and E2 (figure 0.6).

The total mass of the whole load of the TN 90 container (material transported + primary container) is limited to 60 kg. The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 packaging (material transported + internal fittings + spacers) is 116 kg.

3. CRITICALITY STUDY

This is covered by attachment 1 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

Criticality Safety Index: CSI = 2.5 ("N" = 20).

The presence of hydrogen-bearing materials with a hydrogen content greater than that of water is not permitted.

ANNEXE 42

CONTENT NO. 42

MIXTURE OF URANIUM-BASED MATERIALS IN VARIOUS FORMS

1. DEFINITION OF AUTHORISED CONTENT

This content comprises a mixture of uranium-bearing materials in various forms. The uranium may be from reprocessing but must not have been irradiated after this reprocessing.

The presence of materials other than those included in the appendix (content and internal fittings) is not authorised, specifically the presence of powdered metallic thorium.

The hydrogen-bearing materials authorised for transport are polyethylene, polyurethane and PVC. The presence of polyethylene in content 42b-6 is not permitted. In other contents, its maximum mass is limited to 500 g.

Several cases are possible, depending on the physical and chemical nature of the content.

1.1 Content 42a

Chemical form

The material may be present in the following forms:

- Uranium oxide UO_2, U_3O_8;
- UO_2F_2
- Ammonium diuranate (ADU)
- mixture of various chemical forms.

The presence of thorium, in metal or oxide form, alloyed or mixed closely with the uranium, is authorised in all quantities. The thorium is mainly in the form of isotope 232.

Isotopic composition, masses, packaging and number of packages permitted.

Content No.	Guaranteed containment diameter (mm)	Thickness of internal fittings guaranteeing containment	Max. uranium enrichment level	Maximum weight of uranium (kg)	Number of packages
42a1	$\varnothing \leq 120$	2 mm	Any	2,4	4
42a2	$\varnothing \leq 115$	2 mm	94 %	3,066	Infinite
42a3	$\varnothing \leq 127$	2 mm	87 %	2,801	1
42a4	$\varnothing \leq 115$	2 mm	85 %	4,082	Infinite
42a5	$\varnothing \leq 120$	2 mm	60 %	13,285	4
42a6	$\varnothing \leq 115$	2 mm	27 %	11	Infinite
42a7	$\varnothing \leq 120$	2 mm	20 %	60*	4
42a8	$\varnothing \leq 120$	2 mm	70 %	3,327	10

* without prejudicing the maximum load mass for internal fittings - also limited to 60 kg (See Section 2).

Physical characteristics

The maximum density of the fissile materials is 10.96.

Special form
The material is not in a special form.

Specific
The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

1.2 Content 42b

Chemical form
The material may be present in the following forms:
- Metallic Uranium;
- Alloys of uranium and aluminium;
- Mixtures of metallic uranium and oxides.

The presence of thorium, in metal or oxide form, alloyed or mixed closely with the uranium, is authorised in all quantities. The thorium is mainly in the form of isotope 232.

Isotopic composition, masses, packaging and number of packages permitted.

Content No.	Guaranteed containment diameter (mm)	Thickness of internal fittings guaranteeing containment	Max. uranium enrichment level	Maximum weight of uranium (kg)	Number of packages
42b1	$\varnothing \leq 120$	2 mm	Any	2	4
42b2	$\varnothing \leq 115$	2 mm	94%	2,906	Infinite
42b3	$\varnothing \leq 120$	2 mm	93 %	2,5	4
42b4	$\varnothing \leq 115$	2 mm	35 %	6,811	Infinite
42b5	$\varnothing \leq 120$	2 mm	20 %	60*	4
42b6	$\varnothing \leq 130$	$4 \leq e \leq 5$	94 %	Disks with a diameter of 130 mm and a thickness of 51 mm (max. mass of U = 12970 g).	2

Note: Mixtures of different 42b contents are not permitted.

* without prejudicing the maximum load mass for internal fittings - also limited to 60 kg (See Section 2).

Physical characteristics
Any density

Special form
The material is not in a special form.

Specific
The activity of the content must be such that, given the nature and energy of the radiation emitted, the regulatory limits for dose-rates around the package are not exceeded.

2. INTERNAL FITTINGS AND CONTAINERS

The content is placed in a primary container, which may be metal boxes or polymer flasks. The packing of sub-content 42b-6 in flasks or casings with a higher hydrogen content than water is forbidden.

Primary containers may be placed inside secondary containers comprising a metal box or metal sleeve. The resulting assembly [radioactive material + primary container + secondary container] must then by placed inside a stainless steel internal fitting comprising an enclosed tube fitted with sealed covers (checkable or not).

Five tertiary containers may be used. The cylindrical containers are types AA 41; AA 203; AA 204; TN 90 or TN 90 Type 2. They are represented on figures 0.2 to 0.5 and 42.1. Their safety-related characteristics are listed below:

AI	Internal diameter (mm)	E (mm)
AA-41 - AA203 - AA204	≤ 115	2
TN90	≤ 120	2
TN90 type 2	≤ 130	$4 \leq e \leq 5$

The following spacers (figures 0.6 to 0.9) should be used to position and secure the tertiary container in the packaging cavity:

- for the TN 90 : spacers E1 and E2;
- for the AA 204 : spacers E1 and E10 or E6;
- for the AA 203 : spacers E1 and E8;
- for 1 x AA 41 : spacers E1 and E11;
- for 2 x AA 41 : spacers E1, E12 and E13;
- for 3 x AA 41 : spacers E1, E9 and 2 × E13;
- for the TN90 type 2 : spacer E1.

The total mass of the whole load of internal fittings (AA41, AA203, AA204, TN90 and TN90 - Type 2 (materials + primary & secondary containers) must not exceed 60 kg.

The maximum admissible mass of the whole load within the cavity of the TN-BGC 1 packaging (material transported, primary/secondary/tertiary containers & shims) is 116 kg.

Special provisions

When the content is in powder form and if the primary container has been in storage for over a month, the crown must be renewed before loading into the secondary and tertiary containers then into the packaging.

The time between the closure of the secondary containment in the dispatching plant and the arrival of the package at the destination must be less than one year.

3. CRITICALITY STUDY

This is covered by attachments 10 and 14 in chapter 8 reference CEA DSN/STMR/LEPE/TNBGC1 DSEM 0608 Rev. 01 dated 17 July 2012.

Criticality Safety Index = 0 for contents 42a-2, 42a-4, 42a-6, 42b-2 and 42b-4 ("N" = infinity).
Criticality Safety Index = 12.5 for contents 42a-2, 42a-4, 42a-6, 42b-2 and 42b-4 ("N"= 4).
Criticality Safety Index = 25 for content 42b-6 ("N" = 2).
Criticality Safety Index = 50 for content 42a-3 ("N" = 1).

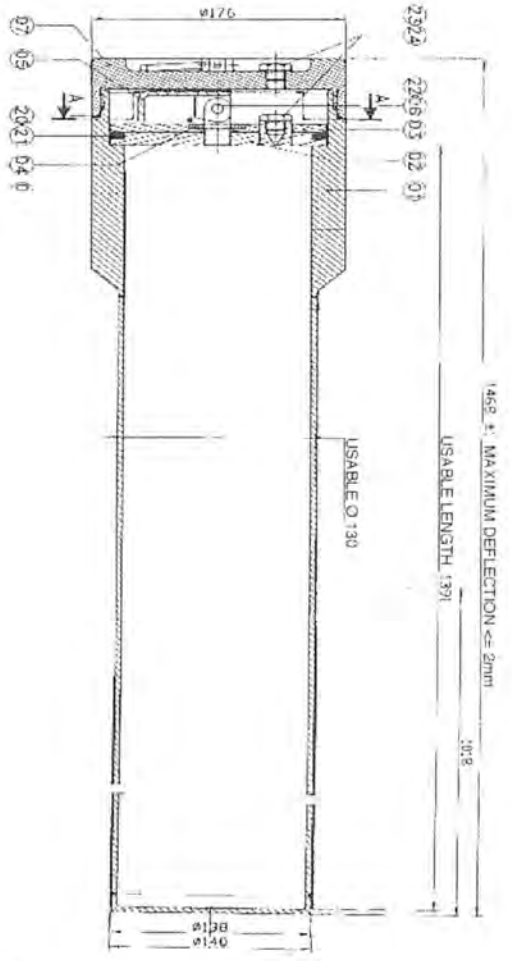
4. SPECIAL PROVISIONS

In the event that metallic powders are transported, the containers, the secondary and tertiary containers and the TN-BGC1 cavity itself must all be inerted at ambient pressure, and a leakage test must be carried out on the tertiary container (leakage rate below 1.33×10^{-5} $Pa.m^3s^{-1}$).

FIGURE 42.1
SCHEMATIC VIEW OF TN90 TYPE 2 CONTAINER

GENERAL CHARACTERISTICS:

Overall dimensions	⌀(mm)	h(mm)	H(mm)	Unitary mass (Kg)	Handling
TN-90	176	1391	1468	Max 45	



Note: dimensions are in millimetres.