



ADVANCED NUCLEAR FUELS GmbH

Certificate of Approval

Titel/Title: D/4340/IF-96 (Rev. 10) for a transport package sample of type IP-2 for fissionable radioactive materials	
	<small>Number/Number</small> D/4340/IF-96 (Rev. 10)

Translation verified:	<u>D. Steinigeweg</u> D. Steinigeweg	<u>28.11.2014</u> Date
Translation approved:	<u>R. Witten</u> R. Witten	<u>28.11.2014</u> Date

Certificate of Approval

D/4340/IF-96 (Rev. 10)

for a transport package sample of type IP-2 for fissionable radioactive materials

Based on the application of Advanced Nuclear Fuels GmbH, Lingen, dated April 30, 2014 (File Ref · 651/14/BfS/DST), last amended on October 29, 2014 (File Ref 671/14/BfS/DST), the container with manufacturer's designation "**Fuel assembly shipping container type ANF-10**" is approved as a type IP-2 transport package for fissionable radioactive materials according to the following regulations for transports by road, rail and sea.

Regulations for the Safe Transport of Radioactive Material, 2009 Edition, International Atomic Energy Agency (IAEA), No TS-R-1,

European Convention of September 30, 1957 governing the international conveyance of dangerous goods by road (ADR) (BGBl. 1969 II p 1489), Appendices A and B in the edition of the notification of June 3, 2013 (BGBl 2013 II p 648),

Ordinance for the international conveyance of dangerous goods by rail (RID) – Annex C of the Convention governing international rail transportation of May 9, 1980 (COTIF-Convention) (BGBl. 1985 II, p. 130), in the edition of the notification of May 16, 2008 (BGBl 2008 II p 475, 899; 2009 II p 1188, 1189; 2010 II p 1273; 2012 II p. 168, 169, 1338), last amended by the 18th RID Amendment Ordinance of May 25, 2013 (BGBl. 2013 II p. 562),

International Maritime Dangerous Goods Code (IMDG Code), Amendment 36-12,

Ordinance governing the domestic and cross-border conveyance of dangerous goods by road, rail and inland waterways (Dangerous Goods Ordinance, Road, Rail and Inland Waterways – GGVSEB) in the edition of the notification of January 22, 2013 (BGBl 2013 I p 110),

Ordinance governing the conveyance of dangerous goods by seagoing vessels (Dangerous Goods Ordinance, Maritime – GGVSee) in the edition of the notification of March 26, 2014 (BGBl 2014 I p 301),

In conjunction with the Directive for the procedure of the design approval of packages for transporting fissionable materials, special form radioactive materials and easily dispersible radioactive materials (R003) in the edition of the notification of November 17, 2004 (VkB1. 2004 p 594) and the BAM Dangerous Goods Regulation on quality assurance measures of package designs requiring approval for the transport of radioactive materials (BAM-GGR 011) Rev. 0 dated June 25, 2010 (official information sheet of BAM 2011 p. 323) effective by notification of July 1, 2010 (VkB1. 2010 p. 282).

It is hereby confirmed that the Bundesamt für Strahlenschutz (Federal Office for Radiation Protection), Salzgitter, is the authority authorized by the Federal Ministry for Transport and Digital Infrastructure pursuant to Section 7 9 of the IMDG Code.

Certificate holder: ADVANCED NUCLEAR FUELS (ANF) GmbH
Am Seitenkanal 1
49811 Lingen, Germany

Documents:

- 1 Letters of ANF GmbH dated April 30, 2014 (File Ref : 651/14/BfS/DST), August 28, 2014 (File Ref.: 661/14/BfS/DST) and October 29, 2014 (File Ref : 671/14/BfS/DST), respectively with enclosures
2. Safety report of ANF GmbH, no. ANFG-11.105 (01), Rev. 41, dated October 27, 2014
3. Test certificate by the Federal Institute for Material Research and Testing (BAM), Berlin, dated September 14, 2000 (File Ref.: III 3/20708) with 1st supplement dated November 8, 2000 and 2nd supplement dated January 24, 2005 (File Ref. III 3/20925), expert opinions of BAM dated February 16, 2005 (File Ref.. III.3/20925), June 26, 2008 (File Ref.: III 3/21279), July 29, 2008 (File Ref. III.3/21279), August 27, 2008 (File Ref.. III 3/21279), October 27, 2011 (File Ref : 3.3/21413), January 12, 2012 (File Ref.: 3.3/21413), March 15, 2012 (File Re 3.3/21413) and November 5, 2014 (File Ref.. 3.3/21413)

With respect to the verification of criticality safety, we refer specifically to the reports ANFG-5.060 (007), Rev. 5, ANFG-5.060 (061), Rev 4, PEPA/G/2014/de/0010, Rev. A, ANFG-5.060 (077), Rev 0, PEPA/G/2013/en/0018, Rev. B, PEPA/G2014/de 0033, Rev. A and ANFG-5.060 (064), Rev 0, contained in the safety report

Manufacturer's designation: Fuel assembly shipping container type ANF-10

Identification mark of the package: D/4340/IF-96

Period of validity of the certificate: up to and including November 30, 2019

Criticality Safety Index (CSI): 2.8

Permissible contents:

- A) Maximum of two non-irradiated BWR fuel assemblies of type ATRIUM™ 10A, 10B, 10XP or 10XM according to the figures in Appendix 2 with water channel, with or without fuel channel, containing uranium oxide pellets and gadolinium oxide / uranium oxide pellets with a ²³⁵U enrichment (mass content) of max. 5.35 % The pellets are enclosed in zirconium alloy cladding tubes (e.g. Zry-2 Liner, Zry-2-0.4 Fe Liner or LTP-2) with an internal pressure of max. 0.6 MPa at 25°C. Furthermore, the conditions specified in Tables 1 and 2 are to be observed.

The fuel assemblies must contain at least five gadolinium oxide fuel rods, which must be no partial-length fuel rods, with a Gd₂O₃ mass content of at least 1.6% and a minimum density of 10 g/cm³ and gadolinium-free end fittings with a maximum length of 320 mm The gadolinium oxide fuel rods including the gadolinium-free end fittings may contain enriched uranium oxide with a ²³⁵U mass content of maximum 5.35 %. Gadolinium oxide fuel rods at peripheral fuel rod positions must not be considered in the number of gadolinium oxide fuel rods. The partial-length fuel rods must be arranged according to the figures in Appendix 2, their length is arbitrary. For full-length fuel rods, the upper plenum may be lengthened (i.e. the uranium oxide stack may be shortened).

- B) Maximum of two non-irradiated BWR fuel assemblies of type ATRIUM™ 11 with an almost square array of the fuel rod lattice and a water channel (replaces 3x3 fuel rods in the center of the fuel assembly), containing uranium oxide pellets and gadolinium oxide / uranium oxide pellets with a ²³⁵U enrichment (mass content) of max. 5 %. The pellets are enclosed in zirconium alloy cladding tubes (e.g. Zry-2 Liner, Zry-2-0.4 Fe Liner or LTP-2) with an internal pressure of max. 0.6 MPa at 25°C. Furthermore, the conditions specified in Tables 1 and 2 are to be observed The fuel assemblies must be enclosed in a fuel channel with square cross-section and with a maximum inside width of 136 mm.

The fuel assemblies may contain gadolinium oxide fuel rods (even with gadolinium-free end fittings of any length) and partial-length fuel rods of any quantity and arrangement All fuel rods may

contain zones of natural uranium oxide at both ends which also may be shortened at the upper end.

- C) Maximum of two non-irradiated fuel rods for BWR of type SVEA-96/L, SVEA-96 Optima2 or SVEA-96 Optima3, consisting of four fuel rod partial bundles with constant division of the lattice over the entire fuel assembly length. The four partial bundles are mounted in a fuel assembly with integrated water cross and central channel. They contain uranium oxide pellets and gadolinium oxide / uranium oxide pellets with a ²³⁵U enrichment (mass content) of max. 5 %. The pellets are enclosed in zirconium alloy cladding tubes with an internal pressure of max 0.85 MPa at 25°C. Furthermore, the conditions specified in Tables 1 and 2 are to be observed. The fuel assemblies must be enclosed in a fuel channel with square cross-section and with a maximum inside width of 136.8 mm. The fuel assemblies may contain gadolinium oxide fuel rods (even with gadolinium-free end fittings of any length) and partial-length fuel rods of any quantity and arrangement.
- D) Non-irradiated fuel rods for BWR or PWR packed in maximum two fuel rod shipping tubes. The fuel rods contain uranium oxide pellets or gadolinium oxide / uranium oxide pellets and they are enclosed in zirconium alloy cladding tubes (e.g. Zry-2 Liner, Zry-2-0.4 Fe Liner or LTP-2 with an internal pressure of max 0.85 MPa at 25°C for BWR fuel assemblies or Zry-4, PCA-2b, Duplex, Zr1 0Nb or M5 with an internal pressure of max. 2.62 MPa at 20°C for PWR fuel assemblies), with their outside diameter exceeding the pellet diameter by at least 1.1 mm. The fuel rods must correspond to the data specified in Table 3. The number of fuel rods is limited by the shipping tubes' capacity and admissible overall mass only

The parameters detailed in Appendix 1 regarding the composition of the fuel must be complied with. The uranium contained in the fuel assemblies or fuel rods may also be provided in the form of enriched reprocessed uranium ("ERU")

Table 1: Geometry data of the fuel assemblies

Type of fuel assembly	No. of fuel rods in total	No. of full-length fuel rods	No. of partial-length fuel rods	Active length	Fuel rod pitch	Diameter of uranium oxide pellets	Cladding tube outside diameter
				[mm]	[mm]	max. [mm]	min. [mm]
ATRIUM™ 10A	91	83	8	3450 to 3900	12.95	8.90	10.00
ATRIUM™ 10B	91	83	8	3450 to 3900	12.95	8.90	10.00
ATRIUM™ 10XP	91	81	10	3450 to 3900	12.95	8.90	10.00
ATRIUM™ 10XM	91	79	12	3450 to 3900	12.95	8.90	10.00
ATRIUM™ 11	112	any	any	max 3900	variable 11.35 to 12.85	8.20	9.30
SVEA-96/L	96	any	any	max 4000	any	8.60	9.50
SVEA-96 Optima2	96	any	any	max. 4000	any	8.60	9.75
SVEA-96 Optima3	96	any	any	max. 4000	any	8.60	9.75

Table 2: Fuel data and overall mass of the fuel assemblies

Fuel assembly type	Enrichment (mass content) of ²³⁵ uranium in the uranium max. [%]	Pellet density max. [g/cm ³]	Overall mass per fuel assembly incl. structure material max. [kg]	Uranium mass per fuel assembly max. [kg]	²³⁵ U mass per fuel assembly max. [kg]
ATRIUM™ 10A, 10B, 10XP, 10XM	5.35	10.96	320	236	12.62
ATRIUM™ 11	5.00	10.96	320	236	11.8
SVEA-96/L, SVEA-96 Optima2, Optima3	5.00	10.96	320	236	11.8

Table 3: Fuel rod data

²³⁵ U enrichment (mass content) max. [%]	5.00
Pellet density max. [g / cm ³]	10.96
Pellet diameter [mm]	7.6 to 10.0
Active length max. [mm]	3920
Cladding tube wall thickness min. [mm]	0.15
Uranium mass per fuel rod shipping tube max.[kg]	236
²³⁵ U mass per fuel rod shipping tube max. [kg]	11.8

Package design

In terms of its mechanical and thermal properties, in accordance with the test certificate and the BAM, Berlin, expert report detailed above, and in terms of its criticality safety and radiation shielding, according to testing by the Federal Office for Radiation Protection - BfS, the design for the fuel assembly shipping container Type ANF-10 conforms to the requirements laid down for a Type IP-2 transport package for fissionable radioactive substances (IAEA Regulations §§ 622 and 671)

In the criticality safety analysis, the penetration of water into all cavities/hollow spaces of the transport package was assumed

Description of the package:

The transport package sample consists of the following components: container bottom, container cover, head cover with two guide tubes and top-end adapters, two inner protective boxes with bottom-end adapters and the enclosure of the inner protective boxes with polyethylene and foam material. The top-end and bottom-end adapters are removed for transporting fuel rods in shipping tubes. The container walls, the central divider in the container bottom, the container cover and the head cover, all of which form part of the outer protective enclosure, consist of multiple layers of aluminum honeycombs covered with aluminum sheeting and enclosed on all sides by austenitic steel plates. The inner protective boxes

are made of boronized, austenitic steel plate with a natural boron mass content of at least 0.8% and have a wall thickness of minimum 3 mm.

A schematic diagram of the package (drawing no. ANF-5-121-3075-03, Rev. 1) is attached as Appendix 3.

The containment system is formed by the fuel rod cladding tubes which are welded gastight

The confinement system is formed by the container bottom, container cover, the head cover with the guide tubes and top-end adapters, the inner protective boxes with the bottom-end adapters and the fuel assemblies with the fuel channels (if available) or fuel rod shipping tubes with the fuel rods

The external dimensions are: length approx. 4725 mm, width approx. 668 mm and height approx. 362 mm

Mass. packing (tare) 1160 kg max., package (gross) 1550 kg max.

The packages identified by the relevant revisions of the Index of Drawings in Appendix 4 currently comply with this approval (see also supplementary condition no. 7).

Supplementary conditions and notes:

1. All quality assurance measures relating to planning, monitoring inspections and operation must be performed in accordance with the BAM dangerous goods regulation "Quality Assurance Measures of Packagings for Competent Authority Approved Package Designs for the Transport of Radioactive Material" (BAM-GGR 011, Rev 0).
2. The remanufacture of packing materials is only permissible in accordance with Index of Drawings 5-3 21-3100-04 with the highest revision index in Appendix 4, including the changes in accordance with supplementary condition no. 7.
3. This approval applies only in conjunction with the certificate of acceptance issued for the relevant series-production sample; this certificate shall be sent to the BAM (Federal Institute for Material Research and Testing) and BfS (Federal Office for Radiation Protection) unasked. Any deviations tolerated by the BAM in accordance with BAM-GGR 011 and any changes as per supplementary condition no. 7 shall be documented in this certificate of acceptance. In the case of series-production samples already manufactured, the deviations tolerated by the BAM and the changes as per supplementary condition no. 7 shall be documented for the series-production sample in the inspection log book.
4. It must be ensured that each user of the package registers with the BfS before first-time use and confirms that he has received and complies with the inspection log book, which mainly contains the Certificate of Approval, the instructions for handling and maintenance and the instructions for in-service inspections. These are in particular
 - Container instruction "Handling and maintenance of ANF10 BWR fuel assembly shipping containers" ANFG-11.101 (11), Rev. 8,
 - Container instruction "Recurring tests of ANF-10 fuel assembly shipping containers" ANFG-11.101 (12), Rev 4

Within the framework of this Approval, the use of documents with a higher revision index is only permissible after prior release by the BAM and with authorization of the BfS

5. Each series-production sample shall be subjected to in-service inspections in due time. For series-production samples that are to be used solely outside the Federal Republic of Germany, the in-service inspections can be performed and certificated by testing personnel authorized by the responsible authorities in the relevant country. The certificates for the in-service inspections conducted shall be forwarded unasked to the Federal Institute for Material Research and Testing (BAM) and to the Federal Office for Radiation Protection (BfS).
6. Each series-production sample must be provided permanently with the identification mark detailed above and with the date (month/year) of the next in-service inspection.
7. Changes relating to the Index of Drawings and the drawings listed therein, upon which the approval is based, require after their release by the BAM the consent of the BfS for the Revision Certificate or an extended type list (in accordance with Appendix 4). Thus they become part of the present approval
8. The package shall be transported under sole use.

If the maximum dose rate on the surface of the package exceeds 2 mSv/h, it is pointed out that transportation by ship will require special arrangement, unless the package on board the ship is in or on a train or road vehicle under sole use from which it is at no time unloaded

9. The certificate D/4340/IF-96 (Rev 9) remains valid up to and including March 31, 2015
10. This approval does not relieve the sender from the obligation to comply with all statutory regulations of any country through which or in which the transport package is conveyed

Costs:

1. Costs, charges and expenses shall be levied for this Decision in accordance with § 12 paragraph 1 and 2 of the Act Governing the Conveyance of Dangerous Goods (GGBefG) in the version of the notification of July 7, 2009 (BGBl. I p. 1774, 3975), that has been amended by Article 2 paragraph 148 of the law of August 7, 2013 (BGBl. I p. 3154), in connection with § 1 paragraph 2 of the Order Governing Costs for Safety Measures with Conveying Dangerous Goods (GGKostV) of March 7, 2013 (BGBl. 2013 I p 466). Fees arise from §2 in connection with attachment 2 of GGKostV.
2. The costs shall be borne by Advanced Nuclear Fuels GmbH, in accordance with § 12 paragraph 1 of the GGBefG in conjunction with § 13 paragraph 1 no 1 of the Administrative Costs Act (VwKostG) of June 23, 1970 (BGBl. I p 821), in the version valid up to August 14, 2013 of December 5, 2012 (BGBl. I p 2415)
3. The costs shall be determined by a separate decision

Information about available legal remedies:

Objections may be lodged within one month of notification of this decision. Objections must be lodged either in writing or be recorded at the Bundesamt für Strahlenschutz (Federal Office for Radiation Protection), Willy-Brandt-Strasse 5, 38226 Salzgitter, Germany.

Salzgitter, November 21, 2014

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Dr Reiche

Appendices

Appendix

Appendix 1: Characteristics of fuel from ERU or uranium

Appendix 2: Arrangement of partial-length fuel rods in ATRIUM™-10x10 fuel assembly

Appendix 3: Data sheet for FA shipping container of type ANF-10, drawing number ANF-5-121-3075-03,
Rev. 1

Appendix 4: Type list

- Appendix to the Certificate of Approval D/4340/IF-96 (Rev. 10) -

Rev no	Date of issue	Validity	Reason for revision
0*	16.10.2000	31.10.2003	Initial issue
1*	10.11.2000	31.10.2003	Alteration to the sections "Documents", "Permissible contents", "Description of the package" and "Supplementary conditions", omission of the section "Drawings", introduction of a type list as Appendix 3, replaces Rev 0
2*	09.11.2001	30.06.2002	Increase of the maximum cladding tube thickness for contents B, implementation of the new quality assurance program Revision 1 is valid up to June 30, 2002
3*	07.02.2002	28.02.2005	Alteration to the sections "Rules and regulations", "Documents", "Permissible contents", "Package design" and "Supplementary conditions", Revisions 1 and 2 remain valid until June 30, 2002.
4	23.02.2005	29.02.2008	Approval according to regulations based on TS-R-1, alteration to the permissible contents including the characterization of the fuel in Appendix 1 to the Certificate of Approval, increase of the CSI, extension of the type list
5	09.05.2005	31.05.2008	Alteration to the permissible contents, item A) Revision 4 remains valid until October 31, 2005.
6	02.02.2006	31.01.2009	Alteration to the permissible contents, item A), alteration to the criticality safety index (CSI) Revision 5 remains valid
7	10.10.2008	31.10.2011	Update of the regulations, alteration to the sections "Documents", "Permissible contents", "Supplementary conditions and notes", extension of the type list Revision 6 remains valid
8	13.01.2012	30.09.2012	Update of the regulations, alteration to the sections "Documents", "Permissible contents", "Supplementary conditions and notes", extension of the type list
9	22.03.2012	31.03.2015	Alteration to the sections "Documents", "Permissible contents" and "Supplementary conditions and notes"
10	21.11.2014	30.11.2019	Alteration to the sections "Regulations", "Documents", "Permissible contents", "Supplementary conditions and notes" and Appendix 1 of the Certificate of Approval Revision 9 remains valid.

¹⁾ Revisions of the Certificate of Approval D/4340/IF-85

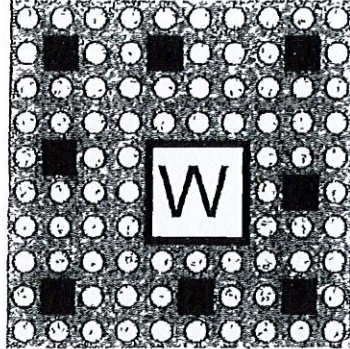
Characteristics of fuel from ERU or uranium

Nuclide	Mass content max. [%]	Activity per gram of uranium max. [Bq]	Gamma output per gram of uranium max. [MeV · Bq]
U-232	5.0E-06 ¹⁾	4 14E+04	
Th-228		4.13E+04	
U-234	0.2	4.60E+05	
U-235			
ATRIUM™-10x10 FA	5.35	4 28E+03	
otherwise	5.00	4 00E+03	
U-236	2 5	5 98E+04	
U-238	100	1 15E+04	
Fission nuclides			440 ²⁾
Transuranic elements		250	

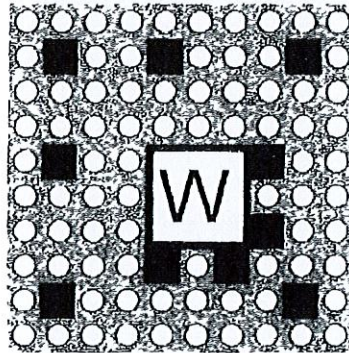
1) That means: $5.0E-06 = 5.0 \cdot 10^{-6}$

2) Restriction of fission nuclide activity is nuclide-independent and is governed by the upper limit (specified above) for energy release from gamma radiation per second and gram of uranium.

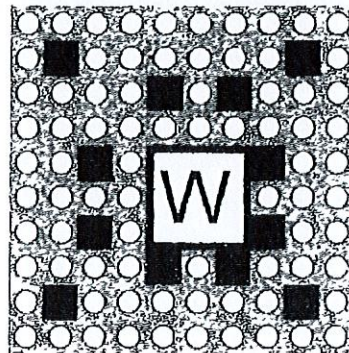
Type Atrium 10A, 10B



Type Atrium 10XP

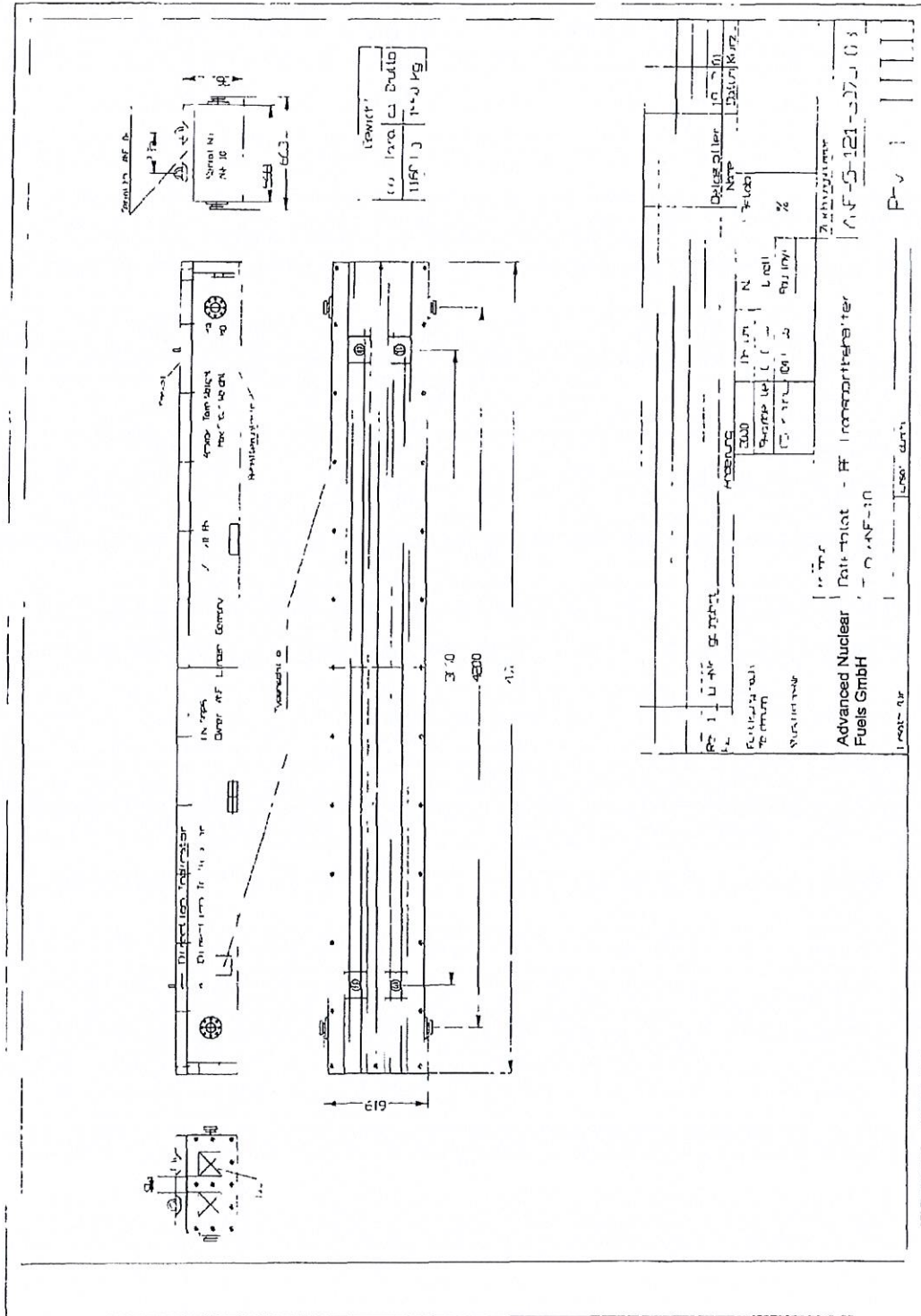


Type Atrium 10XM



- W Water channel
- Partial-length fuel rod
- Full-length fuel rod

Arrangement of partial-length fuel rods in ATRIUM™-10x10 fuel assembly



Appendix 4 to the Certificate of Approval D/4340/IF-96 (Rev. 10)

**Type list
for ANF-10 fuel assembly shipping container**

Type ANF-10 shipping containers, which shall be or have been manufactured in accordance with the following Index of Drawings, conform to the model type specified in this Certificate of Approval (see alsosupplementary conditions 2, 3 and 7).

Revision of the Index of Drawings	Release by the BAM
5-3 21-3100-04, Rev. 2	Test certificate of BAM dated September 14, 2000 (File Ref.: III.3/20708)
5-3 21-3100-04, Rev. 4	1 st Supplement to test certificate of BAM (File Ref.: III.3/20708) Dated November 8, 2000
5-3 21-3100-04, Rev. 5	Expert opinion of BAM (File Ref.: III.32/Ma) dated January 12, 2001
5-3 21-3100-04, Rev. 6	Expert opinion of BAM (File Ref.: III.32/Ma) dated May 4, 2001
5-3 21-3100-04, Rev. 7	Expert opinion of BAM (File Ref.: III.32/Ma) dated August 7, 2001
5-3 21-3100-04, Rev. 8	Expert opinion of BAM (File Ref.: III.32/Dau) dated January 16, 2002
5-3 21-3100-04, Rev. 10	Expert opinion of BAM (File Ref.: III.3/20925) dated March 12, 2004
5-3 21-3100-04, Rev. 13	Expert opinion of BAM (File Ref.: III.3/20925) dated February 16, 2005
5-3 21-3100-04, Rev. 14	Expert opinion of BAM (File Ref.: III.3/20925) dated July 15, 2005
5-3 21-3100-04, Rev. 15	Expert opinion of BAM (File Ref.: III.3/21145) dated June 27, 2007
5-3 21-3100-04, Rev. 16	Expert opinion of BAM (File Ref.: III.3/21145) dated August 14, 2007
5-3 21-3100-04, Rev. 17	Expert opinion of BAM (File Ref.: III.3/21145) dated January 21, 2008
5-3 21-3100-04, Rev. 20	Expert opinion of BAM (File Ref.: III.3/21279) dated July 29, 2008
5-3 21-3100-04, Rev. 21	Expert opinion of BAM (File Ref.: III.3/21279) dated June 23, 2010
5-3 21-3100-04, Rev. 22	Expert opinion of BAM (File Ref.: 3.3/21413) dated October 27, 2011
5-3 21-3100-04, Rev. 24	Expert opinion of BAM (File Ref.: III.3/21413) dated June 26, 2012
5-3 21-3100-04, Rev. 25	Expert opinion of BAM (File Ref.: III.3/21413) dated January 20, 2014
5-3 21-3100-04, Rev. 26	Expert opinion of BAM (File Ref.: 3.3/21431) dated March 04, 2016
5-3 21-3100-04, Rev. 27	Expert opinion of BAM (File Ref.: Ma) dated October 21, 2016
5-3 21-3100-04, Rev. 28	Expert opinion of BAM (File Ref.: 3.3/17025957/2017/01/Ku) dated November 22, 2017

Salzgitter, November 29, 2017
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