GNS Gesellschaft für Nuklear-Service mbH · Postfach 10 12 53 · 45012 Essen

Document Control Desk
Director, Division of Fuel Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555–0001
USA

Our reference:	T1213-CO-00010
Contact person:	Dominik Bussmann
Phone:	+49 (0)201/ 109-1891
Fax:	+49 (0)201/ 109-1186
Email:	dominik.bussmann@gns.de
Date:	07/02//2021

Subject: Response on request for supplemental information for 10 CFR 71 Application of the CASTOR® geo69 Spent Nuclear Fuel Transportation Package (Docket No. 71-9383; EPID No. L-2021-NEW-0002)

Reference: REQUEST FOR CERTIFICATE OF COMPLIANCE FOR THE MODEL NO. CASTOR® GEO69 PACKAGE – REQUEST FOR SUPPLEMENTAL INFORMATION MAY 7, 2021

By letter dated May 7, 2021 NRC submitted a request for supplemental information on the application for approval acc. to 10 CFR 71 of the CASTOR® geo69 spent fuel package.

The response on this request is enclosed to this letter. This response and the therein referenced documents contain certain information that is proprietary, confidential and a trade secret to GNS. Therefore, a non-proprietary version of the response together with an affidavit prepared pursuant to 10 CFR 2.390 providing the basis for withholding of the GNS-proprietary information from public disclosure is enclosed to this letter.

Should the NRC staff require additional information to support review of this response, please do not hesitate to contact Mr. Dominik Bussmann at +49 201 109 1891, or by email at dominik.bussmann@gns.de.

Sincerely,

NMSS20
NMSS

GNS Gesellschaft für Nuklear-Service mbH

i.V. F. Kotte

i.A. D. Bu

Enclosure 1: Affidavit Pursuant to 10 CFR 2.390
Enclosure 2: Response on request for supplemental information, Proprietary Version
Enclosure 3: Response on request for supplemental information, Non-Proprietary Version

Enclosure 1 to T1213-CO-00010

AFFIDAVIT

PURSUANT TO 10 CFR 2.390

I, Dr.-Ing. Jens SCHRÖDER, depose and say that I am the Chief Technology Officer (CTO) of GNS Gesellschaft für Nuklear-Service mbH (a company duly organized under the German Law, having its seat at Frohnhauser Strasse 67, 45127 Essen, Germany), duly authorized to execute this affidavit.

I, Dr.-Ing. Sascha KLAPPERT, depose and say that I am Divisional Director of Engineering of GNS Gesellschaft für Nuklear-Service mbH (a company duly organized under the German Law, having its seat at Frohnhauser Strasse 67, 45127 Essen, Germany), duly authorized to execute this affidavit.

We, Dr.-Ing. Jens SCHRÖDER and Dr.-Ing. Sascha KLAPPERT, have reviewed or caused to have reviewed the information which is identified as confidential and referenced in the paragraph below. We are submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information sought to be withheld from public disclosure is contained in the following Enclosures of letter T1213-CO-00010 and is listed below:

- Enclosure 2, Response on Request for supplemental information, Proprietary Version

and in the therein referenced documents

- 1014-TR-00009 Rev. 0, Material Data CASTOR® geo69
- 1014-TR-00011 Rev. 0, Material Qualification NEXUS®-3000
- 1014-TR-00012 Rev. 0, Material Qualification GUR® 4120 Tempered
- 1014-TR-00017 Rev. 0, Material Qualification Metal Gaskets
- 1014-TR-00029 Rev. 0, Structural Evaluation Impact Limiters, Transport Package CASTOR® geo69
- 1014-TR-00071 Rev. 0, Overview of Documents Related to Methodology, Verification and Validation CASTOR® geo69

This documents has been appropriately designated as proprietary.

We have personal knowledge of the criteria and procedures utilized by GNS Gesellschaft für Nuklear-Service mbH in designating information as a proprietary trade secret, privileged or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

(1) The information sought to be withheld from public disclosure involves certain design details associated with the SAR analyses and SAR drawings of the CASTOR® geo69 transport package design, which are owned and have been held in confidence by GNS Gesellschaft für Nuklear-Service mbH.

(2) The information is of a type customarily held in confidence by GNS Gesellschaft für Nuklear-Service mbH and not customarily disclosed to the public. GNS Gesellschaft für Nuklear-Service mbH has a rational basis for determining the types of information customarily held in confidence by it.

(3) The information is being transferred to the Commission in confidence under the provisions of 10 CFR 2.390 with the understanding that it is to be received in confidence by the Commission.

(4) The information, to the best of our knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or confidentiality agreements which provide for maintenance of the information in confidence.

(5) Public disclosure of the information is likely to cause substantial harm to the competitive position of GNS Gesellschaft für Nuklear-Service mbH because:

(a) A similar product is manufactured and sold by competitors of GNS Gesellschaft für Nuklear-Service mbH.

(b) Development of this information by GNS Gesellschaft für Nuklear-Service mbH required expenditure of considerable resources. To the best of our knowledge and belief, a competitor would have to undergo similar expense in generating equivalent information.

(c) In order to acquire such information, a competitor would also require considerable time and inconvenience related to the development of a design and analysis of a cask for the dry storage and transport of spent nuclear fuel.

(d) The information required significant effort and expense to obtain the licensing approvals necessary for application of the information. Avoidance of this expense would decrease a competitor's cost in applying the information and marketing of the product to which the information is applicable.

(e) The information consists of design features, analyses methods and calculation results related to the design and analyses of a transport package of spent nuclear fuel, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to unfairly get a better competitive position with GNS Gesellschaft für Nuklear-Service mbH, take marketing or other actions to improve their product's position or impair the position of GNS Gesellschaft für Nuklear-Service mbH's product, while avoiding the expense of developing similar data and analyses in support of their processes, methods or apparatus.

(f) In pricing GNS Gesellschaft für Nuklear-Service mbH's products and services, significant research, development, engineering, analytical, licensing, quality assurance and other costs and expenses must be included. The ability of GNS Gesellschaft für Nuklear-Service mbH's competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

Date: 24.06.2021

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Dr.-Ing. Jens SCHRÖDER
- Chief Technology Officer (CTO) -

GNS Gesellschaft für
Nuklear-Service mbH

Date: 24.06.2021

.....

.....

Dr.-Ing. Sascha KLAPPERT
- Divisional Director of Engineering -

GNS Gesellschaft für
Nuklear-Service mbH

Subscribed and sworn to me before this 24 day of June, 2021.

.....

Notary Public *(Unterschrift des Notars)*

Number 202 of Notary's Register of 2021

I herewith certify that the foregoing signatures are given by

Dr.-Ing. Jens Schröder, born on 16.01.1969,
of known identity, and

Dr. Ing. Sascha Klappert, born on 21.08.1972,
of known identity,

both with their business address at
Frohnhauser Str. 67, 45127 Essen.

The signatures were given today in Frohnhauser Str. 67, 45127 Essen.

Obligatory Statement according to German law:

According to Sec. 3 Para. 1 S. 1 No. 7 German Notarisation Law the Notary Public asked the appearers whether he or any member of his firm had acted in the matter which is the subject of this instrument, except in a notarial capacity. The appearers replied in the negative.

Essen, June, 24, 2021

(Dr. Gores)
Notary Public

APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1. **Country / Land:**
   Federal Republic of Germany / Bundesrepublik Deutschland

   This public document / Diese öffentliche Urkunde

2. **has been signed by / ist unterschrieben von**
   Notary Public Dr. Joachim Gores / Notar Dr. Joachim Gores

3. **acting in the capacity of / in seiner Eigenschaft als**
   Notary Public in Essen / Notar in Essen

4. **bears the seal / sie ist versehen mit dem Siegel**
   of the Notary Public Dr. Joachim Gores in Essen / des Notars Dr. Joachim Gores in Essen

Certified/Bestätigt

5. **at / in** Essen **6. the / am** 28. JUNI 2021

7. **by / durch** the President of the Regional Court Essen /
   die Präsidentin des Landgerichts Essen

8. **No./ unter Nr.** 91 E 1 / 8 du 2120 | 2021

9. **Seal / Stamp Siegel / Stempel:** **10. Signature / Unterschrift:**

Die Präsidentin des Landgerichts 9 Essen

In Vertretung

Dr. Ostheide
Vorsitzender Richter am Landgericht

Response on Request for supplemental information dated May 7 2021
Model No. CASTOR® geo69
Docket-No.: 71-9383, EPID No. L-2021-NEW-0002
Non-Proprietary Version

2.0 Structural Evaluation

2-1 *Provide information to demonstrate that the structural design of the package meets the moderator exclusion criterion or revise the criticality safety analyses to evaluate a flooded package under normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as well as for the criticality safety index calculations.*

The applicant assumed that the internals of the package were dry in some of the criticality safety analyses. In the application, the applicant states: "Due to a very low reactivity of dry fuel, the cask reactivity under normal and hypothetical accident conditions is bounded by the reactivity of the fully flooded cask." Although the packaging design includes two closure seals, the structural design has not demonstrated that the package design is qualified for moderator exclusion pursuant to Title 10 of the Code of Federal Regulations (10 CFR) 71.55(d) and 71.55(e) because the structural analysis did not provide specific acceptance criteria linked to moderator exclusion for both normal conditions of transport and hypothetical accident conditions.

This information is required to determine compliance with 10 CFR) 71.55(d) and 71.55(e).

Answer:

For the bolts, the stress criteria of the normal conditions (Level A) are applied for all conditions. According to WB-3234 (Level D Service Limits) the requirement of leak-tightness of the closure may be satisfied by using the rules of WB-3232 (Level A service limits). By ensuring that the Level A service limits are satisfied during HAC, the lid systems of both the transport cask and canister remain functional. Thus, by demonstrating that the corresponding acceptance criteria for moderator exclusion, (i.e. confirmation of the cited Level A service limits) are met, it is shown that two independent watertight boundaries remain intact also under HAC, so that moderator exclusion can be assumed.

The information will be added in the corresponding section during revision of the SAR.

2-2 *Provide the following documents to confirm that requirements related to lifting, NCT, and HAC have been satisfied:*

The following references are needed to confirm bolt loads, material properties, impact limiter performance, and loads to be applied for NCT and HAC drop tests.

[redacted]

DIN EN 1993-1-5, 2019/10
Eurocode 3: Design of steel structures
Part 1-5: Plated structural elements

DIN EN 1999-1-1, 2014/03
Eurocode 9: Design of aluminum structures

VDI-Richtlinie 2230, Part 1
Systematic calculation of highly stressed bolted joints,
Joints with one cylindrical bolt.
Version 11/2015

VDI 2230:2014-12 Part 2
Systematic calculation of highly stressed bolted joints
Multi bolted joints
Safety Standards of the
Nuclear Safety Standards Commission (KTA)

KTA 3201.2
Components of the Reactor Coolant Pressure Boundary
of Light Water Reactors
Part 2: Design and Analysis
2017-11

[redacted]

This information is required to determine compliance with 10 CFR 71.71, 10 CFR 71.73, and 10 CFR 71.45.

Answer:

The technical reports [redacted] and [redacted] are submitted to NRC as attachment to enclosure 2 of letter T1213-CO-00010. They shall be treated as proprietary information, to be withheld from public disclosure.

The DIN and VDI standards are provided as printed copy for inspection as attachment to enclosure 2 of letter T1213-CO-00010. After completion of NRC's review, these documents are required to be returned to GNS due to license holder requirements.

KTA 3201.2 can be obtained from:
http://www.kta-gs.de/e/standards/3200/3201_2_engl_2017_11.pdf

2-3 *Provide justification/benchmarking used to support and validate drop simulations and stress analysis in ANSYS and LS-DYNA for NCT and HAC.*

The applicant provided drop test results for NCT and HAC that were based on simulation without any supporting physical testing or any reference to actual drop testing to verify such results. Without physical testing to confirm simulations (LS-DYNA and ANSYS) which are meant to replace actual physical testing, staff cannot confirm any of the results or assumptions made in the safety analysis report (SAR). Data related to physical testing should be provided so that staff can confirm that the simulations produce reasonable results. The physical data that staff needs to confirm drop simulations should include specimen description, drop orientation, target information, prototype details (if any), specimen construction, package instrumentation, atmospheric test conditions, testing methodology, validation, etc. Note that drop test data used to benchmark the CASTOR® geo69 analysis does not have to be for this specific package but could be for a package whose behavior and/or physical properties (i.e. shape, dimensions, weight, impact limiters characteristics, etc.) are similar to this package. Attachment 2A of NUREG 2216, specifically Section 2A.4 "Computer Model Validation", provides additional validation guidance.

This information is required to determine compliance with 10 CFR 71.33, 10 CFR 71.71 and 10 CFR 71.73.

Answer:

The requested justification/benchmarking used to support and validate drop simulations and stress analysis in ANSYS and LS-DYNA for NCT and HAC is performed in various GNS reports partly in English and in German language. To guide the reviewer through these documents GNS prepared a compendium

[redacted]

to be attached to the SAR during revision. This compendium is submitted to NRC as attachment to enclosure 2 of letter T1213-CO-00010. All technical reports attached to the compendium shall be treated as proprietary information, to be withheld from public disclosure. The following appendices are currently in translation and will be submitted to NRC after completion.

[redacted]

[redacted]

2-4 *Provide information to demonstrate that the borated metal matrix composite (MMC) material used in the basket will not deform as a result of the tests for NCT and HAC.*

The package design uses borated MMC plates to make the fuel basket cells in the canister. Therefore, the MMC plates serve as both the structural components and neutron poison plates. The applicant performed criticality safety analyses for the package with the assumption that the borated MMC plates will retain their geometric shape and dimensions. The shielding analyses also credit the borated MMC plates. Because the borated MMC is an aluminum-based alloy, it is not clear if the MMC plates will deform under NCT and HAC.

This information is necessary for the staff to determine compliance with 10 CFR 71.47, and 10 CFR 71.51, 10 CFR 71.55(d), 10 CFR 71.55(e) 10 CFR 71.59, 10 CFR 71.71, and 10 CFR 71.73.

Answer:

In Appendix 2-2 of the SAR ([redacted]) the deformations of the MMC plates are evaluated by considering a sequence of the loads resulting from NCT and HAC. Including the intermediate and final unloading phases, the load sequence has the following form: NCT → 1 g → HAC → 1 g. The residual deformations and plastic strains from the cumulative loads are determined for the decisive HAC drop orientations with and without additional thermal load. Furthermore, it is shown that even under maximum load the plates will not cause loads on the FA.

The deformation of MMC plates for NCT loads only are calculated but not explicitly shown. As an example, Figure 1 exemplarily shows the deformation of the discharged MMC plates after NCT under consideration of thermal loads. It can be seen that the relative displacement of the neighbouring plates is well below [redacted].

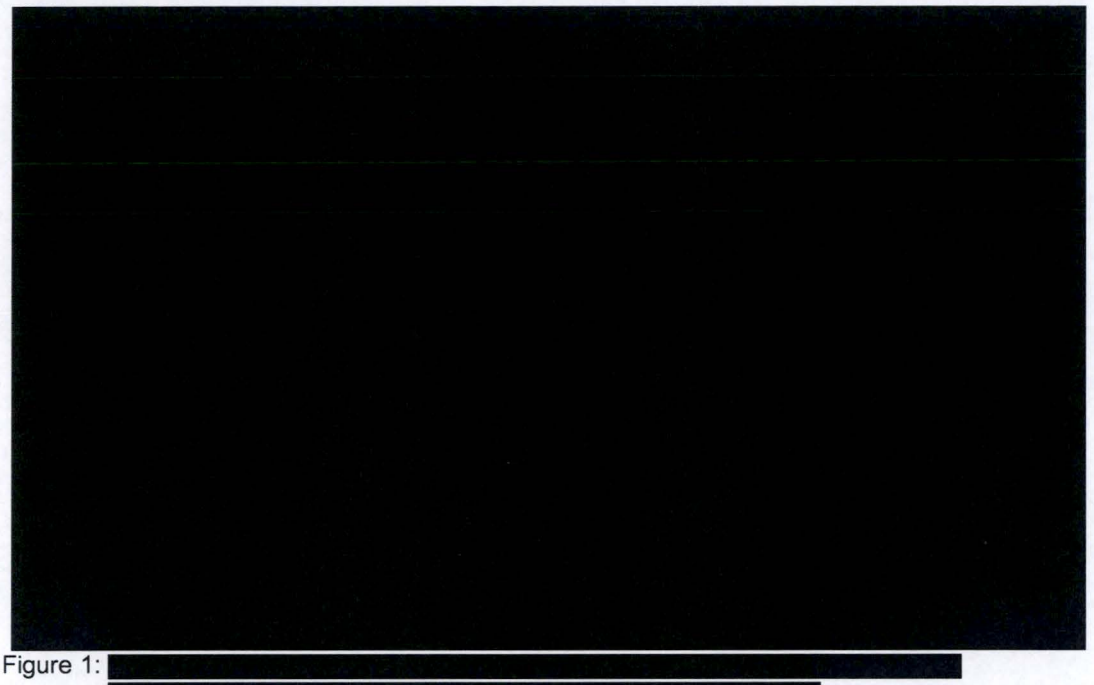


Figure 1: [redacted]

The criticality safety analysis is performed with the assumption that the borated MMC plates will retain their geometric shape and dimensions under NCT and HAC, and that the FA are radially displaced towards the centre of the fuel basket. This conservative assumption is based on the following considerations.

The structural analysis of the basket shows:

- the FA are displaced in the direction of the drop orientation
- the relative displacement of the neighbouring borated MMC plates under NCT is well below [redacted] for all investigated drop orientations.

As can be seen from the sensitivity analysis in SAR Subsections 6.3.4.1.8 "Radial Displacement of FA" and 6.3.4.1.13 "Dimension of Basket Receptacles",

- the maximum possible radial displacement of all FA towards the centre of the fuel basket, as implemented in the bounding model for NCT, corresponds to the reactivity increase of Δk = [redacted] and
- the decrease of the inner dimension of all basket receptacles by [redacted] leads to the reactivity increase of Δk = [redacted]

The model for NCT, which conservatively takes into account the radial displacement of all FA towards the centre of the basket, can consequently be considered as bounding for the basket deformations under NCT.

The leak-tightness of the cask and canister lids under HAC is demonstrated in SAR Section 2.7. The structural analysis of the cask and canister as well as of the basket under HAC is provided in SAR Appendix 2-1 and Appendix 2-2, respectively.

As the damage of the cask wall and bottom as well as the loss of integrity of the cask and canister lid systems under HAC are excluded, the reactivity of the credible basket configurations under dry conditions is bounded by the fully flooded cask configuration,

as provided by the bounding model for NCT. Thus, the separate analysis of the basket deformations under HAC is not necessary.

This information will be added at a suitable section during revision of the SAR.

2-5 *Provide the following documents in English referenced in the CASTOR® geo69 SAR for the proprietary materials properties.*

The CASTOR® geo69 package uses several proprietary materials that are not described in the American Society of Mechanical Engineer's Boiler and Pressure Vessel Code, including the neutron shielding material, fuel basket structure (i.e., fuel cell partitioning plates), impact limiter foam, and containment seals. The staff needs the following documents referenced in the SAR Section 2.2, "Materials," to verify that the materials properties support the safety analyses:

[4] Material data by manufacturer Ticona GmbH, GUR [redacted] Domininghaus, "Die Kunststoffe und ihre Eigenschaften", Springer, 1998

Answer:

The referenced information is written in German language. To provide English information the cited documents will be replaced by a new material qualification report

[redacted]

within a revision of the SAR. This technical report is submitted to NRC as attachment to this enclosure of letter T1213-CO-00010. It shall be treated as proprietary information, to be withheld from public disclosure. However, the mistaken reference [1] in this report

Peter Elsner, Peter Eyerer, Thomas Hirth
Domininghaus – Kunststoffe, 8. Auflage, S. 224
Springer-Verlag, Berlin Heidelberg 2012

is replaced by the manufacturer's data sheet, attached to this enclosure

[redacted]

[6] [redacted]

Answer:

The referenced documents will be replaced by a new material qualification report

[redacted]

within a revision of the SAR. This technical report is submitted to NRC as attachment to this enclosure of letter T1213-CO-00010. It shall be treated as proprietary information, to be withheld from public disclosure.

[7] Material data by manufacturer General Plastics, USA

Answer:

Information and material data for the [redacted] foam ([redacted]) are provided online by the manufacturer General Plastics:

[redacted]

The data provided by the manufacturer will be supplemented by a new material qualification report currently in preparation to be submit to NRC after completion.

[8] HELICOFLEX Federelastische Metalldichtungen, Garlock Sealing Technologies Catalogue July 2017 [redacted]

Answer:

The referenced documents will be replaced by a new material qualification report

[redacted]

within a revision of the SAR. This technical report will be submitted to NRC as attachment to this enclosure of letter T1213-CO-00010. It shall be treated as proprietary information, to be withheld from public disclosure. The "Metal Seals Technical Catalog by Technetics Group, 2020" can be obtained from https://technetics.com/technetics-products/metal-seals/.

In Document No. [redacted] *provide the following reference:*

[11] [redacted]

Answer:

This technical report will be submitted to NRC as attachment to enclosure 2 of letter T1213-CO-00010. It shall be treated as proprietary information, to be withheld from public disclosure.

This information is needed to determine compliance with 10 CFR 71.31(c) and 10 CFR 71.33(a)(5).

2-6 *Provide details of the fuel contents, cask drying process, and the structural performance of the fuel cladding during NCT and HAC (if needed to demonstrate that the analyzed fuel configuration of the fuel will be maintained).*

The staff needs the following information to evaluate the allowable fuel contents and potential content reactions:

- *The specific types of allowable cladding alloys (e.g., "Zircaloy-2"),*

  Answer:

  The fuel rod cladding is made of Zircaloy-2. Internal water rods and channels as well as outer channels are made of Zircaloy-2 and Zircaloy-4.

  Table 1.2-11 of the SAR will be adjusted during revision.

- *The definition of "undamaged" fuel assemblies,*

  Answer:

  Undamaged fuel is according to ISG-11 [1] fuel, that can meet all fuel-specific and system-related functions. Undamaged fuel may be breached. Fuel assembly classified as undamaged may have assembly defects.

  The definition will be added to the glossary during revision of the SAR.

- *The cask drying criteria (e.g., vacuum pressure, hold time) that ensure a dry, inert environment, and*

  Answer:

  The following typical drying procedure for CASTOR® casks will also be considered for the geo69 cask:

  [redacted]

[redacted]

The drying process is performed according to written and approved procedures.

- *The maximum allowable fuel cladding temperatures during short-term operations (e.g., cask drying).*

Answer:

The maximum allowable fuel cladding temperatures during short-term operations is limited to 400 °C in accordance with ISG 11 [1].

The information will be added at a suitable section during revision of the SAR.

In addition, if the geometric form of the fuel is assumed to be unaltered during NCT and HAC, the staff needs the following information on the structural performance of the fuel assemblies:

- *The cladding mechanical properties used in the structural analysis,*
- *A description of how the structural evaluation accounts for a reduced cladding thickness due to oxidation during reactor service,*
- *An analysis of the fatigue performance of the fuel rods,*
- *For high burnup fuel in dry storage for more than 20 years prior to transport, a demonstration that long term aging degradation issues will not prevent the fuel from fulfilling its safety functions (See NUREG-2224, "Dry Storage and Transportation of High Burnup Spent Nuclear Fuel – Final Report," Figures 4-1 through 4-3 for some examples of approaches considered to be acceptable),*

Alternatively, if the fuel is assumed to reconfigure during NCT or HAC, revise the criticality, shielding, and thermal analyses with consideration of fuel reconfiguration, beyond what is already addressed in the application.

Answer:

Since for at least one of the fuel types which shall be loaded into the canister of the CASTOR® geo69 cask the burn-up exceeds 45 GWd/t_{HM} and for all fuel types the intended dry storage time is beyond 20 years, according to NUREG-2224 [2] age-related uncertainties connected with transport after extended dry storage of HBU SNF are to be considered in the safety analyses.

The chosen approach is to supplement the design basis with safety analyses that demonstrate that the cask can still meet the pertinent regulatory requirements by assuming hypothetical reconfiguration of the HBU SNF contents into justified geometric forms. This approach demonstrates that during transport after 20 years of dry storage, even if reconfigured, SNF can still meet the 10 CFR Part 71 requirements for thermal, criticality safety and shielding during NCT and HAC.

Following NUREG-2224 [2], the impact of cladding failures of Category 1 with breached rods (Scenario 1(a) according to [2]) and with damaged rods (Scenario 1(b) according to

[2]) is considered by the external dose rate evaluation in chapter 5 assuming rupture of 3 % and 100 % of the fuel rods for NCT and HAC, respectively.

The cask is designed to exclude the water leakage into the canister cavity under NCT and HAC. Due to very low reactivity of dry fuel, the behaviour of the spent fuel as a result of accident conditions during transport after more than 20 years of storage does not need to be explicitly evaluated and is bounded by the reactivity of the fully flooded cask with pure unborated water, as assumed in the bounding criticality safety model for NCT (see Section 6.4).

The impact of cladding failures of Category 1 with breached rods (Scenario 1(a) according to [2]) and with damaged rods (Scenario 1(b) according to [2]) on the fuel cladding and package component temperatures as well as on the canister pressure assuming rupture of 3 % of the fuel rods for NCT and of 100 % for HAC, respectively, is evaluated in the following:

The case of 10 % fuel rod failure for HAC with a fraction of fission gas release of 0.3 leads to a strongly reduced heat conductivity of the gas atmosphere in the canister resulting in a temperature increase of [redacted] inside the canister. The maximum heat power of a single FA is reduced to [redacted] of dry storage leading to a reduced maximum total heat power of about [redacted] (instead of 18.5 kW) for the cask loading. In that case, [redacted] lower temperatures inside the canister result. Both effects lead to [redacted] higher temperatures for the components and the fuel rods in the canister in sum.

Maximum FA temperatures occur if the fuel remains inside the fuel cladding. A variation calculation with a concentration of the [redacted] heat power in the bottom (or lid) part of the canister (fuel reconfiguration) shows that higher heat power density is compensated by the higher thermal conductivity within an assumed fuel pouring in the bottom part of the canister ([redacted]), see Figure 2.

The maximum temperature of the fuel is slightly reduced, but not significantly changed. The mean gas temperature in the canister will be much lower, because the main gas volume is now present in the colder zones above the fuel pouring.

A slight temperature increase occurs only for some cask components in the bottom (or lid) part, but the admissible temperatures for all cask components are further not reached.

The maximum temperature of the content for HAC in case of 100 % fuel rod failure after 20 years dry storage amounts to [redacted]. This temperature is below the admissible value of 400 °C for NCT resp. of 570 °C for HAC with very large safety margins. The mean gas temperature inside the canister amounts to [redacted]. The admissible temperatures for FA and all cask components are not reached.

During revision the SAR will be supplemented by the aforementioned Information.

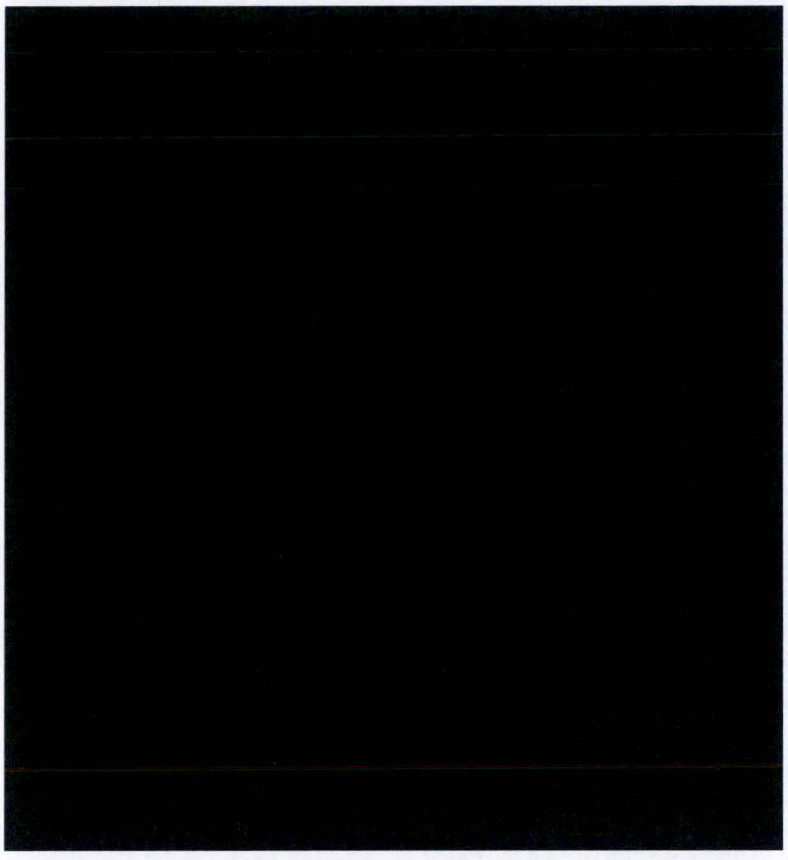


Figure 2: Thermal canister model with fuel particle release in the bottom part

This information is needed to determine compliance with 10 CFR 71.33(b), 10 CFR 71.43(d), 10 CFR 71.47, 10 CFR 71.51(a), 10 CFR 71.55(d), 10 CFR 71.55(e) and 10 CFR 71.73(c)(4).

2-7 *Provide the fuel basket material qualification documentation and acceptance testing criteria for the required mechanical properties, thermal properties, and neutron attenuation performance.*

SAR Section 8.1.5.1 states that the Al-B_4C MMC basket material does not conform to the requirements of the American Society of Mechanical Engineer's Boiler and Pressure Vessel Code. The SAR also states that:

> *"These materials and their requirements are either specified by other standards, or they are tested individually for the use in the CASTOR® packages and their qualification is documented."*

The SAR does not provide information on the qualification or acceptance testing requirements for the basket material structural, thermal, or neutron attenuation performance. As a result, the staff requests this information for:

- *mechanical properties (e.g., yield strength, tensile strength, elongation, fracture performance), including effects of temperature,*

- *inspection requirements to verify that the material is free of defects that could affect mechanical performance,*
- *thermal properties (e.g., thermal conductivity, density, specific heat)*
- *neutron attenuation performance, and*
- *porosity, considering implications on corrosion*

NUREG-2216, Section 7.4.7 provides guidance on the staff's review of neutron absorber materials, which includes reference (with some exceptions) to ASTM International C1671-15, "Standard Practice for Qualification and Acceptance of Boron Based Metallic Neutron Absorber Materials for Nuclear Criticality Control for Dry Cask Storage Systems and Transportation Packaging."

This information is needed to determine compliance with 10 CFR 71.33(a)(5), 10 CFR 71.43(d), 10 CFR 71.47, 10 CFR 71.51(a), 10 CFR 71.55(d) and (e), and 10 CFR 71.85(a).

Answer:

For the material qualification and acceptance test criteria for the required mechanical properties, thermal properties, and neutron attenuation performance of the borated MMC used in the basket, a new material qualification report

[redacted]

is prepared and within revision the SAR will be supplemented accordingly in section 8.1.5.1. This technical report will be submitted to NRC as attachment to this enclosure of letter T1213-CO-00010. It shall be treated as proprietary information, to be withheld from public disclosure.

3.0 Thermal Evaluation

3-1 *Provide the thermal analyses and results associated with the transfer and loading operations discussed in SAR Section 7.1 "Package Loading".*

There was no discussion in Chapter 3, "Thermal Evaluation," about the thermal analyses or results for the various operations mentioned in the SAR's Section 7.1. Relevant thermal issues during operations (e.g., loading, unloading, transfer) include, for example, time limits of transient operations, flushing water flow rate associated with loading the fuel assemblies into the canister, the basis of the time limits associated with the vacuum drying process (e.g., Step E2.7 and the remedy if the time limit is not met), and measures to ensure that the water used for cooling purposes during loading operations does not boil.

This information is needed to determine compliance with 10 CFR 71.31(a) and 10 CFR 71.35.

Answer:

The package loading which is described in SAR Section 7.1 is performed under utilization of several equipment like a transfer cask for handling of the canister and a transfer lock for canister transhipment between transfer cask and transport cask called cask loading unit (CLU). The CLU design and evaluation is part of the 10 CFR 72 application, which has just been submitted to NRC with letter T1213-CO-00009 under Docket-No. 70-1052.

In the related SAR detailed descriptions and safety evaluations including a thermal evaluation, showing compliance of the cask component and fuel cladding temperature limits can be found.

However, it is correct, that short-term operations like canister loading impacts also the transport package. For this reason, we intend to define requirements and boundary conditions in an appropriate section of SAR (transport) that must be complied with during canister loading, so that the package is in the condition specified as soon as it is transported on public roads. These requirements and boundary conditions are derived from the (thermal) evaluations for canister loadings using the CLU conducted as part of the 10 CFR 72 application.

GNS intends to include a reference to the relevant sections of the Part 72 SAR in the Part 71 SAR to avoid a redundant assessment.

Subsequently it will be integrated in the SAR during revision.

3-2 *Provide Section 3.5, "Appendix" in the SAR Thermal chapter so that a review can be performed.*

The SAR's Table of Contents and SAR page 3.5-1 mention a thermal-related Appendix. However, there is no information provided.

This information is needed to determine compliance with10 CFR 71.31(a) and 10 CFR 71.35(a).

Answer:

Section 3.5 is intended to provide space in case any appendix needs to be added. Currently there is no thermal related appendix. A blank page with the comment "with intent no items" will be added within a revision of the SAR.

3-3 *Provide the fin performance calculations and the relevant portion(s) of Reference [2] "VDI Heat Atlas" listed in Section 3.3, in English, so that a review of the finned surface enlargement factor can be performed.*

SAR Section 3.3.1.3 mentioned that a finned surface enlargement factor was calculated analytically according to the "VDI Heat Atlas". A review of the calculations and the relevant portion of the reference is needed because the finned surface contributes to the thermal performance of the package.

This information is needed to determine compliance with 10 CFR 71.31(a), 10 CFR 71.35(a), and 10 CFR 71.41(a).

Answer:

With E-Mail dated May 13 2021, NRC confirmed they were able to receive the relevant pages of the VDI Heat Atlas by themselves. The relevant portions can be found in Chapter M1 (p. 1271 ff.), sections 2 and 3.1. The calculation of the finned surface enlargement factor (including formulas) is described in SAR section 3.3.1. From GNS perspective further information cannot be provided and is not necessary to review the calculation.

5.0 Shielding Evaluation

5-1 *Provide the following specifications for the identified packaging components:*

a. *The minimum areal density of the boron-10, the maximum weight percent of boron carbide (B_4C), and the tolerances for the thickness of the* [redacted] *borated aluminum [metal matrix composite] MMC basket components, and*
b. *The dimensions and tolerances of the* [redacted] *for both the top and bottom impact limiters.*

This information should also be included in the package drawings because the drawings will be incorporated by reference as part of the certificate.

This information is needed for staff review to confirm compliance with 10 CFR 71.33(a)(5), 10 CFR 71.47, 10 CFR 71.51(a), 10 CFR 71.55(b), 10 CFR 71.55(d), 10 CFR 71.55(e), and 10 CFR 71.59.

Answer:

a. Please find the minimum areal density of B-10 and the maximum weight-% of B_4C in the corresponding material qualification report [redacted]. The tolerances for the thickness of the [redacted] borated MMC plates is [redacted].
[redacted]
b. [redacted]

These information will be added at a suitable section during revision of the SAR.

8.0 Acceptance Tests and Maintenance Program

8-1 *Provide descriptions of the acceptance tests, maintenance tests, and acceptance criteria for the fabricated packaging items that are relied on to perform a shielding function.*

Sections 8.1.5.1 and 8.1.6 of the application include statements that acceptance tests of shielding components will be performed to ensure that certain characteristics of the components that are relevant for shielding are met by the fabricated components. However, the application does not include any kind of description of those tests, nor does it include the criteria that will be used in those tests to determine whether the fabricated components comply with the necessary characteristics (e.g., minimum density, composition and dimensional uniformity, minimum hydrogen content, minimum boron content, minimum thickness, lack of internal voids) as defined in the package design and needed to perform the shielding function as designed and evaluated in the application. This is particularly important for those components which are fabricated from non-standard materials, such as the borated aluminum MMC basket plates and the high molecular weight polymer components. For components made from standard materials, ensuring conformance to the material standards and the dimensions and tolerances (all of which are specified in the package drawings) is sufficient to ensure their shielding function.

The staff notes that Table 8.2-1 of the application indicates that shielding components may be replaced as needed. Thus, the replacement items would also need to undergo the same acceptance tests with the same acceptance criteria as should be described Sections 8.1.5.1 and 8.1.6 of the application. Sections 5.4.1.1, 5.4.3.2, and 9.4.1.7 of NUREG-2216, "Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material," provide information that may be helpful in understanding the kind of information that should be provided. For items like the borated aluminum MMC basket plates, which also serve a criticality safety function, qualification and acceptance tests that demonstrate the basket plates' performance of that criticality safety function may be sufficient for demonstrating the shielding function of those plates as well (see item 2-7, above in Section 2, "Structural Evaluation" regarding neutron absorber qualification and acceptance tests).

This information is needed to confirm compliance with 10 CFR 71.85 and to ensure the package will be fabricated consistent with the design to meet the requirements in 10 CFR Part 71 Subparts E and F.

Answer:

Neutron Absorber Material

See comment to 2-7. The qualification report [redacted] provides information on acceptance tests and acceptance criteria relevant for both, criticality and shielding performance.

Moderator Material:

The moderator rods in the lateral area of the cask body and the moderator plates (bottom and lid area) are made of the tempered UHMW-PE [redacted]. The shielding properties of the material are defined by the hydrogen content and its temperature related change of dimensions and density.

[redacted]

Dimensional checks are to be applied to the finished component.

These information will be added at a corresponding section during revision of the SAR.

References

[1] Interim Staff Guidance - 11, Revision 3
Cladding Considerations for the Transportation and Storage of Spent Fuel
Spent Fuel Project Office

[2] NUREG-2224, Dry Storage and Transportation of High Burnup Spent Fuel
Office of Nuclear Material Safety and Safeguards, November 2020

[3] [redacted]

[4] [redacted]

[5] [redacted]

Celanese

GUR® 4120 | PE-UHMW | Unfilled

Description

GUR 4120 UHMW-PE is a linear polyolefin resin in powder form with a molecular weight of approximately 4.5 MM g.mol calculated using Margolies equation. The extremely high molecular weight of this resin yields several unique properties including superior abrasion resistance and highest impact strength of all standard grades. Outstanding properties include a low coefficient of friction that results in self-lubricating, non-stick surfaces after processing. The resin is normally processed by compression molding, ram extrusion or free sintering of porous parts.

Physical properties	Value	Unit	Test Standard
Density	**930**	kg/m³	ISO 1183
Mass melt-flow rate (MFR) 190°C/21.6 kg		g/10 min	ISO 1133
Water absorption (23°C-sat)		%	ISO 62
Humidity absorption (23°C/50%RH)		%	ISO 62
Elongational Stress F (150/10)	**0.24**	MPa	ISO 11542-2
Intrinsic viscosity	**2000**	ml/g	ISO 1628-3
Viscosity number	**2300**	cm³/g	ISO 307, 1157, 1628

Mechanical properties	Value	Unit	Test Standard
Tensile modulus (1mm/min)	**680**	MPa	ISO 527-2/1A
Tensile stress at yield (50mm/min)	**20**	MPa	ISO 527-2/1A
Tensile strain at yield (50mm/min)	**13**	%	ISO 527-2/1A
Nominal strain at break (50mm/min)	**>50**	%	ISO 527-2/1A
Tensile creep modulus (1h)	**460**	MPa	ISO 899-1
Tensile creep modulus (1000h)	**230**	MPa	ISO 899-1
Charpy impact strength @ 23°C	**NB**	kJ/m²	ISO 179/1eU
Charpy impact strength @ -30°C	**NB**	kJ/m²	ISO 179/1eU
Charpy notched impact strength @ 23°C	**NB**	kJ/m²	ISO 179/1eA
Charpy notched impact strength @ -30°C	**NB**	kJ/m²	ISO 179/1eA
Charpy impact strength (14° V-notch both sides)	**240**	kJ/m²	ISO 11542-2
Shore hardness D scale 15 sec value	**60**	-	ISO 868
Ball indentation hardness 30 sec value	**36**	N/mm²	ISO 2039-1
Wear by sandslurry method (based on GUR 4120=100)	**100**	-	Internal

Thermal properties	Value	Unit	Test Standard
DTUL @ 1.8 MPa	**38**	°C	ISO 75-1/-2
DTUL @ 0.45 MPa	**65**	°C	ISO 75-1/-2
Vicat softening temperature B50 (50°C/h 50N)	**80**	°C	ISO 306
Coeff.of linear therm. expansion (parallel)	**2**	E-4/°C	ISO 11359-2
Flammability @1.6mm nom. thickn.	**HB**	class	UL94
thickness tested (1.6)	**1.6**	mm	UL94
Thermal conductivity at 23°C	**0.41**	W/(m K)	Internal
Specific heat at 23°C	**1.84**	kJ/(kg-°K)	Internal

Electrical properties	Value	Unit	Test Standard
Relative permittivity - 100 Hz	**2**	-	IEC 60250
Relative permittivity - 1 MHz	**2**	-	IEC 60250
Dissipation factor - 100 Hz	**3.9**	E-4	IEC 60250
Dissipation factor - 1 MHz	**10**	E-4	IEC 60250
Volume resistivity	**>1E12**	Ohm*m	IEC 60093
Surface resistivity	**>1E12**	Ohm	IEC 60093

Celanese

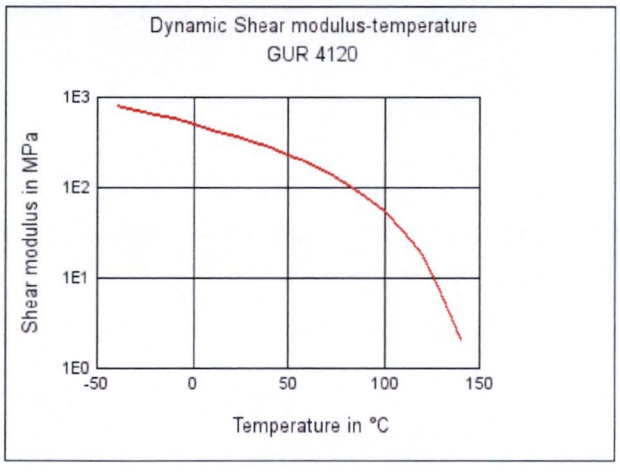
GUR® 4120 | PE-UHMW | Unfilled

Electrical properties	Value	Unit	Test Standard
Electric strength	**45**	kV/mm	IEC 60243-1
Comparative tracking index CTI	**600**	-	IEC 60112

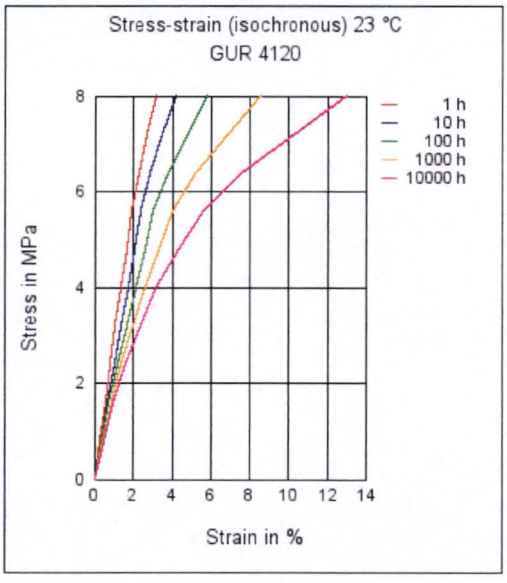
Processing properties	Value	Unit	Test Standard
Powder	**Yes**	-	ASTM D638

Test specimen production	Value	Unit	Test Standard
Comp. molding mold temperature	**210**	°C	ISO 293
Comp. molding cooling rate	**15**	K/min	ISO 293

Dynamic Shear modulus-temperature



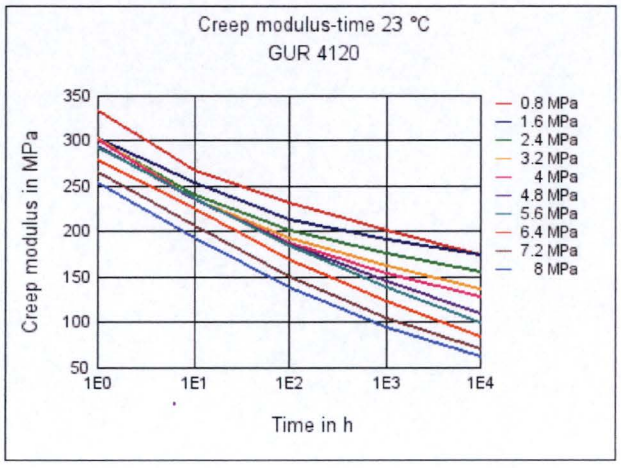
Stress-strain (isochronous)



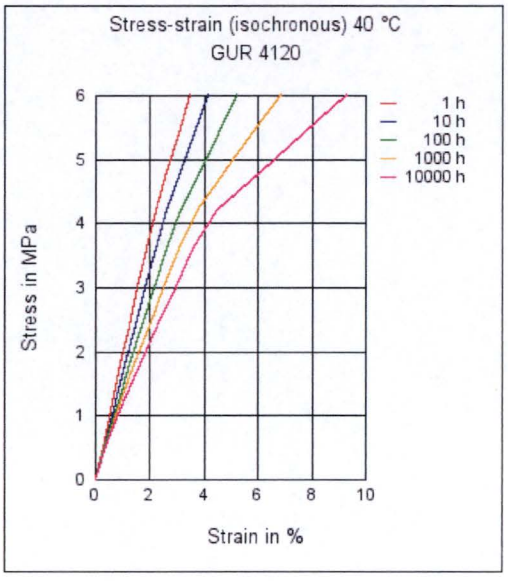
Celanese

GUR® 4120 | PE-UHMW | Unfilled

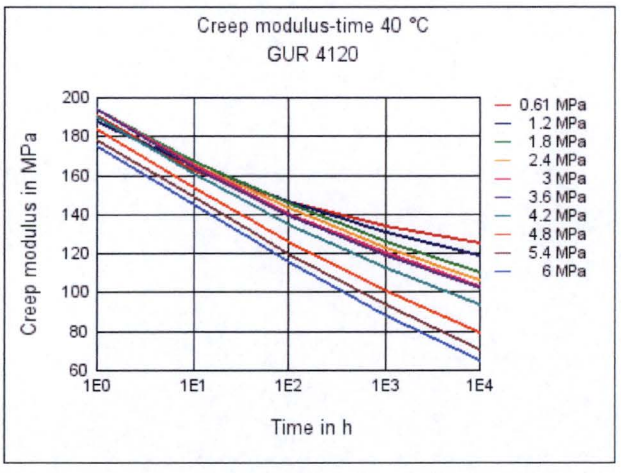
Creep modulus-time



Stress-strain (isochronous)

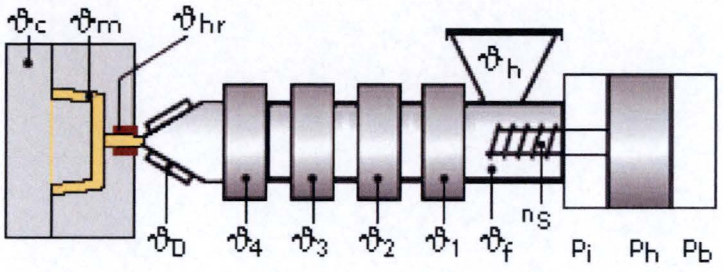


Creep modulus-time



GUR® 4120 | PE-UHMW | Unfilled

Typical injection moulding processing conditions



Special Info:

Not for Injection Molding. For Ram Extrusion and Compression Molding only. See Ticona for processing.

Contact Information

Americas

8040 Dixie Highway, Florence, KY 41042 USA

Product Information Service

t: +1-800-833-4882 t: +1-859-372-3244

Customer Service

t: +1-800-526-4960 t: +1-859-372-3214

e: info-engineeredmaterials-am@celanese.com

Asia

4560 Jinke Road, Zhang Jiang Hi Tech Park

Shanghai 201203 PRC

Customer Service

t: +86 21 3861 9266 f: +86 21 3861 9599

e: info-engineeredmaterials-asia@celanese.com

Europa

Am Unisys-Park 1, 65843 Sulzbach, Germany

Product Information Service

t: +(00)-800-86427-531 t: +49-(0)-69-45009-1011

e: info-engineeredmaterials-eu@celanese.co

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