Change Report

Licensing of an alternative supplier for the thermal insulation layer of the DN30 PSP

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S. Fels	M. Hennebach	F. Hilbert
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1 Introduction

The DN30 Protective Structural Packaging (DN30 PSP) is designed for the transport of 30B cylinders containing commercial grade uranium or reprocessed uranium with an enrichment of not more than 5 wt.% U-235 in uranium.

This report aims to include an alternative supplier for the thermal insulation material of the DN30 PSP in its certificate of approval. Supply difficulties or other circumstances may require using an alternative supplier than the currently certified supplier Promat providing the MICROTHERM (Overstitched 1000R HY) [1] thermal insulation material.

In this report, it is shown that MICROTHERM can be replaced with WDS Multiflex (ST Grade) [2] by the supplier Morgan Advanced Materials. Therefore, the impact of the material for the thermal insulation is discussed with respect to the package design safety report for the package design DN30 [3] hereafter in chapter 2. It is shown that WDS Multiflex has similar or improved properties compared to MICROTHERM.

2 Comparison of WDS Multiflex to MICROTHERM

MICROTHERM [1] and WDS Multiflex [2] are both custom made flexible microporous insulation panels with very good thermal properties. They provide excellent thermal stability up to more than 1000 °C. Both panels are produced in a glass cloth outer envelope, making them clean and easy to handle. The stitched grid guarantees the necessary flexibility and twisting properties. Finally, a hydrophobic version is available of both materials as well. Table 2-1 summarizes some of the properties of MICROTHERM and WDS Multiflex. Further details on both materials are provided in the technical data sheets [1] and [2], respectively.

Table 2-1: Comparison of MICROTHERM and WDS Multiflex

MICROTHERM (Overstitched 1000R HY)	WDS Multiflex (ST Grade)
E-glass as standard finishing	E-glass as textile covering
Custom made + flexible	Twist & Flex type of insulation
Extremely low thermal conductivity	Remarkable low and flat thermal conductivity
High thermal stability	High operating temperature limit with negligible shrinkage
Shock + vibration resistant	Homogeneous, compact and robust matrix core
Environmentally friendly, free of organic binders and non-combustible	Inorganic and non-combustible
Clean & easy to install	Easy and fast handling, installation and fixing
Simple to cut & shape	Easy to cut and preform in complex shapes
Available in different temperature grades, including a hydrophobic version	Available in two temperature grades, including a hydrophobic version
No harmful respirable fibers	Fibers used for mechanical reinforcement are not respirable
Resistant to most chemicals	Core material does not liberate hazardous decomposition products

3 Impact of the Thermal Insulation Layer of the DN30 PSP with Respect to the Safety Analysis for the DN30 Package

3.1 Structural Analysis

In the calculation model used for the structural analysis of the DN30 package, the thermal insulation layer is not explicitly represented. The thermal insulation layer has been included in a later development stage of the DN30 PSP and a small fraction of the impact limiting foam between the foam and the inner shells of the DN30 PSP needed to be removed to be able to include the thermal insulation layer. As the compression strength of the MICROTHERM thermal insulation layer is lower than that of the foam, the covering assumption has been made in a subsequent analysis to reduce the foam thickness by the thickness of the thermal insulation layer without filling the resulting gap with MICROTHERM. In addition to this analysis, real tests with a prototype including the thermal insulation layer have been performed. Both in the simulations and the real tests, the deformations were very similar to simulations and tests with prototypes not including the thermal insulation layer.

Consequently, with respect to the structural analysis, the only requirement of a thermal insulation material from another supplier is a compression strength that is equal to or higher than that of MICROTHERM. With this requirement, the compression of the thermal insulation layer can be expected to be similar or reduced compared to the application of MICROTHERM. This requirement is mandatory with respect to the thermal test. The technical data sheets of MICROTHERM [1] and WDS Multiflex [2] provide minimal compression strengths of 0.12 MPa and 1 MPa, respectively. Thus, the above requirement is fulfilled in case of WDS Multiflex.

3.2 Thermal Analysis

As the thermal insulation layer is included in the thermal analysis of the DN30 package [3], a new thermal analysis was conducted using the alternative material WDS Multiflex [2]. The material properties of both insulating materials are given in Table 3-1 and are taken from [1] and [2], respectively.

Table 3-1: Material Properties for the Thermal Analysis

Temperature in °C	MICROTHERM	WDS Multiflex
	Density in kg/m³	
-	260	210
	Thermal conductivity in W/(m·K)	
200	0.026	0.025
400	0.030	0.030
600	0.038	0.038
800	0.049	0.049
	Heat capacity in J/(kg·K)	
200	920	1050
400	1000	1050 [1)]
600	1040	1050
800	1080	1050

[1)] Value given in [2] for 400 °C is assumed for the whole temperature range.

The calculation for the evaluation of the alternative thermal insulation material is done according to the IAEA/ADR-guidelines for accident conditions of transport (ACT). These conditions consider a fire accident with a temperature of 800 °C lasting for 1800 s. The complete boundary conditions for the thermal analysis, including the material properties for other materials used in the calculation model, allowable temperatures for the package, heat generation, solar insolation and heat transfer in gaps and to the ambient, are listed in detail in the package design safety report [3].

The maximum temperatures calculated with both thermal insulation materials are listed in Table 3-2 below, including the time after the beginning of the fire when the highest temperatures are reached.

Table 3-2: Maximum Temperatures Calculated for the DN30 Package

Location	MICROTHERM		WDS Multiflex	
	Temperature in °C	Time in s	Temperature in °C	Time in s
30B cylinder valve	122.4	12710	121.7	12710
30B cylinder plug	120.6	10910	119.9	10910
30B cylinder mantle	124.7	10310	124.0	10310
DN30 inner shell	187.7	3650	187.9	3650
DN30 outer shell	785.4	1810	785.4	1810

The new thermal analysis proves that the maximum temperatures for critical components are nearly identical with differences of less than 1 °C. The maximum temperatures calculated with the alternative material for the thermal insulation are slightly lower. Consequently, considering the thermal analysis, WDS Multiflex has even better properties than MICROTHERM.

3.3 Containment Analysis

The thermal insulation layer is not considered in the containment analysis as the containment system is entirely made up by the 30B cylinder. Any alternative material for the thermal insulation layer will not have an impact on this part of the safety analysis for the DN30 package.

3.4 External Dose Rate Analysis

The external dose rate analysis under routine conditions of transport (RCT) and normal conditions of transport (NCT) will not be affected as well since the thermal insulation layer is not explicitly considered in the calculation model. Instead, a covering assumption has been made by assuming a density of 0.1 g/cm³ for the foam, which has a nominal density of 0.12 g/cm³. This assumed density of 0.1 g/cm³ covers both the density of MICROTHERM (0.26 g/cm³) and WDS Multiflex (0.21 g/cm³) with a large margin. Consequently, the analysis of the external dose rate covers this alternative material for the thermal insulation.

3.5 Criticality Analysis

The thermal insulation layer is not relevant for the criticality analysis as only the 30B cylinder and the steel shells of the DN30 PSP are considered in the covering criticality calculation model. Hence, changes to the thermal insulation layer will not have an impact on this analysis as well.

4 Summary

In this report, it has been shown that WDS Multiflex by Morgan Advanced Materials [2] can be used as an alternative material for MICROTHERM provided by Promat [1]. The impact on all safety analyses performed for the DN30 package has been considered. As the thermal analysis is most affected by using a different material for the thermal insulation, a variation calculation has

been performed to investigate the impact. This variation calculation proves that the impact is negligibly small and that WDS Multiflex can be used without lowering the safety of the DN30 package. For the structural, containment, external dose rate and criticality analysis, the thermal insulation layer is not considered. Consequently, using a different material for the thermal insulation layer does not affect these analyses at all.

Literature

[1] Promat
Technical Data Sheet – MICROTHERM OVERSTITCHED

[2] Morgan Advanced Materials
Technical Data Sheet – WDS Multiflex

[3] DAHER NUCLEAR TECHNOLOGIES GmbH
Package Design Safety Report for Package Design DN30
0023-BSH-2016-001, Rev3, 2018