Criticality

1 **RAI1**: The "Guide to Verification and Validation of the SCALE-4 Criticality Safety Software" can be used for SCALE5 and SCALE5.1 based on following reasons:

- The central KENO VI calculation module was not revised from SCALE4 to SCALE5
- The above mentioned guide provides a route for the V&V, but does actually not serve as only V&V document
- The V&V of the SCALE5 and SCALE5.1 criticality software is based on the installation verification, which has been carried out on the respective computers used for the safety analysis; and the V&V is especially based on recalculation of benchmarks, which is documented in the SAR NCS 0017 section 8.3.
- The criticality analyses have been checked and confirmed by the German competent authority by using an independently V&Ved SCALE5 criticality safety software system.

We forwarded the question whether the SCALE-4 guide could be used to Mr. Steve Bowman, Reactor Physics Group Leader of the Nuclear Science & Technology Division, ORNL, (e-mail: ScaleHelp@ornl.gov). His response was, "Yes, the report can be used with SCALE 5" (e-mail dated 22.09.2009).

2 **RAI2**: Enclosed please find the input files for the fissile material distributions 5.4156 g/cm, 26.2983 g/cm and 50.0981 g/cm for content 1.2.
The input files starting with "water_tube" contain the input for a theoretical diameter restriction to 18 cm with a tube consisting of "water". For the most reactive case the "water tube" is replaced by the "steel tube" required by the certificate of package approval in reality. The comparison between the two calculations show, that the proof of content 1.2 is very conservative.
The enclosed Excel file "water fractions" shows the calculation of the respective water fractions. These values are based on the formulas given in SAR NCS 0017 section 8.5.3.1.
The naming convention for the files is
content no – restricting tube material – fuel – fuel rods/homogeneous – number of fuel rods – fuel mass per cm – water fraction – 1 – running number – fissile material distribution

3 **RAI3**: Enclosed please find the 3 input files for the fissile material height of 52 cm. The enclosed Excel file "water fractions" shows the calculation of the respective water fractions.
The naming convention for the files is
content no – fuel – fuel rods/homogeneous – number of fuel rods – fuel mass per cm – water fraction – 1 – running number

4 **RAI4**: Content 1.5 was analyzed with model HET4; the title of Table 4 as well as Figure 7 and 8 of the response to RAI 5-7 should state HET4 and not HET1. We apologize for this error.

5 **RAI5**: Calculations in NCS 0017 for the array of packages are based on following assumptions:

- For contents 1.1, 1.2, 1.3 and 1.5 the cavity is dry with the exception that water to the extent of the H/U-235 ratio of 1 is present (see section 8.7.1).
- For content 1.3 the cavity is dry with the exception that water to the extent of the H/U-235 ratio of 100 is present (see section 8.7.2).
- Between the packages in variation calculations vacuum and water with different layer thicknesses are assumed (see Table 8-16). This Table shows that vacuum between the packages leads to maximal reactivity.
- The possible drying out of the thermal insulation layer is also accounted for by reducing the water content in the insulation material to zero (see Table 8-16).

Enclosed please find the input files for the most reactive case for ARRAY1 and ARRAY2.

In additional calculations documented in calculation note RN-09-06-NCS-45 submitted to DOT/NRC July 17, 2009 the influence of water in the cavity was analyzed comprehensively. This analysis is based on highly theoretical assumptions concerning water ingress into the cavity requested by another competent authority during the validation process of the certificate and verifies the high safety margin of the NCS 45 package under accident conditions of transport.

6 **Additional calculations**

Enclosed please find for your information report RN-09-03 Rev. 1 containing additional calculations for content 1.4. In this report the influence of the fuel diameter, cladding thickness and cladding material on the reactivity of content 1.4, uranium oxide fuel with a maximal enrichment of 3.4 wt% was investigated. These additional calculations were requested by another competent authority during the validation process (completed) and confirm the conservative approach used in the criticality analysis.