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Next Generation Nuclear Plant Pre-Application Activities
Department of Energy - Idaho National Laboratory
Docket No. PROJ 0748
SRP Section: NGNP INS - Ceramic Insulation
Application Section: Ceramic Insulation

QUESTIONS for Advanced Reactor Branch 1 (ARB1)

NGNP INS -1

INS-1. Table 7 in Section 3.4.2 provides properties data for carbon insulation and nuclear graphite. What ASTM material specification standard exists for carbon insulation materials for nuclear application to state nuclear grade carbon? Considering that the thermal conductivity of carbon insulation is lower than graphite, and thus potentially reducing resistance to thermal shock, what structural integrity requirements are contemplated for carbon insulation? Later, in Section 3.4.4, it is mentioned that Structural Reliability Class (SRC)-3 will be assigned to ceramic insulation components. What information is available on the strength of this insulation after multiple thermal shock loadings, and after irradiation?

NGNP INS -2

INS-2. In Section 3.4.3, “nuclear grade ASR-0RB carbon” is discussed. What is the specification for this “nuclear grade” material? Is NBC-07 also a “nuclear grade” carbon? If so, what specification makes it a “nuclear grade”?

NGNP INS -3

INS-3. In Section 3.4.3, it is stated that “Shaped carbon blocks are used at various locations in the core structures to insulate selected components from hot gas flow.” What type of thermal (heat transfer) analysis procedures are used to ensure adequate carbon thickness for the “shaped” carbon component to provide the required insulation? Does the thermal conductivity of carbon depend on temperature and neutron dose? If so, how this dependence accounted for in thermal calculations? Are such calculations based on consensus standard procedure?

NGNP INS -4

INS-4. In Section 3.4.3, it is stated that “the carbon blocks around the reflector, at the top of the reflector and the upper insulation layer below the reflector have 5 wt% boron carbide added to the carbon to reduce neutron irradiation to the adjacent metallic components in these areas.” How does the addition of boron carbide affect the thermal conductivity as a function of temperature? What is the time-dependency of thermal conductivity at temperature for the life time of the carbon component?

NGNP INS -5

INS-5. In Section 3.4.3, it is stated that “the carbon insulation blocks were produced by the Lanzhou Carbon Works to ensure low thermal conductivity and good dimensional stability at high temperature.” Clarify this statement to clearly identify what component or components are being described (e.g. the insulating block, or metallic structures) Why is dimensional stability important and to what extent? How do you assure that the good dimensional stability is maintained? What inspections would be conducted to assure this expected behavior?

NGNP INS -6

INS-6. In Section 3.4.4, it is stated that “the use of ceramic insulation in the CSC is restricted to areas where it is not exposed to significant fast neutron irradiation (e.g., <1018 n.cm-2 EDN) and, consequently, irradiation-induced changes in properties will be negligible.” The value given for fast neutron irradiation appears to be misformatted. Is it correct to assume that it should appear as $<10^{18}$ n cm^{-2}? Throughout Section 3.4, clarify the various operating conditions, the specific materials to be used, and properties required to assure expected design performance.

NGNP INS -7

INS-7. Table 8 in Section 3.4.5, characterizes baked carbon insulation properties. Temperature-dependent friction coefficient in helium between graphite and carbon is one of the properties. This friction property between graphite and baked carbon insulation has not been identified for characterization in Sections 3.3.6.2 or 3.3.6.3 for graphite. Explain this discrepancy.

NGNP INS -8

INS-8. In Section 3.4.5, is the PBMR procedure for determining equivalent boron content, mentioned in Table 8, publicly available? Provide a description of the procedure, and discuss any review and approval by a consensus standards organization, such as ASTM?

NGNP INS -9

INS-9. Section 3.4: Cracking and continuously inter-connected porosity is a possibility for ceramic materials. Thus, while insulating characteristics may be functionally adequate, what is the possibility of the coolant flowing through this inter-connected porosity (“thermal streaking”) which could potentially lead to hot spots continuously impinged by hot gas on the metallic strictures? If such thermal streaking is possible, then how can the design assure the structural integrity of pressure boundary material?

NGNP INS -10

INS-10. Section 3.4 states that ceramic insulation will be adjacent to metallic components. How will reactor operating conditions contribute to thermodynamic and chemical reactions which may occur between these materials? What are the consequences resulting from potential degradation due to such reactions? If there is spalling of insulation refractory materials, as is typical in the case of refractory (thermal protection) use, what are the consequences? How will such degradation be detected and its effects mitigated?