Enclosure 1-NP to
LD-83-035

CESSAR FUEL AND CEA
DESIGN EVALUATION SUMMARY REPORT

NUCLEAR POWER SYSTEMS DIVISION

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POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

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Design Evaluation

The fuel assembly, fuel rod, burnable poison rod, and CEA designs satisfy the design criteria and limits specified in Section 4.2.1. The analytical methods employed to calculate stresses, strains, fatigue usage, growth, and holddown force are consistent with accepted conventional engineering practices. All calculations are subjected to formal review procedures in accordance with Combustion Engineering's Quality Assurance of Design Manual for safety related components.

The following paragraphs highlight the analytical results of a portion of the fuel system design calculations presently designated as requiring applicant-specific information by the CESSAR Safety Evaluation Report.

Stress

Stress evaluations of the fuel assembly, fuel rod, burnable poison rod, and CEA are based upon conventional equations recommended by Seely and Smith (Advanced Mechanics of Materials, 2 nd Edition), Timoskenko and Young (Engineering Mechanics, 4th Edition), Roark (Formulas for Stress and Strain, 4th Edition), McAdams (Heat Transmission, 3rd Edition), etc. The stresses are calculated considering the appropriate loading parameters as specified in Subsection 4.2.1, and in accordance with the ASME General Guidelines for evaluating primary and secondary stresses. The results of the evaluations verify that all calculated stresses are within their appropriate design stress criteria. Table 1 summarizes the limiting normal operating stress conditions for the fuel assembly structure, fuel rod, burnable poison rod, and the control element assembly. The limiting stress condition is defined as the analytical result showing the minimum stress margin (allowable stress minus calculated stress).

TABLE 1

ITEM	COMPONENT	CALCULATED STRESS (PSI)	ALLOWABLE STRESS (PSI)
Fuel Assembly Structure	[ ]	[ ]	[ ]
Fuel Rod	[ ]	[ ]	[ ]
Poison Rod	[ ]	[ ]	[ ]
Control Element Assembly	[ ]	[ ]	[ ]

The calculated stresses for the fuel assembly structure, fuel rods, and poison rod are applicable for 3 cycles of operation* and the control element assembly stress is applicable for 10 years. The fuel assembly structure includes all the components shown in Figure 4.2-6 with the exception of fuel and poison rods.

*All reference in this report to 3 cycles of operation refers to 38,127 MWD/T core average burnup.

Strain

The strain design basis for evaluating the fuel rod, poison rod, and control rod cladding is that the net unrecoverable circumferential strain shall not exceed one percent as predicted by computations considering cladding creep and pellet swelling. In regard to the fuel assembly structure, there are no uniform plastic strains predicted for normal operating conditions since all stresses are within the unirradiated yield strength.

The individual models used to analytically describe the cladding creepdown and pellet swelling that result in fuel rod cladding strain are documented in Report CENPD-139-P, "Fuel Evaluation Model" July, 1974 with its revisions and supplements. Analysis of the fuel rod predicts that the maximum unrecoverable circumferential cladding strain is [ ] for the peak local rod after [ ] of operation.

The analysis of the poison rod cladding predicts that a radial gap between the pellets and the cladding remains after 3 cycles of operation. Therefore, the circumferential strain is essentially zero. The analytical models used to describe poison pellet swelling and thermal expansion are based on data presented in subsection 4.2.1.3.2. The cladding characteristics are the same as described for the fuel cladding.

The limiting CEA case regarding circumferential plastic strain is based on the maximum predicted B_4C pellet burnup for a 10 year lifetime. The analysis method evaluates pellet swelling, pellet thermal growth, and worst case pellet and cladding dimensions. The result of this analysis predicts that there is no net unrecoverable circumferential cladding strain.

Strain Fatigue

The cumulative fatigue usage factor limit of 0.8 and the design curve for the relationship between cycles and strain (Figure 4.2-2) are the design bases for fuel rod cladding strain fatigue analysis. The same methodology used to predict cladding strain is used for predicting strain fatigue, with the cumulative effective strain range evaluated after preselected intervals to establish a total usage factor for the approproate burnup conditions. Analysis predicts a maximum cumulative cladding damage factor of [ ] for three cycles of operation, which is less than the limit of 0.8.

The fuel assembly structure cumulative fatigue damage factor is essentially zero since all the stresses are within the respective material endurance limits and/or the stress duty cycles are limited to preclude any appreciable damage factor.

CEA Axial Growth

A minimum axial clearance of [ ] between the bottom of the CEA finger and the fuel assembly guide tube represents the limiting design condition. This clearance has been calculated on the basis of worst-case dimensional tolerances. The use of inconel and stainless steel materials in the CEA does not result in any significant radiation induced axial growth. There is no significant axial increase anticipated for the control rod due to the design features of the control rod tip region and the limited axial exposure to the active core environment.

Adequate clearance margin is anticipated for the CEA to perform its function for its intended lifetime. On-going CEA surveillance will provide additional assurance that axial growth is not a design concern.

Fuel Assembly Holddown

The total fuel assembly holddown force is the sum of the holddown spring forces and the assembly wet weight. The fuel assembly holddown springs are designed such that sufficient downward force will be maintained to counteract hydraulic forces on the assembly.

The minimum combined spring force and assembly wet weight is [ ]. This compares to a maximum upward hydraulic force of [ ].