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ADDENDUM TO SAXTON CORE III
LICENSE APPLICATION

by

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ADDENDUM TO SAXTON CORE III LICENSE APPLICATION

Introduction

This addendum to the Saxton Core III Safeguards Report contains proprietary information on load follow fuel rod design which amplifies the description of these rods in the main body of the report. The types of experimental fuel rods and the ranges of rod design values are given here.

The calculational basis for nuclear and thermal-hydraulic designs is discussed in full in the safeguards report and is not repeated here. Mechanical design, with the exception of a detailed listing of fuel rod variables, is covered in the main report; only a brief description of assembly design is repeated here. An evaluation of thermal-hydraulic and mechanical performance of these test rods which confirms that all test rods satisfy the applicable design criteria is summarized in this report.

Test Objective and Mode of Operation

The objective of the load follow experiment is to determine the effect of fuel rod linear power level, fuel density, fuel-clad gap and internal pressure on fission gas release, fuel swelling, and clad strain behavior under power cycling conditions. The study includes combinations of rod design variables representative of both current and developmental fuel designs.

Throughout Core III operation the assemblies will be subjected to several power cycles each day. The lower limit of the cycling range may be restricted by Saxton plant capabilities, but is expected to be in the vicinity of 40% of full power. The upper limit of the cycle will be limited to 100% of full power, as defined in the safeguards report. In addition, mid-way through Core III life the positions of these two assemblies will be interchanged to simulate power level increases associated with fuel management techniques which require movement of fuel assemblies from low power core regions to high power core regions.

Load Follow Assembly Design

The load follow assemblies are similar in design to previous Saxton assemblies. The arrangement of fuel rods and other fuel bundle components of the assemblies is shown in cross section in Figure 1. Three tie rods hold the removable top nozzle in place. Two tie rods are Inconel-filled stainless steel tubes and the third tie rod is a stainless steel tube with a stainless steel filler rod. Five water-filled tubes are used to increase the water-fuel ratio in the center of the assembly and thus increase the power level of the adjacent fuel rods.

Fuel Rod Design

A number of combinations of the variables listed in Table I are included in the 124 fuel rods comprising the two load follow assemblies. The majority of the rods are Zircaloy-4 clad. The several stainless steel rods are included to study fission gas release and fuel swelling with minimized sensitivity to clad-pellet gap conductance. Twelve pressurized rods will contain pressure control chambers located in the top plenum space to limit the range of internal gas pressure from beginning to end of core life.

The chambers will consist of rigid stainless steel or mild steel sleeves with brazed thin diaphragm end closures designed to rupture at pressures close to, but below, the coolant pressure. All rods with pressure control chambers will operate at peak linear powers in the range 13.9 to 19.9 kw/ft. Five pressure control rods will operate throughout Core III at peak linear powers in the range 17.8 to 19.9 kw/ft.

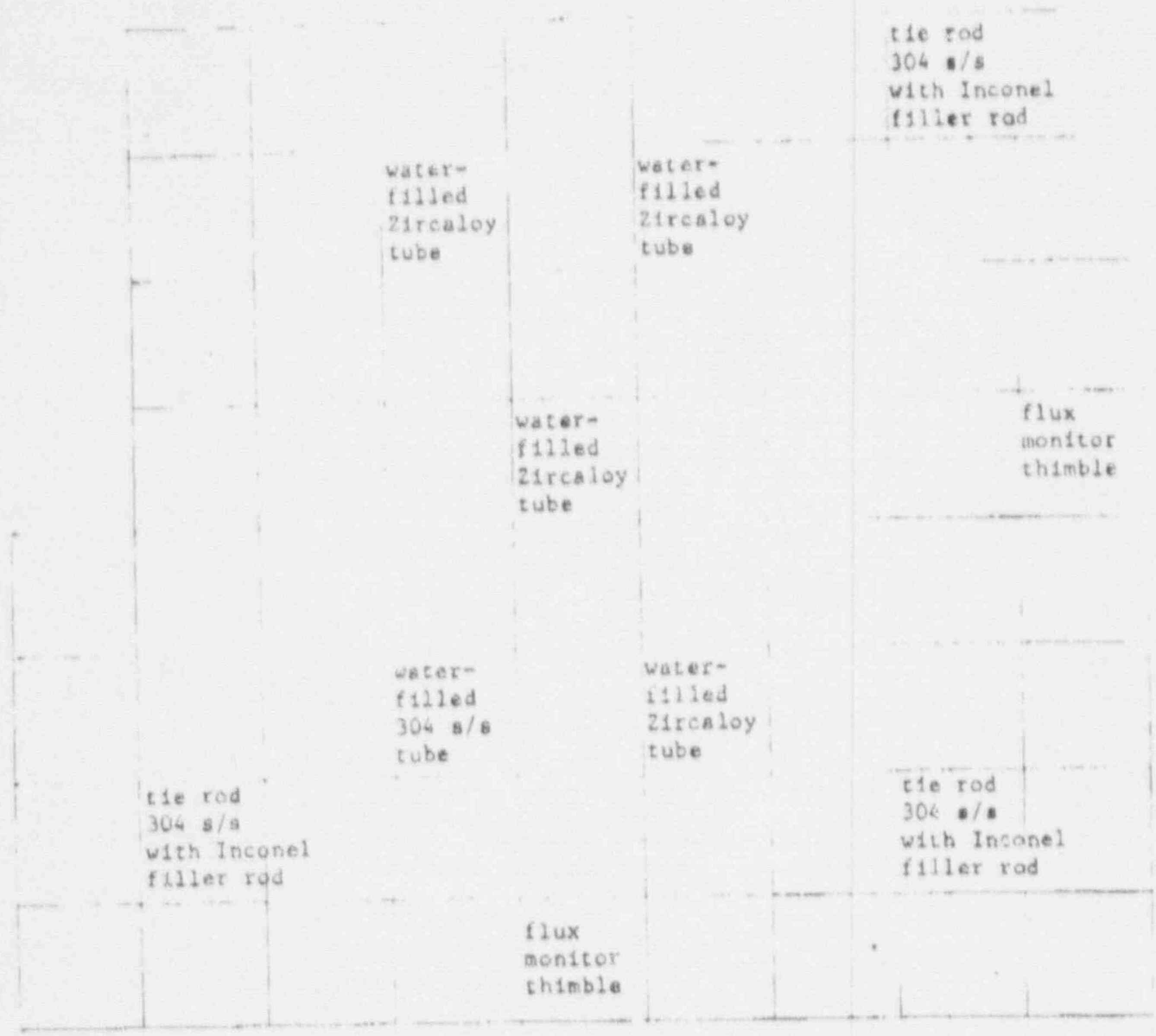

Figure 1: Schematic diagram of load follow assembly cross section showing general arrangement. (All positions not otherwise noted are occupied by fuel rods.)

Table I

LOAD FOLLOW TEST ROD DESIGN VARIABLES

A. Fuel

Composition - UO_2

Density - 89.5% T.D. - 13 rods in each assembly
92% T.D. - 30 rods in assembly E-3
32 rods in assembly C-3

94.5% T.D. - 12 rods in assembly C-3
14 rods in assembly E-3

Mixed 89.5% T.D. and 99% T.D. - 3 rods in each assembly

Enrichment - 5.7% U-235 - 2 rods in each assembly
9.5% U-235 - 16 rods in each assembly
12.5% U-235 - 44 rods in each assembly

B. Cladding

Zircaloy-4 - .3445" I.D. x .3910" O.D.

8 rods in recrystallization annealed condition

94 rods in stress-relief annealed condition

Type 304 Stainless Steel - .361" I.D. x .391" O.D. - 22 rods

C. Fuel Clad Diametral Gap

5.5, 7.5, 9.5 mils for Zircaloy clad rods
3-10 mils for stainless steel clad rods

D. Fuel Rod Internal Atmosphere

air at 15 psia
helium at 15, 300, 400, 500 psia

Fuel Rod Performance

All of the load follow test rods were designed to avoid fuel melting and to limit end-of-life internal gas pressure to less than the coolant pressure (2250 psia). The highest temperature will occur in a rod at peak design power of 19.9 kw/ft with 89.5% dense fuel, , initial fuel-clad diametral gap of 7.5 mils, and an initial gas pressure of 15 psia. For these conditions, the beginning-of-life design peak temperature is predicted to be 4900F, about 200°F below the melting point. With continued irradiation, fuel thermal expansion, and clad creep-down, all tend to increase the fuel-clad gap conductance and therfore decrease the fuel temperature. The extreme fuel-clad gap of 9.5 mils was not evaluated in combination with 89.5% dense fuel and 15 psia initial rod internal pressure because all load follow test rods with 9.5 mil gap will be pressurized to at least 300 psia.

Other design combinations were evaluated for initial internal gas pressures up to 500 psia, fuel density up to 94.5% T.D. and fuel-clad gap up to 9.5 mils. Because of the higher fuel-clad gap conductance resulting from the higher pressure and because of the higher thermal conductivity of this higher density fuel, peak fuel temperatures were predicted to be less than 4900F.

Calculations show that the end-of-life internal pressure will be greatest (about 1700 psi maximum at operating temperature) in a lead rod with 89.5% dense fuel, 500 psia initial internal pressure and 9.5 mil initial fuel-clad diametral gap. At the design peak burnup of 21,000 MWD/MTU, fission gas realease is expected to have a minor effect on the total internal pressure. The expected clad creep-down will reduce the fuel-clad gap with the result that fual peak temperature and fission gas release will be less than predicted for the case of a constant 9.5 mil gap.

Higher fuel density and smaller fuel-clad gaps are more moderate design combinations leading to increased fuel-clad gap conductance, lower fuel temperatures, lower fission gas release and lower end-of-life pressure.

Although an initial internal pressure less than 500 psia will result in early life reduced fuel-clad gap conductance (compared to a rod pressurized to 500 psi) the lower initial pressure and greater clad creep-down yield a lower end-of-life internal pressure than in the limiting case discussed above.

In none of these temperature and pressure limiting combinations does the total clad strain exceed the design limit of 1% in the Zircaloy clad fuel rods.

The questions of fuel temperature and internal pressure were also considered for the 22 stainless steel-clad fuel rods in these two assemblies. The combinations of gap, fuel density and linear power have been chosen to avoid fuel melting and end-of-life internal pressures exceeding coolant pressure in the stainless steel rods. The higher strength of the stainless steel cladding assures that clad strain at end-of-life will be less than 1%.