AMENDMENT NO. 5

to the

SAFETY ANALYSIS REPORT

for the

OREGON STATE TRIGA REACTOR (OSTR)

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Introduction

The purpose of this amendment to the Oregon State TRIGA Reactor (OSTR) Safety Analysis Report (SAR) is to support the request of Oregon State University to increase the maximum licensed steady-state power of the OSTR to 1.1 MW. The request for this power increase is being submitted to help clarify the OSTR Technical Specifications in light of an earlier U.S. Nuclear Regulatory Commission (NRC) determination indicating that there were inconsistencies between the OSTR's currently licensed power level of 1 MW and certain wording in the OSTR Technical Specifications. As a result of this determination, on February 11, 1988 the NRC revised OSTR Technical Specification 3.1 to read: "The reactor power level shall not exceed 1.0 megawatt under any condition of operation." The wording in this change has caused the OSTR staff a number of difficulties with respect to its application and interpretation, and we believe it is in the best interest of the University and the NRC to eliminate this source of confusion. Specific examples of the difficulties encountered are discussed below:

First, when the OSTR is operating in automatic mode at an allowed steady-state power level of 1.0 MW, there are normal feedback effects of a properly functioning servo system which result in small (1-2%) power oscillations around the mean power.

Second, the phrase "under any condition of operation" is confusing since the OSTR is clearly licensed to pulse, which results in a peak power level much greater than 1.0 MW.

Third, Table I of the OSTR Technical Specifications indicates that the power level scram point on the safety channel and the percent power channel may be set at 110%. This presents two difficulties. First, if these scrams are set at 110% they cannot now be tested by increasing the reactor power, and therefore the Channel Test required by Technical Specification 4.3.2.d has to be performed electronically. (We feel an actual power level test is much better.) Second, and more importantly, if the reactor should be shut down by the 110% power level scram, this would appear to constitute a violation of the Technical Specifications because of the way the licensed power limit is now worded. Hence, to maintain the overpower scram protection without exceeding 1.0 MW it would be necessary to set the scrams at 1.0 MW or less and then operate the reactor at some even lesser power level such as 0.9 MW. However, as mentioned above, even this is inconsistent with the current Technical Specifications because Table I indicates that the scrams may set at 110%.

The staff of the OSTR feel that the best solution to all of these difficulties is to request a slight increase in the licensed steady-state power level to 1.1 MW. There are now many TRIGA reactor-years of experience which attest to the safety of this reactor type at power levels measurably in excess of 1.1 MW. However, we would like to reference the NRC's Safety Evaluation Report (SER) for the University of Texas TRIGA reactor, wherein a 1.1 MW peak power was found to be completely safe and acceptable. With respect to the OSTR, the following additional information is being submitted to establish the safety of the proposed change.

Normal Operation - Fuel Safety Limits

The safety limits on the fuel are designed to assure continuous integrity of the fuel element cladding. During a reactivity excursion, the limiting condition is fuel temperature and the corresponding hydrogen overpressures at which fuel cladding rupture may occur. Studies show that in FLIP fuel the hydrogen pressure which would result from a transient for which the peak fuel temperature is 2100°F (1150°C) would not produce a stress in the clad in excess of the ultimate cladding strength.

For steady-state operation, fuel temperatures are dependent upon the heat transfer characteristics of the fuel element and coolant. Thus, a limit on power density is selected to ensure fuel element integrity. This limit is well below the maximum allowable power density at which there is a departure from nucleate boiling. TRIGA reactors with FLIP fuel have operated safely with power densities up to 32 kW per element. The highest power density calculated in Amendment 4 to the OSTR SAR for an operational mixed FLIP and standard fuel element core at 1 MW was 16.98 kW per element, and for a full FLIP core the value was 15.93 kW. Increasing the maximum steady-state power level to 1.1 MW will slightly increase these ratings to 18.68 and 17.52 kW per element respectively. Thus, the maximum power density is still well below that of safely operated reactor cores, and these in turn are well below the maximum safety limit for FLIP fuel. Therefore, no problems due to cooling or fuel temperatures will occur at a steady-state operation of 1.1 MW. The OSTR limiting safety system setting used for 1.0 MW operations will remain exactly the same (950°F (510°C)) for the 1.1 MW power level.

Pulsing Operations

No changes are required in the OSTR SAR Amendment No. 4 relating to pulsing operations as the pulsing limits will remain unchanged.

Fuel Element Reactivity Worth

No changes are required in the SAR (Amendment No. 4) section dealing with reactivity worth of fuel elements.

Loss of Coolant Accident

SAR Amendment No. 4 quotes from previous studies which showed that a FLIP fuel element can tolerate a temperature of 1720°F (938°C) suspended in air without damage to the cladding. This temperature will not be exceeded under the conditions of coolant loss if the maximum thermal power in a FLIP element does not exceed 24 kW, which is the case for FLIP fuel even if the reactor is operated for an infinite time prior to the accident. In another case, after prolonged operation at 32 kW per element, an instantaneous loss of water produced a maximum fuel temperature of about 590°C. Therefore, even with an increased fuel element power rating to 18.68 kW per element the OSTR fuel will still be well below these values.

Design Basis Accident

The OSTR design basis accident involves a loss of fuel cladding integrity for one fuel element. This accident is analyzed in SAR Amendment No. 4 using a conservative maximum power density of 24 kW per element. Since this value is still well over the new calculated worst-case value of 18.68 kW per element for the OSTR at 1.1 MW, this accident analysis does not need to be revised.

Reactivity Accident

This section of the OSTR SAR (Amendment No. 4) does not need changing since accidental pulsing from higher power levels results in lower pulses due to the larger prompt negative fuel temperature coefficient at higher fuel temperatures, and the fact that this feedback effect is significant from the moment the pulse rod starts its motion.

Cooling

The basis for Technical Specification 3.1 states: "TRIGA fuel may be safely operated up to power levels of at least 2.0 MW with natural convection cooling." In addition, the existing OSTR heat exchanger is rated for 1.03 megawatts, and the cooling tower is rated for 1.32 megawatts. Therefore, there are no unfavorable safety implications associated with a steady-state power level of 1.1 MW, since prior to the installation of the current heat exchanger and cooling tower the OSTR had a cooling system rated at 250 kW, but was licensed to operate at a steady-state power of 1.0 MW. Use of the previous 250 kW cooling system was not deemed to introduce unfavorable safety implications, but simply meant that the reactor could not operate continuously at full power. Consequently, it was shut down when the temperature of the primary coolant reached a predetermined level below the limit set by the Technical Specifications. Since it is our stated intention to limit routine steady-state operations to 1.0 MW, we anticipate no changes in cooling capabilities, but in any case the reactor would simply be shut down if the primary coolant temperature reached the above-mentioned predetermined level.

Relevant TRIGA Literature

Oregon State University, "SAR for the Oregon State University TRIGA Research Reactor," Docket 50-243 (August 1968).

Oregon State University, "Amendment No. 4 to the Safety Analysis Report for the Oregon State University TRIGA Reactor," (April 3, 1975, Revised September 11, 1985).

Texas A&M, "SAR for the Nuclear Science Center Reactor, Texas A&M University (Docket 50-128), June 1979.

General Atomic, "Safety Analysis Report for the Torrey Pines TRIGA Mark III Reactor," GA-9064, January 5, 1970.

University of Texas, "SAR for the TRIGA Reactor Facility Nuclear Engineering Teaching Laboratory," November 1984.

USNRC, "Safety Evaluation Report Related to the Construction Permit and Operating License for the Research Reactor at the University of Texas," (Docket 50-602), NUREG 1135, May 1985.

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Shoptaugh, J.F., Jr., "Simulated Loss-of-Coolant Accident for TRIGA Reactors," GA-6596, 1970.

Coffer, C.O., J.R. Shoptaugh, Jr., and W.L. Whittemore, "Stability of the U-ZrH TRIGA Fuel Subjected to Large Reactivity Insertion," GA-6874, January 1966.

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Fouchee, F.C., "Release of Rare Gas Fission Products From U-ZrH Fuel Material, GA-8597, March 1968.

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