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November 5, 2018

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Reference: Oregon State University TRIGA Reactor (OSTR)
Docket No. 50-243, License No. R-106

Subject: License Amendment Request to Remove Requirement for Fuel Temperature Measuring and Safety Channels while Transient Operation Modes are Precluded

Mr. Balazik:

This letter serves as a request for a license amendment for the purpose of modifying the existing technical specifications (TS) to allow for operation without an instrumented fuel element (IFE) and thus operation without a fuel temperature measuring/safety channel. The proposed modified TS would allow for operation without an IFE with the caveat that transient operation modes (i.e. Square Wave and Pulse modes) would be precluded.

The current IFE has seen temperature increases since a $2.20 pulse was performed on 5/21/18. Normal operating temperature was 340°C, only to increase to 385°C after that pulse and continue increasing on a consistent trendline. As of the morning of 10/30/18, the IFE temperature was 474°C and is predicted to exceed the current LSSS within weeks. We believe that these temperatures are an artifact of fuel cracking and the position of the thermocouples within the cracked fuel and do not represent an actual representative temperature within the fuel. These temperatures necessitate this license amendment in order to remove the IFE from the core and continue steady state OSTR operations. Once approved, we are committed to removing the IFE and inserting a spare standard 30/20 fuel element in its grid location, as well as precluding transient operation modes while operating without an IFE.

We believe this is safe based upon our SAR analysis, which shows that we are unable to approach the safety limit during steady state operations. As such, we believe that the safety limit cannot be approached during our maximum licensed steady state power operation. Furthermore, the reactor is monitored by redundant and independent power measuring channels and their associated safety channels which would prevent exceeding the maximum licensed steady state power and therefore the safety limit. This would be consistent with the approach taken by the Dow TRIGA Research Reactor (License R-108), thus we propose to revise the LSSS to be consistent with the Dow reactor.

We propose to revise the current relevant sections of the TS (Sections 2.2, 3.2.2, 3.2.3, 4.2.e and 4.2.f) as follows, with the added revisions noted in bold underlined italics:

A020
NRR

2.2 Limiting Safety System Setting

Applicability. This specification applies to the scram settings which prevent the safety limit from being reached.

Objective. The objective is to prevent the safety limits from being reached.

Specifications. The limiting safety system setting ***(LSSS)*** shall be equal to or less than 510°C (950°F) as measured in an instrumented fuel element. The instrumented fuel element shall be located in the B-ring. ***If transient operation modes (square wave and pulsing) are precluded, the LSSS instead shall not exceed 1.1 MW as measured by the calibrated power level channels.***

Basis. During steady state operation, maximum temperatures are predicted to occur in the LEU MOL ICIT core. Linear extrapolation of temperature and power from Table 4-27 of section 4.7.8 indicates than ***a maximum single B-ring fuel element power of 23.1 kW in conjunction with the highest ratio of maximum to minimum power for elements in the B-ring is 1.121, limits the maximum power in any B-ring element to 23.1 x 1.121 = 25.9 kW.*** Figures 4-59, 4-64 and 4-69 indicate that at 25.9 kW, the maximum temperature anywhere in the hot channel fuel element will be less than 600°C.

Additional analysis has shown that if a B-ring element in the LEU MOL ICIT or LEU EOL ICIT core is replaced with fresh fuel, the highest ratio of maximum to minimum power in the B-ring is 1.378. In these cores, if the ***maximum single B-ring fuel element*** is generating 23.1 kW, the maximum power in any B-ring element would be limited to 23.1 x 1.378 = 31.8 kW. Figures 4-59, 4-64 and 4-69 indicate that at 31.8 kW, the maximum temperature anywhere in the hot channel fuel element will be less than 700°C. ***This analysis was performed at the maximum licensed steady state power of 1.1 MW. Therefore, measurement of the reactor power by two redundant and independent power channels will ensure that the safety limit is not reached during steady state operations and when transient operation modes are precluded.***

3.2.2 Reactor Measuring Channels

Applicability. This specification applies to the information which shall be available to the reactor operator during reactor operation.

Objective. The objective is to specify the minimum number of measuring channels that shall be available to the operator to assure safe operation of the reactor.

Specifications. The reactor shall not be operated in the specified mode unless the minimum number of measuring channels listed in Table 1 are operable.

Table 1 - Minimum Measuring Channels

Measuring Channel	Effective Mode		
	S-S	Pulse	S-W
Fuel Element Temperature	1	1	1
Linear Power Level	1	-	1
Log Power Level	1	-	1
Power Level	2	-	2
Nvt-Circuit	-	1	-

(1) Any single Linear Power Level, Log Power Level or Power Level measuring channel may be inoperable while the reactor is operating for the purpose of performing a channel check, test, or calibration.

(2) If any required measuring channels becomes inoperable while the reactor is operating for reasons other than that identified in Technical Specification 3.2.2 (1) above, the channel shall be restored to operation within 5 minutes or the reactor shall be immediately shutdown.

(3) The Fuel Element Temperature measuring channel is not required if transient operation modes (Square Wave and Pulse) are precluded, and if precluded, should be considered removed from this table.

Basis. Fuel temperature displayed at the control console gives continuous information on this parameter which has a specified safety limit. The power level monitors assure that the reactor power level is adequately monitored for both steady-state, square wave and pulse modes of operation. The specifications on reactor power level indication are included in this section, since the power level is related to the fuel temperature. For footnote (1), taking these measuring channels off-line for short durations for the purpose of a check, test or calibration is considered acceptable because in some cases, the reactor must be operating in order to perform the check, test, or calibration. Additionally there exist two redundant ***and independent*** power level indications operating at any given time while the third single channel is off-line. For footnote (2), events which lead to these circumstances are self-revealing to the operator. Furthermore, recognition of appropriate action on the part of the operator as a result of an instrument failure would make this consistent with TS 6.7.2. ***For footnote (3), by precluding transient operation modes, the reactor can continue to safely operate in steady state mode without this measuring channel as there are two redundant and independent power level measuring channels operating at any given time.***

3.2.3 Reactor Safety System

Applicability. This specification applies to the reactor safety system channels.

Objective. The objective is to specify the minimum number of reactor safety system channels that shall be available to the operator to assure safe operation of the reactor.

Specifications. The reactor shall not be operated unless the minimum number of safety channels described in Table 2 and interlocks described in Table 3 are operable.

Table 2 - Minimum Reactor Safety Channels

Safety Channel	Function	Effective Mode		
		S.-S.	Pulse	S.-W.
Fuel Element Temperature	SCRAM @ 510°C	1	-	1
Power Level	SCRAM @ 1.1 MW(t) or less	2	-	2
Console Scram Button	SCRAM	1	-	1
Preset Timer	Transient rod SCRAM @ ≤ 15 sec after a pulse	-	1	-
High Voltage	SCRAM @ ≥25% of nominal operating voltage	1	1	1

Table 3 - Minimum Interlocks				
		Effective Mode		
Interlock	Function	S.-S.	Pulse	S.-W.
Wide-Range Log Power Level Channel	Prevents control rod withdrawal @ less than 2 cps	1	-	-
Transient Rod Cylinder	Prevents application of air unless fully-inserted	1	-	-
1 kW Pulse Interlock	Prevents pulsing above 1 kW	-	1	-
Shim, Safety, and Regulating Rod Drive Circuit	Prevents simultaneous manual withdrawal of two rods	1	-	1
Shim, Safety, and Regulating Rod Drive Circuit	Prevents movement of any rod except transient rod	-	1	-
Transient Rod Cylinder Position	Prevents pulse insertion of reactivity greater than that which would produce a maximum fuel element temperature of 830°C	-	1	1

(1) Any single Linear Power Level, Log Power Level or Power Level safety channel or interlock may be inoperable while the reactor is operating for the purpose of performing a channel check, test, or calibration.

(2) If any required safety channel or interlock becomes inoperable while the reactor is operating for reasons other than that identified in Technical Specification 3.2.3 (1) above, the channel shall be restored to operation within 5 minutes or the reactor shall be immediately shutdown.

(3) The Fuel Element Temperature safety channel is not required if transient operation modes (Square Wave and Pulse) are precluded, and if precluded, should be considered removed from this table.

Basis.

Fuel Element Temperature Scram: The fuel element temperature scram causes a scram in excess of ~~the LSSS, which is~~ 510ºC. The supporting arguments for the safely limit of 1150ºC are given in SAR 4.5.3.1. The ~~LSSS~~ ***fuel element temperature scram*** is set to less than half for the safety limit. This is more than adequate to account for uncertainties in instrument response and core position of the instrumented fuel element.

Power Level Scram: The set point for both the safety and percent power channels are normally set to 106% of 1 MW(t), which is below the licensed power of 1.1 MW(t). The 6% difference allows for expected and observed instrument fluctuations at the normal full operating power of 1 MW(t) to occur without scramming the reactor unnecessarily. Conversely, SAR 13.2.2.2.2 shows that this set point is more than sufficient to prevent exceeding the reactivity insertion limit during non-pulsing operations and prevent the operator from inadvertently exceeding the licensed power.

Manual Scram: The manual scram must be functional at all times the reactor is in operation. It has no specified value for a scram set point. It is initiated by the reactor operator manually.

Preset Timer Scram: The preset timer ensures that the reactor power level will reduce to a low level after pulsing and preclude an unintentional restart or ramped increase to some equilibrium power.

High Voltage Scram: The high voltage scram must be set to initiate a scram before the high voltage for any of the three detectors reaches 25% or less of the nominal operating voltage. The loss of operating voltage down to this level is an indication of detector failure. Many measuring channels and safety systems are fundamentally based upon accurate response of the detectors.

Wide-Range Log Power Level Channel Interlock: The rod withdrawal prohibit interlock prevents the operator from adding reactivity when the count rate on the wide-range log power channel falls below 2 cps. When this happens, the count rate is insufficient to produce meaningful instrumentation response. If the operator were to insert reactivity under this condition, the period could quickly become very short and result in an inadvertent power excursion. A neutron source is added to the core to create sufficient instrument response that the operator can recognize and respond to changing conditions.

Transient Rod Cylinder Interlock: This interlock prevents the application of air to the transient rod unless the rod is fully inserted. This will prevent the operator from pulsing the reactor in steady-state mode.

1 kW Pulse Interlock: The 1-kW permissive interlock is designed to prevent pulsing when wide range log power is above 1-kW. SAR 13.2.2.2.1 shows that the peak temperature reached during an end-of-life core will be 1,150ºC for an initial fuel temperature of 20ºC. The methodology clearly shows that if the initial temperature was higher, the resulting peak temperature must be lower. However, there has not been analysis or experiment to look at the relationship between heat generated within the fuel at power (i.e., > 1-kW) and heat generated on the surface of the fuel during a pulse. Therefore, this interlock prevents the reactor from pulsing at power levels which produce measurably significant increases in fuel temperature.

Shim, Safety and Regulating Rod Drive Circuit: The single rod withdrawal interlock prevents the operator from removing multiple control rods simultaneously such that reactivity insertions from control rod manipulation is done in a controlled manner. The analysis in SAR 13.2.2.2.2 and 13.2.2.2.3 show that the reactivity insertion due to the removal rate of the most reactive rod or all the control rods simultaneously is still well below the reactivity insertion design limit of $2.59.

Shim, Safety and Regulating Rod Drive Circuit: In pulse mode, it is necessary to limit the reactivity inserted to less than the design limit of $2.59 at the end of core life analyzed in SAR 13.2.2.2.1. This interlock ensures that all pulse reactivity is due to only the transient rod while in pulse mode. Otherwise, any control rod removal in pulse mode would add to the inserted reactivity of the transient rod and create an opportunity for exceeding the reactivity insertion limit.

Transient Rod Cylinder Position Interlock: For the transient rod cylinder interlock, SAR 13.2.2.2.1 shows that the designed limiting reactivity insertion for the fuel is $2.59 at the end of core life. This interlock limits transient rod reactivity insertions below this value. Furthermore, this interlock is designed such that if the electrical (i.e., limit switch) portion fails, a mechanical (i.e., metal bracket) will still keep the reactivity insertion below the criterion.

For footnote (1), taking these safety channels off-line for short durations for the purpose of a check, test or calibration is considered acceptable because in some cases, the reactor must be operating in order to perform the check test or calibration. Additionally there exist two redundant ***and independent*** power level indications operating at any given time while the third single channel is off-line. For footnote (2), events which lead to these circumstances are self-revealing to the operator. Furthermore, recognition of appropriate action on the part of the operator as a result of an instrument failure would make this consistent with TS 6.7.2. ***For footnote (3), by precluding transient operation modes, the reactor can continue to safely operate in steady state mode without this safety channel as there are two redundant and independent power level safety channels operating at any given time.***

4.2 Reactor Control and Safety Systems

Applicability. This specification applies to the surveillance requirements of reactor control and safety systems.

Objective. The objective is to verify performance and operability of those systems and components which are directly related to reactor safety.

Specifications.

a. The control rods and drives shall be visually inspected for damage or deterioration biennially.

b. The scram time shall be measured annually.

c. The transient rod drive cylinder and associated air supply system shall be inspected, cleaned and lubricated as necessary, semi-annually.

d. A channel check of each of the reactor safety system channels for the intended mode of operation shall be performed prior to each day's operation or prior to each operation extending more than one day.

e. A channel test of each item in Table 2 and 3 in section 3.2.3 shall be performed semi-annually.

f. A channel calibration of the fuel temperature measuring channel shall be performed annually.

(1) Sections 4.2.e (specifically the Fuel Element Temperature Safety Channel) and 4.2.f may be deferred if transient operation modes (Square Wave and Pulse) are precluded.

They shall be completed prior to returning the Fuel Element Temperature Measuring Channel back to operations.

Basis. Experience has shown that the identified frequencies will ensure performance and operability for each of these systems or components. ***For footnote (1), by precluding transient operation modes, the reactor can continue to safely operate in steady state mode without this measuring and safety channel as there are two redundant and independent power level measuring and safety channels operating at any given time.***

Other TRIGA facilities have similarly received license amendments to operate without an IFE (e.g. Dow TRIGA Reactor). Previous safety analyses performed in support of the OSTR HEU to LEU conversion have shown that the OSTR is physically unable to exceed the safety limit under all operating conditions, which should allow for safe operations without an IFE.

This amendment is requested due to the current IFE approaching the current LSSS and the unavailability of a spare IFE. As part of this amendment, the OSTR operations staff will remove the IFE from the core and replace it with a spare standard 30/20 fuel element.

I hereby affirm, state, and declare under penalty of perjury that the foregoing is true and correct.

Executed on: 11/5/18.

If you have any questions, please do not hesitate to contact me.

Sincerely,

Steve Reese
Director

cc: Document Control, USNRC
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