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RADIATION LABORATORY

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

REFERENCE: University of Massachusetts-Lowell Research Reactor
Docket No. 50-223; License No. R-125

SUBJECT: Log Power Measuring Channel – Revised SAR Section 7.4.1.2 for Renewal of Facility Operating License No. R-125 for the University of Massachusetts-Lowell Research Reactor.

Please find the enclosed revision to the above referenced SAR section as previously discussed in site visits and telephone conversations related to license renewal. Enclosure 1 is the revised SAR section for review as part of the license renewal process. Enclosure 2 provides a list of facilities currently using, or will use, the proposed replacement for the Log Power Measuring Channel. As noted in previous RAI responses, a final updated version of the SAR, including this Chapter 7 revision, will be completed when all RAIs and responses associated with relicensing are complete.

Please direct any requests for additional information regarding this submittal to Mr. Leo Bobek, Reactor Supervisor at the above address.

I declare under penalty of perjury that to the best of my knowledge the foregoing is true and correct.

Sincerely,

Leo M. Bobek
Reactor Supervisor, Radiation Laboratory

Enclosures:
1. Revised SAR Section 7.4.1.2
2. List of Facilities Using TR-10 Wide Range Log Power/Period Monitor

Cc: Edward Helvenston, Project Manager
Research and Test Reactor Licensing Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

7.4.1.2 Wide-Range Logarithmic Power/Period Channel

The function of the Wide-Range Logarithmic Power/Period Monitor (Log-PPM) channel is to measure the neutron fluence rate (power level) in ranges that overlap the start-up channel and the linear power measuring channels. In addition, the Log-PPM channel provides the rate of change in reactor power (reactor period) and provides multiple trip functions for alarm and scrams. The Log-PPM provides neutron flux measurement from reactor shutdown to reactor full power level spanning from 10^{-2} n/cm^2-s to 10^{10} n/cm^2-s. The power measurement is calibrated in units of thermal watts and provides measurements from sub-critical levels up to 120% of the steady state licensed power level of 1MW.

The Log-PPM channel consists of a fission chamber neutron detector and the rack mounted wide-range logarithmic neutron flux monitor. The monitor chassis is physically installed in the control room Instrument Panel (P26 of Fig. 7.9). The chassis contains the electronics for signal processing, bistable trips, isolated outputs, and the high voltage and low voltage power supplies. The front panel of the chassis (Fig. 7.5) displays source range counts and period, wide range log power and period, wide range linear power, and bi-stable trip indicators. A manufacturer supplied remote readout module installed on the Control Console (C3 of Fig. 7.10) provides for identical indications of counts, period, and reactor power.

The signal processing electronics provide amplification, pulse shaping, and discrimination against alpha, gamma, and electronic noise. The processed signals provide the log and linear power levels and their rate of change. Isolated analog output signals are provided for the remote indicators. The signal processing circuitry also provides for continuous self-diagnostics of the high voltage and low voltage power supplies integrity. The bistable trip circuits provide for reactor scram and alarm indication. Several adjustment circuits and test points are provided for calibration and to aid in troubleshooting. Integrated test circuits provide a means for verifying the proper performance of the current amplifier and differentiator circuit, and to ensure the functionality of all trip circuits. The manufacturer specifications for the Log-PPM monitor are provided in Table 7-3.

Table 7-3: Log-PPM Monitor Specifications

	SR Log	SR Rate	WR Log	WR Rate	Linear Power
Sensitivity*	0.4 cps/nv		0.1 cps/nv $1.9x10^{-9}$ V^2/nv		1.2×10^{-13} A/nv
Flux Range (nv)	10^{-1} to 10^6	10^{-1} to 10^6	1 to 10^{10}	1 to 10^{10}	10^6 to 10^{10}
Output Range	0.1 to 10^5 cps	-30 to +3 sec	10^{-8} to 200%	-30 to +3 sec	0 to 125%
Linearity**	±2%	±2%	±1%	±2%	±0.5%
Temp Drift %/deg C	0.04	0.05	0.04	0.05	0.05
Output Volts	0 to 10 VDC 4 to 20 mA	0 to 10 VDC 4 to 20 mA	0 to 10 VDC 4 to 20 mA	0 to 10 VDC 4 to 20 mA	0 to 10 VDC 4 to 20 mA

7.4.1.2.1 Log Count Rate/Current and Period Circuits

SOURCE RANGE (SR): The SR indication originates from an output charge pulse produced by a neutron interaction with the fission chamber detector. The pulse signal is amplified by the Log-PPM preamplifier electronics module. The preamplifier output signal is then conditioned by a discriminator circuit to provide a pulse of fixed amplitude width for each input neutron pulse that exceeds the discriminator threshold. The source range discriminator circuit uses an adjustable low-level threshold. The discriminator output signal is processed by the SR log count rate and rate (period) circuit board. The log count rate circuit provides an output that is proportional to the logarithm of the average count rate of detector signal pulses over a range of 0.1 to 10^5 cps.

WIDE RANGE (WR): The WR indication originates from the pulse and mean square voltage (MSV) produced by neutron interactions with the fission chamber detector. The pulse and MSV signal from the fission chamber is amplified in the WR preamplifier module. The signal from the preamplifier is conditioned by the discriminator circuit to provide a signal of fixed amplitude and width for each input neutron pulse that exceeds the discriminator threshold. There are two discriminator circuits; one for intermediate range with a fixed high-level threshold and one for source range with an adjustable low level threshold. The MSV signal is conditioned in a bandpass filter to eliminate frequencies below 5 kHz and above 140 kHz which is then sent to a true root mean square (RMS) converter to provide a DC voltage signal proportional to the mean of the magnitude of the input signal. The charge pulse signal is processed by the WR log count rate and rate circuit board, and the MSV signal is processed by the log amplifier and rate circuit board. An auctioneer circuit on the log amplifier and rate circuit board switches between the count rate and the MSV signals depending on the flux level. The log count rate circuit provides an output that is proportional to pulse count rate over the range of about 10^{-8} % to 3 x 10^{-2} % power. The log amplifier circuit provides an output that is proportional to the MSV signal over the range of about five decades from 10^{-3} % to 200% of reactor power. These two signals are combined by the auctioneer circuit to provide one continuous output over the range of 10^{-8} % to 200% reactor power. Two rate-of-change (period) circuits associated with these log signals provide outputs that are also combined to provide one continuous rate-of change signal over the full reactor flux range. The combined log output and rate output are displayed on the WR meters on the chassis front panel, on the remote display, and are available as isolated output signals.

A signal test generator provides a test input to the WR preamplifier and the power range (PR) linear modules. Test signals are selected from the front panel. The test generator circuit module also monitors the high voltage and low voltage power supplies to verify the correct supply voltage and provides a trip and alarm output when a non-operate condition exists.

7.4.1.2.2 Trip Alarm Circuit

The trip/alarm circuit contains identical bi-stable circuits to generate trips for high voltage, short period, high power, alarm, and low power indications. Once a trip has occurred, the circuit latches in the tripped state. The only way to unlatch the circuit is for the user to apply a reset signal, even if all signal levels return to nominal prior to the reset. Each trip has both a DPDT (Form C) relay and an opto-isolator providing a trip logic signal. The relays are held energized in a fail-safe condition until a trip de-energizes the coil. Taking the monitor out of operate mode (such as during a self-test) will immediately activate the trip relay.

Table 7.4 Log-PPM Trips

TRIP	DESCRIPTION
PERIOD (1)	High period alarm / inhibit (Wide Range)
PERIOD (2)	High period scram (Wide Range)
COUNT LOW (3)	Low count rate inhibit (Source Range)
HV (4)	HV scram also includes drawer power and supply
POWER (5)	High power alarm/inhibit
POWER (6)	High power scram
POWER (7)	Natural convection (110 kW) High Power alarm /inhibit
POWER (8)	Natural convection (110 kW) High Power scram

The trip outputs are summarized as follows:

(1) Short Period Alarm/Inhibit – Relay: A rising trip providing an open relay contact output when measured period exceeds the alarm set-point and a closed contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used to initiate the alarm annunciator and opens an inhibit relay to prevent control blade withdrawal.

(2) Short Period Scram – Relay: A rising trip providing an open relay contact output when measured period exceeds the scram set-point and a closed contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used in the scram safety chain (see also 7.4.3).

(3) Low Count Rate Inhibit – Relay: A decreasing trip providing an open relay contact output when the count rate (source range) drops below the trip set-point and a closed contact

output when un-tripped. This contact opens an inhibit relay to prevent control blade withdrawal.

(4) High Voltage Scram – Relay: A decreasing trip providing an open relay contact output when the high voltage output drops below the trip set-point and a closed contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used in the scram safety chain.

(5) High Power Alarm/Inhibit – Relay: A rising trip providing a closed relay contact output when measured power exceeds the alarm set-point and an open contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used to initiate the alarm annunciator and opens an inhibit relay to prevent control blade withdrawal.

(6) High Power Scram – Relay: A rising trip providing an open relay contact output when measured power exceeds the scram set-point and a closed contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used in the scram safety chain.

(7) Natural Convection Power Alarm/Inhibit – Relay: A rising trip providing an open relay contact output when measured power exceeds the alarm set-point. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used to initiate the alarm annunciator and opens an inhibit relay to prevent control blade withdrawal.

(8) Natural Convection Power Scram – Relay: A rising trip providing a closed relay contact output when measured power exceeds the alarm set-point and an open contact output when un-tripped. The relay coil associated with this contact is de-energized in the trip condition. This trip contact is used in the scram safety chain.

7.4.1.2.3 Display and Indicators

The Log-PPM chassis encompasses a standard 19-inch rack located on the control room instrument panel. The front panel of the chassis includes both bar and numeric readouts for the measured variables, as well as LED indicators for all trips and alarms activated by the trip/alarm board. A selector switch and potentiometers accessible on the front panel allow for the testing of the variables readouts and the alarm/trip functions. A remote readout module having similar dimensions as that used for each of the linear power measuring channels is mounted on the control console.

Figure 7.5 - Wide Range Log Period Power Module (PPM)

7.4.1.2.4 <u>Failure Analysis</u>

Failure of the power source or internal power supplies will cause all the trips to assume their tripped state. Relay contacts associated with trips (1) (2), (3), (4), (5), (6), (7) and (8) above will open. Reactor scram and blade withdrawal inhibit will result.

A component failure in the amplifier circuit causing a false upscale signal output will cause trips (1), (2), (3), (4) to be actuated. Relay contacts associated with trips (2), (3),(4),(6) and (8) will open. Reactor scram and blade withdrawal inhibit will result. A component failure in the amplifier section causing a false downscale signal output will actuate the control drive inhibit relay. A component failure in the amplifier section which would cause the output to neither increase nor decrease, yet not respond to an increase or decrease of signal input, is considered as impractical. However, since the linear power channels operate independently, reactor protection is provided by each of the two operating linear channels.

7.6 Control Console and Display Instruments (Note: figures only)

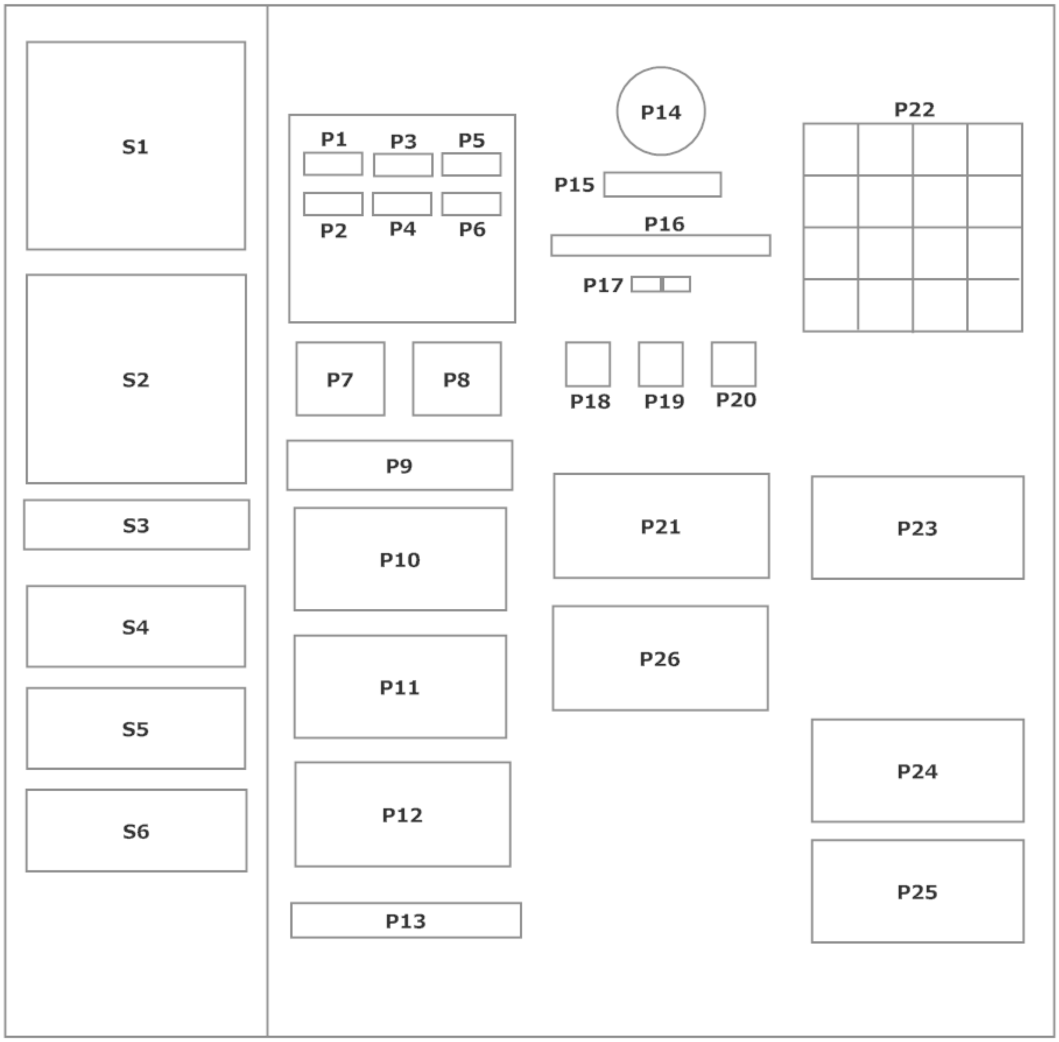

Figure 7.9: Instrument Panel Layout

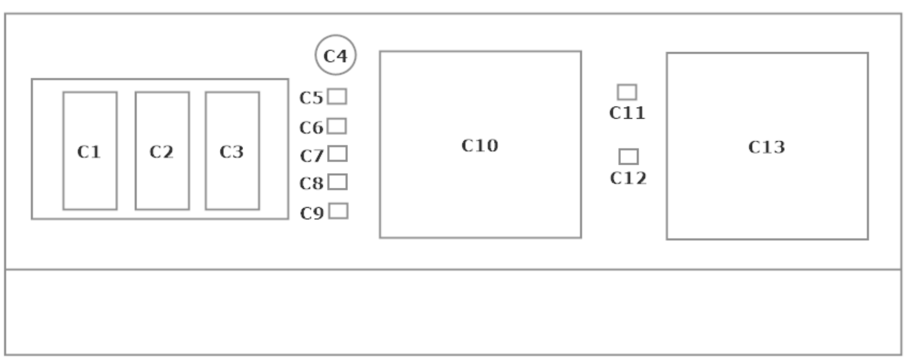

Figure 7.10: Control Console Layout

Enclosure 2
List of Facilities Users– Thermo Scientific TR-10 Neutron Flux Monitor

Facility	Type	Model	Channels	Status
Aerotest Operations Inc.	GA	TR-10	1	Shipped
Chalk River Maple 1 (Canada)	AECL	TR-10	5	Reactor Decommissioned
Chalk River Maple 2 (Canada)	AECL	TR-10	5	Reactor Decommissioned
Idaho National Labs (Advanced Test Reactor)		TR-10	6	In Manufacturing
Institute of Nuclear Energy Research (Taiwan)	GA	TR-10	1	Reactor Decommissioned
Iowa State University	ARGONT	TR-10	1	Reactor Decommissioned
Korea Multi-Purpose Research Reactor	AECL	TR-10	6	Operational
Massachusetts Institute of Technology	MTR	TR-10	3	Shipped
McClellan Nuclear Radiation Center	GA	TR-10	1	Operational
McMaster University (Canada)	MTR	TR-10	1	Shipped
North Carolina State University	PULSTAR	TR-10	2	Operational
Nuclear Energy Corp of South Africa (Safari)		TR-10	3	Operational
Ohio State University	MTR	TR-10	1	Operational
Penn State University	GA	TR-10	1	Operational
Princeton (Tokamak Fusion Test Reactor)		TR-10	3	Operational
Princeton (Tokamak Fusion Test Reactor)		TR-10	2	Shipped
Puspati (Malaysia)	GA	TR-10	3	Shipped
Reed College	GA	TR-10	1	In Manufacturing
Rensselaer Polytechnic Institute		TR-10	1	Operational
Rhode Island Nuclear Science Center	MTR	TR-10	1	Operational
Sandia National Laboratories (ACR & SPR-III)		TR-10	2	Operational
Sandia National Laboratories (ACR & SPR-III)		TR-10	3	Operational
Sandia National Laboratories (ACR & SPR-III)		TR-10	2	Operational
Sandia National Laboratories (ACR & SPR-III)		TR-10	1	Operational
Sandia National Laboratories (ACR & SPR-III)		TR-10	1	Operational
Thailand Institute of Nuclear Technology		TR-10	3	Shipped
University of Maryland	GA	TR-10	1	In Manufacturing
University of Missouri, Columbia	MTR	TR-10	3	Operational
University of Missouri, Rolla	MTR	TR-10	1	Operational
University of Utah	GA	TR-10	1	Shipped
University of Wisconsin	GA	TR-10	1	Operational
Whiteshell (Canada)	AECL	TR-10	1	Operational