Technical Specifications for the Neutron Radiography Facility (TRIGA Mark 1 Reactor)

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6.1 WHC Organization Pertinent to Neutron Radiography
Facility Operation

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TECHNICAL SPECIFICATIONS FOR THE
NEUTRON RADIOGRAPHY FACILITY
(TRIGA Mark I Reactor)

INTRODUCTION

These Technical Specifications state the limits under which the Neutron Radiography Facility, with its associated TRIGA Mark I Reactor, is operated by the Westinghouse Hanford Company for the U. S. Department of Energy. These specifications cover operation of the Facility for the purpose of examination of specimens (including contained fissile material) by neutron radiography, for the irradiation of specimens in the pneumatic transfer system and approved in-core or in-pool irradiation facilities and for operator training.

The Final Safety Analysis Report (TC-344) and its supplements, and these Technical Specifications are the basic safety documents of the Neutron Radiography Facility.

1.0 DEFINITIONS

The following definitions are provided to ensure a uniform interpretation of terms and phrases used in the Technical Specifications.

1.1 ABNORMAL OCCURRENCES

An abnormal occurrence is any of the following:

- 1) Any actual safety system setting less conservative than specified in 2.2, Limiting Safety System Setting.
- 2) Operation in violation of Limiting Conditions for Operation (Section 3).
- 3) Incidents or conditions which prevent or could prevent the performance of the intended safety function of an engineered safety feature or the reactor safety system.
- 4) Release of fission products of a magnitude indicating a failure of the principal physical boundary.
- 5) An uncontrolled or unanticipated change in reactivity.
- 6) An observed inadequacy in the implementation of either administrative or procedural controls, such that the inadequacy causes the existence or development of an unsafe condition in connection with the operation of the reactor.
- 7) An uncontrolled or unanticipated release of radioactivity.

1.2 UNUSUAL OCCURRENCES

An unusual occurrence, in addition to the examples listed in DOE Order 5000.3, related DOE/RL Supplements and WHC Management Requirements and Procedures includes Abnormal Occurrences as defined in Section 1.1.

1.3 EVENT

A significant deviation from normal operation that may or may not be reportable as an unusual occurrence or critique.

1.4 CRITIQUE

An evaluation of those events that WHC Management has determined requires investigation beyond that identified in the Event Fact Sheet.

1.5 NEUTRON RADIOGRAPHY

An operation which involves placing objects in the neutron beam at or near the collimator top for the purpose of performing nondestructive testing on those objects.

1.6 IRRADIATION

An irradiation is any use of the reactor to subject objects or samples to radiation using the pneumatic transfer system, in-pool or the F ring in-core positions. This also includes use of the collimator beam for other than nondestructive testing applications.

1.7 REACTIVITY WORTH OF AN EXPERIMENT

The Reactivity Worth of an Experiment is the maximum absolute value of the reactivity change that would occur as a result of intended or anticipated changes or credible malfunctions that alter experiment position or configuration.

1.8 MOVABLE EXPERIMENT

A movable experiment is one where it is intended that the entire experiment may be moved in or near the core or into and out of the core or into and out of the reactor while the reactor is operating.

1.9 NON-SECURED EXPERIMENTS

Non-secured experiments are those for which it is intended that the experiment should not move while the reactor is operating, but is held in place with less restraint than a Secured Experiment.

1.10 SECURED EXPERIMENT

A secured experiment is any experiment, experiment facility, or component of an experiment that is held in a stationary position relative to the reactor by mechanical means. The restraining forces must be substantially greater than those to which the experiment might be subjected by hydraulic, pneumatic, buoyant, or other forces which are normal to the operating environment of the experiment, or by forces which can arise as a result of credible malfunctions.

1.11 SECURED EXPERIMENT WITH MOVABLE PARTS

A secured experiment with movable parts is one that contains parts that are intended to be moved while the reactor is operating.

1.12 CHANNEL

A channel is the combination of sensor, line, amplifier, and output devices which are connected for the purpose of measuring the value of a parameter.

1.13 CHANNEL CALIBRATION

A channel calibration is an adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures. Calibration shall encompass the entire channel, including equipment actuation, alarm, or trip and shall be deemed to include a Channel Test.

1.14 CHANNEL CHECK

A channel check is a qualitative verification of acceptable performance by observation of channel behavior. This verification, where possible, shall include comparison of the channel with other independent channels or systems measuring the same variable.

1.15 CHANNEL TEST

A channel test is the introduction of a signal into the channel for verification that it is operable.

1.16 MEASURED VALUE

The value of a process variable as it appears on the output of a measuring channel.

1.17 MEASURING CHANNEL

An arrangement of sensors, signal processing equipment and output devices which act together to measure a process variable, indicate the measured value and may provide a trip or alarm signal.

1.18 OPERABLE

A system or component capable of performing its intended function.

1.19 OPERATING

A system or component performing its intended function.

1.20 OFF-STANDARD CONDITION

A condition with an operating parameter outside of the intended operating range.

1.21 NEUTRON RADIOGRAPHY FACILITY SECURED

That overall state where all of the following conditions are satisfied:

- 1) At least 2 of the 3 neutron absorbing control rods are fully inserted or other safety devices are in shutdown position, as required by technical specifications, and

The console key switch is in the off position and the key is removed from the lock, and

- 2) No work is in progress involving core fuel, core structure, installed control rods, or control rod drives unless they are physically decoupled from the control rods, and
- 3) No experiments in or near the reactor are being moved or serviced that have, on movement, a reactivity worth exceeding the maximum value allowed for a single experiment, and
- 4) The reactor control room and hall are locked, motion detectors and remote alarms activated.

1.22 REACTOR SHUTDOWN

The condition of the reactor when it is subcritical by at least the minimum shutdown margin and the magnet power key is removed and in proper custody.

1.23 REACTOR OPERATING

The reactor is considered to be operating whenever it is not secured or shut down.

1.24 SHUTDOWN MARGIN

Shutdown margin shall mean the minimum shutdown reactivity necessary to provide confidence that the reactor can be made subcritical by means of the

control and safety systems starting from any permissible operating condition although the most reactive rod is in its most reactive position, and that the reactor will remain subcritical without further operator action.

1.25 SCRAM

The act of reducing the reactor power level by dropping all of the control rods.

1.26 SAFETY DEVICE

Any device in a safety channel which monitors a channel for an off-standard condition.

1.27 SAFETY CHANNEL

An electrical circuit which automatically and rapidly initiates a scram or alarm when a safety device setting for detection of an off-standard condition is exceeded.

1.28 AVAILABLE EXCESS REACTIVITY

Excess reactivity is that amount of reactivity that would exist if all control rods (control, regulating, etc.) were moved to the maximum reactive condition from the point where the reactor is exactly critical ($K_{eff} = 1$).

1.29 OPERATING PERIOD

The planned interval between startup and shutdown checks which may include several operating modes. An operating period will generally be one day with numerous startups and shutdowns and different power levels but can be extended to several days of 24-hours a day operation.

1.30 TRUE VALUE

The actual value of a parameter.

1.31 REACTOR PERIOD

The time required for the reactor power level (fission density) to change by a factor of e (~2.7).

1.32 ANNUAL*

Occurring within a 12 month period of time which can extend to a maximum of 15 months when specified as an inspection period, with the intent that such surveillance will be done each year at approximately the same date each year.

1.33 SEMIANNUAL*

Occurring within a 6 month period of time which can extend to a maximum of 7-1/2 months when specified as an inspection period, with the intent that such surveillance will be done twice each year at approximately the same date each year.

1.34 QUARTER*

Occurring within a 90-day period of time which can extend to a maximum of 120 days when specified as an inspection period, with the intent that such surveillance will be done once each quarter at approximately the same date each quarter.

1.35 MONTH*

Occurring within a 30-day period of time which can extend to a maximum of 45 days when specified as an inspection period, with the intent that such surveillance will be done each month at approximately the same date each month.

*Extensions of nominal time periods shall not be cumulative.

1.36 WEEK*

Occurring within a 7-day period of time which can extend to a maximum of 10 days when specified as an inspection period, with the intent that such surveillance will be done within the calendar week.

1.37 ENGINEERED SAFETY FEATURE

Features of a unit other than reactor trips or those used only for normal operation, that are provided to prevent, limit or mitigate the release of radioactive material.

1.38 AUXILIARY SAFETY FEATURES

Features of a unit other than safety channels or engineered safety features, that contribute significantly to the overall safety of the reactor, operators and environment.

1.39 NEUTRON RADIOGRAPHY FACILITY

That portion of the 308 Building annex which houses the TRIGA reactor and associated auxiliary and neutron radiography equipment. It consists of the reactor hall and the reactor control room and the irradiated fuel cask handling room.

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1.40 REACTOR HALL

That portion of the Neutron Radiography Facility wherein is located the reactor, the reactor pool and associated components.

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*Extensions of nominal time periods shall not be cumulative.

1.41 REACTOR CONTROL ROOM

The enclosed space adjacent to the reactor hall which houses the reactor control console.

1.42 IRRADIATED FUEL CASK HANDLING ROOM

The room immediately adjacent to the reactor hall which contains the equipment and facilities for handling the irradiated fuel casks used when neutron radiographing irradiated materials.

1.43 OPERATIONAL TEST

A verification of the correct functioning of an instrument channel, electrical circuit or piece of equipment initiated by creating conditions identical to those experienced by the channel, circuit or equipment during its normal use.

1.44 CHANGE IN CORE LOADING

Increasing or decreasing the number of fuel elements or graphite reflector elements or changing the fissile content of fuel elements in the core.

1.45 CHANGE IN CORE CONFIGURATION

A physical change of core components specifically:

- . Changing the location of fuel elements, graphite reflector elements or changing the location of any control rod.
- . Modification of core, reflector, or other reactor structure which could affect core geometry.

2.0 SAFETY LIMIT AND LIMITING SAFETY SYSTEM SETTING

Safety Limits are limits on important process variables which are found to be necessary to reasonably protect the integrity of the principal physical barriers which guard against the uncontrolled release of radioactivity. The principal physical barrier is the fuel cladding.

Limiting Safety System Settings (LSSSs) are those limiting values for settings of the safety channels by which point protective action must be initiated. The LSSSs are chosen so that automatic protective action will terminate the abnormal situation before a safety limit is reached.

2.1 SAFETY LIMIT

The fuel temperature shall not exceed 550°C.

2.2 LIMITING SAFETY SYSTEM SETTING

The trip setpoint of any linear safety channel shall not exceed 285 kW. The trip setpoints shall not intentionally be adjusted to greater than 275 kW except during operational testing of the safety channel scram features, when they may be set to a maximum of 285 kW for the duration of the test only [see section 4.3.2.7].

3.0 LIMITING CONDITIONS FOR OPERATION

Limiting Conditions for Operation (LCO) are those administratively established constraints on equipment and operational characteristics which shall be adhered to during operation of the facility.

3.1 REACTIVITY LIMITATIONS

3.1.1 Minimum Shutdown Margin

The minimum available shutdown margin for the TRIGA Core (in a cold, xenon-free, equilibrium samarium condition) shall be \$1.00 ($\sim 0.72\% \Delta k/k$) with the control rod having the highest worth fully withdrawn. In addition, this limit must be met with all the secured, non-secured or movable experiments in the most positive reactivity state.

3.1.2 Reactivity Insertion Rate

The rate of positive reactivity insertion available from a control rod shall not exceed 17 cents per second ($\sim 0.12\% \Delta k/k$).

3.1.3 Core Reactivity

The core excess reactivity in a cold, xenon-, samarium-free condition shall not exceed \$3.00 ($\sim 2.16\% \Delta k/k$) with the highest worth secured, non-secured or movable experiments in the most reactive state.

3.2 CONTROL AND SAFETY SYSTEMS

3.2.1 Scram Time

The scram time for each control rod, measured from the time the off-normal signal is initiated until the control rod reaches the bottom of its travel, shall not exceed 1.5 seconds.

3.2.2 Measuring Channels

The measuring channels listed below shall be in operation when the reactor is operating:

<u>Channel</u>	<u>Range</u>	<u>Function</u>
Log Power Channel	10^{-8} - 110% (of 250 kW)	Indicate reactor power over full range.
Multirange Linear Power Channel	0.01 W (approx) to 300 kW	Indicate and record reactor power.
Linear Safety Channel #1	0 - 110% (of 250 kW)	Indicate reactor power (in upper 2 decades.)
Linear Safety Channel #2	0 - 110% (of 250 kW)	Indicate reactor power (in upper 2 decades.)
Period Channel	-30 sec to +3 sec	Indicate reactor period.

3.2.3 Safety Channels

The safety channels listed below shall be in operation when the reactor is operating:

<u>Channel</u>	<u>Function</u>
Linear Safety Channel #1	Scram at 275 ± 10 kW
Linear Safety Channel #2	Scram at 275 ± 10 kW
Period Channel	Alarms when the rising period is less than three seconds.
Pool Water Temperature	Alarms at 45°C or more.
Fission Chamber High Voltage Monitor	Alarms if high voltage to a neutron detector drops below 90% of normal.

3.3 RADIATION MONITORING SYSTEMS

3.3.1 Routine Radiation Monitoring System

The radiation monitoring equipment listed below shall be in operation when the reactor is operating:

<u>Feature</u>	<u>Function</u>
Area Radiation Monitor ¹	Monitor gamma radiation level in reactor hall.
Air Particulate Monitor ² (alpha)	Monitor reactor hall for airborne alpha (particulate) activity and record continuously.
Air Particulate Monitor ² (beta-gamma)	Monitor for airborne beta-gamma (particulate) activity and record continuously.
Stack exhaust particulate and Iodine sample stations	Provides for measurement of effluent air from the reactor hall both before and after the HEPA filters.

-
- ¹ An inoperable Area Radiation monitor must be replaced with a continuous area radiation monitor within 15 minutes or the reactor must be shutdown.
 - ² Reactor operation may continue to the end of the operating period with one or more of these systems out of service provided surveys or samples are taken hourly using instruments which have sensitivity and accuracy comparable to the installed systems.

3.3.2 Radiation Monitoring Systems Required for Neutron Radiography of Irradiated Fuel

The radiation monitoring equipment listed below shall be in operation when performing neutron radiography of irradiated fuel

<u>Feature</u>	<u>Function and Alarm Setpoints</u>
High Range Radiation Monitor*	Monitors gamma radiation level within concrete shielded beam stop. Alarm set at 3 R/hr or less. Interlock prevents opening of rolling concrete shield door or movement of cask cart when dose rates ≥ 3 R/hr exist in the beam stop.

- * May be bypassed only with the specific written authorization of the Managers of 300/400 Area Facilities Nuclear Safety, 300/400 Area Operational Health Physics, and Facility Operations and Administration, and then only for repair, replacement or calibration of the channels due to malfunction.

3.4 ENGINEERED SAFETY FEATURE

3.4.1 Reactor Hall Ventilation (HVAC) System

The reactor hall ventilation system shall fulfill the following requirements whenever the reactor is operating, or whenever fuel or other radioactive materials are being handled:

- 1) The air of the reactor hall shall be maintained at a pressure below atmospheric. An alarm shall sound in the reactor control room if pressure rises above the negative setpoint. The nominal alarm setpoint is -0.15 "wg relative to atmosphere.
- 2) All air exhausted from the reactor hall shall pass through two High Efficiency Particulate Air (HEPA) filters (99.95% minimum efficiency each) placed in series.

3.5 AUXILIARY SAFETY FEATURES

The following auxiliary safety features shall be operable when the reactor is operating:

<u>Feature</u>	<u>Function</u>
Magnet Power Key Lock	Prevents energizing the control rod magnets without the proper key. Removal of the key will initiate a scram.
Control Rod Pushbutton Interlock	Prevents more than one control rod from being withdrawn at the same time.
Shielding Door and Cask Cart interlocks	<p>(a) De-energizes all control rod magnets if shielding door is not fully closed.¹</p> <p>(b) Prevents cask cart from being moved when the shield door is not fully closed.¹</p> <p>(c) Prevents shield door from opening when high range monitor inside beam stop is in alarm condition.²</p> <p>(d) Prevents cask cart movement when high range radiation monitor inside beam stop is in alarm condition.²</p>

¹ May be bypassed during maintenance, calibration and test procedures approved in writing by the Managers of 300/400 Area Facilities Nuclear Safety, 300/400 Area Operational Health Physics, and Facility Operations and Administration.

² May be bypassed only with the specific-written authorization of the Managers of 300/400 Area Facilities Nuclear Safety, 300/400 Area Operational Health Physics, and Facility Operations and Administration, and then only for repair, replacement or calibration of the channels due to malfunction.

<u>Feature</u>	<u>Function</u>
Reactor Pool Level Monitor	Alarms when the pool level is outside the range of 15 to 21 inches below the floor level.
Rod Withdrawal Prohibit* (Log Power Channel)	Prevents startup with less than 4×10^{-7} % power indicated.
Manual Scram Bar	De-energizes all control rod magnets.
Loss of Console Power	De-energizes all control rod magnets.
Remote Scram Switch	Permits shutting down the reactor from a remote location.

* May be bypassed during maintenance, calibration and test procedures approved in writing by the Managers of 300/400 Area Facilities Nuclear Safety, 300/400 Area Operational Health Physics, and Facility Operations and Administration.

3.6 REACTOR COOLANT

The reactor shall not be operated unless coolant conductivity can be maintained below five micromhos/cm (averaged over a four-week period).

3.7 LIMITATIONS ON EXPERIMENTS

3.7.1 Reactivity Effects

- 1) Movable parts of secured experiments shall be limited in reactivity insertion rate to less than 17 cents/sec unless their total reactivity worth is less than 5 cents for these movable parts, e.g., rabbit capsules for the pneumatic transfer facility.
- 2) The maximum allowed reactivity worth of any independent experiment must be less than 25 cents.
- 3) The total reactivity worth of all experiments must be less than 25 cents.

3.7.2 Type of Experiment

Only authorized experiments defined in Section 1, are to be performed, e.g., neutron radiography, and irradiation using the pneumatic transfer facility, F-ring in-core capsules, wet or dry tubes, and in-pool irradiation experiments.

3.7.3 Limitation of Materials in Experiments

- 1) Explosive materials such as gun powder, TNT, nitroglycerin, PETN, and corrosive materials shall not be irradiated nor radiographed.
- 2) Irradiation of fissile materials shall be in accordance with an approved Experiment Proposal; taking into consideration the method of encapsulation, reactivity effects, number of fissions, power generation resulting in heat and pressure, and resultant fission product inventory.
- 3) Materials which can off-gas, sublime, are volatile, or produce aerosols must be so indicated on an Experiment Proposal Form, and include an analysis to provide assurance that the irradiation can be performed safely.
- 4) Irradiation of fissionable samples shall be limited to 0.1 gram in the fissionable isotopes per capsule with a total of 4.0 grams total in the reactor in experimental facilities.
- 5) Radiation levels associated with samples removed from the experimental facilities shall follow the as low as reasonably achievable (ALARA) policy.
- 6) All dispersible samples for irradiation shall have double encapsulation. Nondispersible samples shall have at least single encapsulation. Fissionable samples shall be contained in leak-proof metal encapsulation.

- 7) Heat generation rate per irradiation of an individual capsule shall not exceed 30 watts.
- 8) Dummy Irradiation Capsule pressure shall not exceed a calculated value of 30 psi. The capsules shall be designed to withstand an internal pressure of 50 psi.
- 9) The total calculated inventory of irradiated materials in the facility for neutron radiography shall be restricted to material having a total fission product content of less than 5×10^4 curies and 120 watts of heat.
- 10) Irradiated materials accepted for neutron radiography shall be contained in at least one sealed, helium leak tested metal containment vessel.
- 11) The maximum exposure rate measured with the instrument in contact with the surface of the cask used for transport of materials to be neutron radiographed shall not exceed 100 mR/hr.

3.7.4 Thermal-Hydraulic Effects

No experiment shall be designed such that during normal operation or failure, the parameters of the core could exceed the Safety Limit.

3.7.5 Chemical Effects

Sample encapsulation must be adequate to contain the sample material during normal or failure conditions to prevent contamination of the reactor pool

water or experiment apparatus. This is accomplished by double containment of the sample. A minimum purge rate of 200 ml/min (STP) shall be provided for irradiation of nylon and polyethylene capsules exposed to integrated doses in excess of 10^8 rads in open ended irradiation tubes.

3.7.6 Radiation Release

Proposed experiments are to be analyzed for potential radioactive effluent release and be designed to prevent or mitigate release. If any uncontrolled release of radioactivity takes place, significant enough to actuate air particulate alarms the experiment shall be terminated.

3.7.7 Experiment Insertion and Removal

All samples will be inserted and removed from the reactor with the reactor shutdown except that samples worth less than 5 cents may be inserted and removed using the pneumatic transfer tube during reactor operation.

4.0 SURVEILLANCE REQUIREMENTS

4.1 GENERAL

These specifications apply to the surveillance of components and systems which are essential to safety of the reactor and the facility. The purposes of these specifications are to assure that: (1) the instruments, safety trips and interlocks function as designed; (2) the control rod reactivity worths and core excess are within the limits required in the safety analysis; and (3) the structural integrity of the core elements is maintained. These surveillance tests may be deferred during periods when the reactor is shutdown (except as noted) providing they are performed prior to startup. Administrative controls on material and equipment listed in Section 4.4 are to be in effect at all times.

4.2 SURVEILLANCE PERTAINING TO THE SAFETY LIMIT AND LIMITING SAFETY SYSTEM SETTING

4.2.1 Linear Safety Channel Calibration

The two linear safety channels shall be calibrated by adjustment after comparison with the multirange linear power channel calibration annually and after each change in core configuration or detector position. A channel test of the two flux measuring safety channels shall be performed prior to each operating period.

4.3 SURVEILLANCE PERTAINING TO LIMITING CONDITIONS FOR OPERATIONS

4.3.1 Reactivity Surveillance

- 1) The reactivity worth and reactivity insertion rate of each control rod shall be measured and the shutdown margin computed:
 - . Annually
 - . Following any change in core loading or configuration.

- . Whenever a control rod is moved to a new core position.

NOTE: Following replacement of, modification or repair to an individual control rod, rod drive mechanism or rod control circuit only perform reactivity worth determination and reactivity insertion rate measurement on that particular control rod. The shutdown margin shall be computed utilizing this new data.

2) The core excess reactivity shall be measured:

- . At the beginning of each operating period.
- . Following any change in the core loading or configuration, or replacement of any fuel elements.
- . For determination of the amount of reactivity worth of an experiment.

3) The reactivity worth of an experiment shall be estimated and measured before operation with said experiment at full power. The reactivity worth must be within limits as stated in Section 3.7, Limitations on Experiments. Note: Experiment reactivity worth measurements shall be performed at a low reactor power level, less than 1 kW.

4.3.2 Control and Safety Systems Surveillance

- 1) The scram insertion time of each control rod shall be measured annually. Scram insertion time shall also be measured whenever a rod is moved to a new core position or after any maintenance, modification or repair is performed on the control rod, its drive mechanism or control circuit.
- 2) An operational test of the manual scram bar and a channel test of the period alarm shall be performed prior to each operating period.

- 3) A channel check of the linear safety channels, the log power channel, the period channel, and the multirange linear power channel and the pool water temperature channel shall be performed during the first ascent to the operating power level planned for any operating period.
- 4) The rod withdrawal prohibit interlock shall be operationally tested at least monthly.
- 5) The fission chamber high voltage monitor shall be operationally tested semiannually.
- 6) The pool water temperature instrument shall be calibrated and operationally tested semiannually. |R
- 7) The scram function of each of the two linear safety channels shall be operationally tested annually by increasing reactor power to the trip point. Reactor power shall not exceed 285 kW for this test.
- 8) The multirange linear power channel shall be calibrated by calorimetric means and the other power channels adjusted to agree with the linear channel annually and after any change in core loading or configuration or detector position.
- 9) Each control rod shall be visually inspected annually for indication of significant distortion or deterioration.

4.3.3 Radiation Monitoring Systems Surveillance

Each installed radiation monitoring instrument shall be checked daily during operation, and shall be source checked at least monthly. They will be calibrated annually and the alarm function operationally tested semiannually whether or not the reactor is operated. Stack exhaust filter samples shall be changed at a minimum once every two weeks.

4.3.4 Engineered Safety Feature Surveillance

The HVAC pressure control system shall be checked at least monthly. Its pressure-alarm function shall be operationally tested semi-annually. The HEPA exhaust filters shall be tested annually. All tests shall be performed whether or not the reactor is operated.

4.3.5 Auxiliary Safety Feature Surveillance

Each of the features listed in Section 3.5 shall be operationally tested semiannually. The reactor pool level monitor shall be operationally tested quarterly whether or not the reactor is operated.

4.3.6 Coolant Conductivity Surveillance

Coolant conductivity shall be:

- 1) Measured and recorded at the start of each operating period, and at least weekly if the reactor is not operating.
- 2) Averaged at least weekly over the preceding four-week period to determine compliance with the limit.

4.3.7 Experiment Surveillance

- 1) A new experiment shall not be installed in the reactor or conducted, until a hazards analysis and/or Experiment Proposal review (as per Section VI of HEDL MG-93, HEDL NRF Organization and Administration manual) has been completed. Experiment review must include compliance with the limits as set forth in Section 3.7, Limitations on Experiments, of these technical specifications. All new experiments must be approved by the Manager, Facility Operations and Administration.

- 2) If a particular experiment is the same as one previously conducted or is declared similar by the Reactor Operations Supervisor in regards to hazards analysis previously reviewed, the experiment may be performed after completion and approval of an Irradiation Request (as per Section VI of HEDL MG-93, HEDL NRF Organization and Administration Manual).

4.3.8 Radiation Surveillance

- 1) A Radiation Protection Technologist shall be present during all sample insertion and removal operations. |R
- 2) Generalized operational procedures shall be developed to cover the insertion and removal of experiments.
- 3) Radiation Work Procedures (RWP) shall be developed for the insertion, retrieval and storage of samples.

4.4 MATERIAL AND EQUIPMENT CONTROLS

The following administrative controls will apply to specific equipment and materials located in the Neutron Radiography Facility:

4.4.1 Fissile Material Limitations

TRIGA fuel elements shall be stored in standard TRIGA fuel storage racks suspended in the reactor pool. Driver and test fuel pins shall be stored and handled in the NRF outside the reactor pool in batches not exceeding 45% of the minimum critical number. The number of fueled assemblies, containing up to 217 fuel pins, permitted in the NRF at one time shall not exceed one. The edge-to-edge spacing between batches and between the fueled section of an assembly and a batch shall be at least two feet. A fissionable material batch not in pin form shall be limited to a total of either 45% of the minimum critical mass or 45% of the minimum critical number. Storage and handling of fissionable material in the NRF shall be governed by approved Criticality Safety Specifications. |R |R

4.4.2 TRIGA Fuel Limitations

All fuel elements in use will be inspected once every two years. Elements found to exceed the following limits shall not be used in the core.

- 1) Maximum transverse bow - 1/16 inch.
- 2) Maximum longitudinal growth - 1/10 inch.
- 3) Significant changes as observed by visual inspection.
- 4) If 10 percent or more of a core loading exceed either the maximum bow or longitudinal growth, the entire core loading shall be inspected.

4.4.3 Bridge Crane Operation

- 1) The bridge crane shall be in the parked position and placed out of service, using the 308 Building tagging procedure, whenever the reactor is operating or there is a loaded fuel pin cart in the reactor hall.
- 2) All lifts of heavy objects using the bridge crane shall be planned and supervised by the Reactor Operations Supervisor.
- 3) Blocks shall not be raised higher than is necessary for safe placement and removal (approximately 3 inches above another block).

4.4.4 Beam Stop Requirements

- 1) The reactor shall not be operated unless the beam stop shielding is fully assembled and in place except for certain approved maintenance procedures. Any reactor operation for maintenance shall

then be at <1 kW reactor power. A Radiation Protection Technologist is required to be present to perform radiation surveys of the reactor hall during this reactor operation.

R

- 2) The rotating shield of an irradiated fuel cask containing irradiated fuel shall not be opened to the beam stop shielding unless the concrete shielding door is fully closed.

5.0 DESIGN FEATURES

5.1 SITE

The reactor hall is an annex to the 308 Building located in the 300 Area of the DOE Hanford Reservation near Richland, Washington. The 308 Building is in a fenced enclosure with controlled access to the building and reactor hall.

5.2 TRIGA FUEL

Both stainless steel and aluminum-clad TRIGA fuel elements are authorized for the reactor core loading.

The fuel element uranium is enriched to 20% uranium-235 with the following characteristics:

- 1) Stainless Steel - High hydride fuel ($\text{U-ZrH}_{1.6}$) with 8.5% uranium by weight, 1.47-inch outside diameter, 0.02-inch wall thickness, and a 15-inch fuel column.
- 2) Aluminum - Low hydride fuel ($\text{U-ZrH}_{1.0}$) with 8.0% uranium by weight, 1.47-inch outside diameter, 0.03-inch wall thickness, and a 14-inch fuel column.

5.3 REACTOR CORE

The reactor core consists of standard TRIGA fuel elements (paragraph 5.2) and graphite dummy elements arranged in a standard TRIGA Mark I grid plate. A neutron source is installed in a peripheral grid position.

5.4 CONTROL AND SAFETY SYSTEM

The reactor control and safety system consists of the measuring channels (3.2.2), safety channels (3.2.3) and three borated graphite control rods and

their drive mechanisms. The control rods are positioned remotely to control reactor power and fall into the core by gravity after interruption of magnet current by automatic or manual trips or by loss of console power.

5.5 REACTOR HALL

The reactor hall is a confinement structure with a controlled and filtered exhaust.

5.6 SHIELDING

The water in the tank provides radiation shielding for all but the collimator area. A high-density concrete shield attenuates to less than 2 mrem/hr the fission neutron and gamma flux resulting from absorption of thermal neutrons during fuel pin radiography except for gaps and shield penetrations where leakage necessitates the establishment of local radiation zones during reactor operation.

6.0 ADMINISTRATIVE CONTROLS

6.1 ORGANIZATION

6.1.1 Management

The Westinghouse Hanford Company (WHC) Management lines of responsibility for the operation of the Neutron Radiography Facility (NRF) are shown in Figure 6.1. |R

The President and the Executive Vice-President of WHC have overall responsibility for the operation of WHC. They are advised in the safety aspects of this responsibility by the Safety & Environmental Advisory Council, a committee of management personnel having extensive knowledge and experience in various aspects of operational safety. The Council is appointed by and reports to the President of WHC. The duties and responsibilities of this Council are detailed in the FSAR, Section 9.

The President and Executive Vice-President of WHC delegate their operational and safety responsibilities for operations to the Manager of Engineering and Development Divisions, which are further delegated to the Manager of Advanced Reactor Development Division. Responsibilities in the field of reactor fuel fabrication including operation of the NRF TRIGA Reactor are delegated to the Manager, Core Components. The management responsibilities for the operation of the NRF are delegated to the Manager, Fuel Supply. He delegates the general management, operational and safety responsibilities to the Manager, Facility Operations and Administration. Direct supervision of the operation of the reactor is delegated to the Reactor Operations Supervisor (RCS). All of these written delegations of responsibility emphasize safety and carry adequate delegations of authority to support the assigned responsibilities. R

Figure 6.1 WHC Organization Pertinent to the Neutron Radiography Facility Operations

6.1.2 Facility Organization

- 1) The Manager, Facility Operations and Administration is assigned the general management responsibility for the safe operation of the Facility. He shall be a certified Senior Reactor Operator. |R
- 2) The staff reporting to the Manager, Facility Operations and Administration consists of the Reactor Operations Supervisor (ROS), Senior Reactor Operators (SRO), and Reactor Operators (RO). |R
- 3) The qualifications of this staff include a course of training in the operation of the reactor, including recovery from abnormal conditions and emergencies. The qualifications of the ROS and SRO include knowledge of management aspects, such as relationships with user and customer groups within WHC and reporting requirements.
- 4) The ROS may designate a SRO as his alternate. The designation shall be in writing and shall be approved by the Manager, Facility Operations and Administration. While acting as his alternate, the SRO shall have all the authority of the ROS. |R
- 5) The duties of the Reactor Operations staff shall include:
 - a) Either the ROS or his alternate shall be present in the control room or the reactor hall to perform or supervise the following operations:
 - . Any maintenance on a control rod or drive unit.
 - . Change of core configuration or loading and initial operation after any change of core configuration or loading.
 - . The first run of any new type or class of experiment.

b) An SRO shall be present in the control room or reactor hall to perform or supervise the following operations:

- . The initial startup of each operating day.
- . Any rod worth calibrations. |R
- . Any reactor or reactor equipment testing that requires withdrawal of control rods.
- . Precise reactor operation for calibration of instruments, and rod drop time determination. |R

c) Either the ROS or his alternate shall be on call at all times when the reactor is not shut down. "On call" shall mean that all of the following conditions can be met:

- . The Reactor Operator on duty can contact the ROS by telephone or by radio-pager within 5 minutes if an emergency should arise.
- . The ROS can contact the Reactor Operator by telephone within 10 minutes, if paged.
- . The ROS can proceed to the Facility to arrive within 30 minutes of the first call or page by the RO on duty.

d) The ROS is assigned the responsibility for review, approval, scheduling and supervision of experiments. The Manager, Facility Operations and Administration shall review and approve all new experiments. |R

e) The ROS initiates or approves test plans and special procedures and obtains approval of others as required.

- f) The ROS shall maintain an up-to-date file of "as-built" drawings showing the current facility status.
- g) Minimum staff requirement: During reactor operation, a certified RO or SRO shall be at the console. In addition, at least one other person shall be in the laboratory portion of the 308 Building complex while the reactor is operating, and the operator at the console shall have available a rapid means of communications with that person.

6.1.3 Supporting Organizations

Technical support for the facility operation is provided by Nondestructive Examination and Operational Health Physics. Members of support organizations, while performing service functions for the operation of the facility, shall be under the direct authority of the person supervising reactor operations.

- 1) Certified neutron radiographers are provided by Nondestructive Examination and/or Facility Operations and Administration. Their duties are to:
 - a) position the items to be radiographed other than irradiated materials, b) position the film cassette, c) give the reactor operator the desired exposure time, d) remove the items, other than irradiated materials, and the cassette after the exposure, and e) develop and interpret the films. Positioning of all irradiated materials is performed by TRIGA Reactor Operations personnel using approved operating procedures.
- 2) Maintenance of the Facility is performed, and assistance is given in calibration and testing of the Facility equipment, by laboratory maintenance personnel from 300 Area Support Services. Their duties are detailed in the Maintenance Manual.

- 3) Radiation monitoring services are provided by 300/400 Area Health Physics, an organization of Operational Health Physics. The duties of the Radiation Protection Technologists are to assure personnel radiation safety in accordance with the WHC Radiation Protection Procedures. | R
- 4) Facility engineering is provided by an engineer from 300 Area Support Services Maintenance Engineering Service Group. | R

6.2 AUDIT AND REVIEW

WHC has established scheduled audits and reviews of facility operations in compliance with DOE Orders 5480.6 and 5482.1B. These audits and reviews provide assurance that facility procedures and controls are adequate for safe facility operation and that operations are performed in accordance with these procedures and controls. The organizations implementing the audits and reviews are independent of the operating organization to the Executive Vice-President. The organizations performing this function shown in Figure 6.1, and their functions are briefly described below. | R

6.2.1 Audit and Review Organizations

1) Reactor Safety

300/400 Facilities Nuclear Safety will conduct periodic audits of the facility operation for compliance with internal controls, procedures and Technical Specifications, and an annual appraisal of the effectiveness of these administrative controls. Audits for criticality safety will also be conducted. The duties and responsibilities of 300/400 Facilities Nuclear Safety are detailed in the FSAR, Section 9. | R

On a routine basis, the following items shall be submitted to 300/400 Facilities Nuclear Safety for review: | R

- . Proposed tests and procedures.

- . Proposed changes to procedures, equipment or systems having safety significance.
- . Experiment proposals.
- . Proposed changes to the Technical Specifications.
- . Reports of unusual performance of equipment.
- . Reports of violation of DOE regulations, orders, Technical Specifications or internal procedures and controls.
- . Reports of Unusual Occurrences, Critiques, Event Fact Sheets, and incidents.
- . Proposed changes to the FSAR and supplements.

2) Operational Health Physics

Operational Health Physics will review all proposed new facility operations to evaluate the potential radiation hazards.

3) Radiological Safety and Environmental Protection

Radiological Assessment, Packaging & Shipping will perform periodic audits of the facility operations to evaluate conformance to WHC requirements for protection of employees. 300/400 Areas Environmental Protection will perform periodic surveillances to evaluate protection of the environment.

4) Industrial Safety and Fire Protection

Industrial Safety and Fire Protection will conduct periodic audits of the facility and its operations to assure the maintenance of a high standard of industrial safety.

5) Quality Assurance

Quality Assurance will prepare and maintain the QA program plan for the Neutron Radiography Facility and perform audits, reviews and inspections as required by that plan.

6) Safety and Environmental Advisory Council

The Safety & Environmental Advisory Council is a management committee responsible for review of WHC operational safety. The Council reviews nuclear and radiological design criteria for new facilities and significant changes to existing facilities, Safety Analysis Reports, Technical Specifications and changes in operating mode which may increase the probability or consequence of an accident. Council approval will be required prior to implementation of any of the above or changes thereto.

7) Other

Internal criticality safety audits and safety and housekeeping audits will be performed periodically by a 308 Building Laboratory certified Fissionable Material Handler.

Reports of each of the above formal audits and reviews, including recommendations, will be submitted to the appropriate level of management by the auditing group in accordance with the requirements of the individual audit or review programs.

6.3 OPERATING PROCEDURES

The Neutron Radiography Facility including the TRIGA reactor shall be operated in accordance with approved, written procedures. Procedures shall be written for all normal operations, maintenance, anticipated emergency conditions and test or special operations affecting the facility. The specific operations which will be covered by standard procedures include, but may not be limited to:

- . Reactor startup
- . Normal reactor operation
- . Reactor shutdown
- . Refueling the reactor
- . Maintenance

- . Normal facility equipment operation (including precautions)
- . Alarm response
- . Fuel element leak search
- . Facility emergencies response
- . Radiation control (Radiation Work Procedures)
- . Neutron Radiography operations
- . Experiments
- . Facility Modifications

6.4 RECORDS AND LOGS

Facility logs and records will be maintained to provide a complete and accurate history of the TRIGA reactor and its associated equipment. Specific records to be maintained, and the minimum period they will be retained are:

- . Record of normal reactor operations - 5 years
- . Startup and shutdown checkoffs - 5 years
- . Radiation and contamination survey record - 5 years
- . Fuel element histories - life of the facility
- . Reactor power record - 5 years
- . Personnel exposure records - indefinitely
- . Reports of unusual occurrences - life of the facility
- . Records and safety evaluations of procedure changes or equipment alterations - life of the facility
- . Record of significant maintenance tests and inspection - life of the facility
- . Record of material radiography exposures - life of the facility
- . Records of operator training and qualification - life of the facility
- . Facility plans and drawings - life of the facility
- . Record of radioactivity released to environment - 5 years
- . Audit and Appraisals Reports - life of the facility
- . Records of facility modifications - life of the facility
- . Records of material irradiations - life of the facility

6.5 ACTION TO BE TAKEN IN THE EVENT A SAFETY LIMIT IS EXCEEDED

If a safety limit is exceeded, the following actions will be taken:

- . The reactor will be shut down immediately, notify the ROS or his designated alternate.
- . The ROS, or his alternate will inform responsible line management and the Environment, Safety and Security Department. Environment, Safety and Security shall notify the U. S. Department of Energy (DOE).
- . The occurrence will be investigated, including analysis of the cause and extent of possible damage.
- . Corrective action will be taken as required, and actions will be taken to prevent or reduce the probability of recurrence.
- . Written reports will be submitted as required in Section 6.8.
- . Reactor Operation shall not be resumed until written authorization has been received from DOE.

6.6 ACTION TO BE TAKEN IN THE EVENT OF AN UNUSUAL OCCURRENCE

In the event of an unusual occurrence the following actions will be taken:

- . Call First Aid, Fire Protection, Patrol and the Environment, Safety and Security Department as necessary to cope with any emergency situation.
- . The Reactor Operations Supervisor or his alternate will be notified.
- . The Reactor Operations Supervisor or his alternate will determine if operations should be suspended immediately.

- . The Reactor Operations Supervisor or his alternate will inform responsible line management and Environment, Safety and Security Department. DOE and other organizations will be informed as dictated by the specific occurrence. The Operating Department Manager shall determine whether the occurrence is reportable to DOE and shall notify DOE if necessary.
- . Corrective action will be taken as required, and actions taken to prevent or reduce the probability of recurrence.
- . Written reports will be submitted as required in Section 6.8.

6.7 ACTION TO BE TAKEN IN THE EVENT OF AN ABNORMAL OCCURRENCE

In addition to the actions listed for unusual occurrences listed in Section 6.6 the following actions shall be taken.

- . The person in charge of the reactor will shut down the reactor if it is operating.
- . The reactor may be restarted only with 300/400 Area Facilities Nuclear Safety approval.

6.8 REPORTING REQUIREMENTS

In addition to the requirements of applicable DOE Manual Chapters, reports shall be made to DOE as follows:

6.8.1 An immediate report (by telephone) of:

- . Any accidental offsite release of radioactivity above permissible limits, whether or not the release resulted in property damage, personal injury or exposure.
- . Any violation of a safety limit.

6.8.2 An Event Fact Sheet will be submitted within 24 hours of:

- . Any event or unusual occurrence as defined in Section 1.2 or 1.3 of these Specifications.

6.8.3 A written report within 10 days of:

- . Any accidental offsite release of radioactivity above permissible limits, whether or not the release resulted in property damage, personal injury or exposure.
- . Any violation of a safety limit.
- . Any unusual occurrences as defined in Section 1.2 of these Specifications.
- . The results of a Critique as defined in Section 1.4 of these Specifications.

6.8.4 A written report within 30 days of:

- . Any significant variation of measured values from a corresponding predicted or previously measured value of safety-connected operating characteristics occurring during operation of the reactor.
- . Any significant change in the transient or accident analysis as described in the Final Safety Analysis Report.
- . Any significant changes in facility organization or personnel for which minimum qualifications are specified in the Final Safety Analysis Report.

6.8.5 A written report within 60 days:

- . After the initial criticality of the reactor upon receipt of a new facility operating authorization or an amendment authorizing an increase in maximum permissible reactor power level.
- . After installation of a new core or major portion thereof. The report shall describe the measured values of the operating parameters or characteristics of the reactor under the new conditions.

6.8.6 A routine written report within 60 days after completion of the first calendar year of facility operation and at the end of each 12-month period thereafter. The report shall be written by the operating organization and provide the following information (where reports providing the following information are submitted to comply with DOE Manual Chapters or other reporting requirements, duplicate reporting is not required):

- 1) A narrative summary of operating experience and of changes in the facility design, performance characteristics and operating procedures related to reactor safety occurring during the reporting period.
- 2) A tabulation showing the energy generated by the reactor and the number of hours the reactor was critical.
- 3) The number of emergency shutdowns and inadvertent scrams, including the reasons.
- 4) Discussion of the major maintenance operations (preventive and corrective) performed during the period, including the effect, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required.

- 5) A summary of the nature and amount of radioactive effluents released or discharged to the environs as measured at or prior to the point of the release or discharge from the facility.
- 6) A description of environmental surveys performed outside the facility.
- 7) A summary of radiation exposures received by facility personnel and visitors, including the dates and times of any significant exposures, and a summary of the results of radiation and contamination surveys performed within the facility.

6.9 CHANGES TO TECHNICAL SPECIFICATIONS

Changes to these Technical Specifications shall be in accordance with the following requirements:

- 1) Proposed changes shall be submitted by the operating organization to 300/400 Area Facilities Nuclear Safety for review and approval.
- 2) Following review and approval by 300/400 Area Facilities Nuclear Safety, the operating organization shall submit the proposed changes to the Safety & Environmental Advisory Council for review and approval.
- 3) Following review and approval by the Safety & Environmental Advisory Council, the proposed changes will be submitted by WHC Operating Management with the concurrence of 300/400 Area Facilities Nuclear Safety to DOE for review and approval.
- 4) Changes shall be approved by DOE prior to implementation.
- 5) The Manager, 300/400 Area Facilities Nuclear Safety notifies the operating organization of DOE approval.

- 6) The Reactor Operations Supervisor shall transmit the new specifications to the operating staff by verbal and written instructions. All logs, records or procedures affected by the revised specifications shall be updated or appropriately annotated by the Reactor Operations Supervisor prior to their use during facility operations.
- 7) The Manager, 300/400 Area Facilities Nuclear Safety may, at any time impose temporary limits on facility operations, so long as the limits are more restrictive than the Technical Specification limits in effect at that time. Such limits may be imposed while a change to the Technical Specifications is being processed or to allow for a temporary condition during which a more restrictive limit is desirable. The bases for such temporary limits shall be documented in an auditable form.

7.0 TECHNICAL SPECIFICATION BASES

The bases statements are brief summaries of information presented to indicate the source or reason for numerical limits in the Technical Specifications. The following bases are numbered the same (with the prefix A added) as the section of the Technical Specification which gives the limits.

A2. SAFETY LIMIT AND LIMITING SAFETY SYSTEM SETTING

|R

A2.1 SAFETY LIMIT

The safety limit which restricts the fuel temperature to 550°C or less ensures the integrity of the fuel element cladding. This limit ensures cladding integrity by limiting temperature-induced cladding stress to an insignificant level (see FSAR, Section 5). The 550°C temperature is the point at which fuel phase transformation occurs in the aluminum-clad fuel which has a H/Zr ratio less than 1.45 resulting in swelling of the fuel and stressing of the cladding. The stainless steel clad fuel is not subject to fuel phase changes since it has a H/Zr ratio greater than 1.45.

A second possible source of fuel cladding stress is the result of dissociation of the hydrogen in the fuel. The analysis of this problem in the FSAR, Section 5, indicates that there is no significant stress due to the dissociation at 550°C. The aluminum and stainless steel clad fuel safety limits due to hydrogen pressure are 900°C and 1150°C, respectively.

A2.2 LIMITING SAFETY SYSTEM SETTING

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A limiting safety system setting (LSSS) of 285 kW gives assurance that the safety limit will not be exceeded. The maximum calculated power level of the TRIGA reactor with a reactivity of \$3.00 is 625 kW with a fuel temperature of 320°C for the aluminum-clad fuel and 350°C for the stainless steel-clad fuel. The maximum LSSS of 285 kW will limit the fuel temperature to less than 350°C, giving assurance that the safety limit will not be exceeded even assuming maximum instrument error.

A3.1 REACTIVITY LIMITATIONS

A3.1.1 Minimum Shutdown Margin

The \$1.00 ($\sim 0.72\%$ $\Delta k/k$) minimum shutdown margin requirement gives assurance that the reactor can be made adequately subcritical even in the event that the control rod with the greatest worth becomes inoperable. Two or more independent (unlikely) control rod failures would be required before the reactor could not be made subcritical. Shutdown margin must also consider reactivity effects both normal and during failure from experiments which are capable of causing positive reactivity insertions. All precautions should be taken to restrict or limit these effects in accordance with the technical specifications limits.

A3.1.2 Reactivity Insertion Rate

The 17 cents per second ($\sim 0.12\%$ $\Delta k/k$) reactivity insertion rate limit gives assurance that the reactor power will be adjusted in a slow and controlled manner. This limit is several orders of magnitude less than the step insertion of \$3.00 analyzed in Section 10 of the FSAR, which resulted in a safe maximum fuel temperature of 510°C .

A3.1.3 Core Reactivity

The core excess reactivity limit precludes the release of radionuclides due to a fuel failure caused by loss of reactor control. The FSAR analyses of the maximum achievable steady state power (Section 5) and a step insertion (Section 10) of the maximum allowable core excess reactivity indicate a maximum fuel temperature of 510°C , which is 40°C less than the safety limit.

A3.2 CONTROL AND SAFETY SYSTEMS

A3.2.1 Scram Time

A short scram time is desirable to assure that the reactor can be operated in a controlled manner. The limit of 1.5 seconds gives assurance that the scram function is operating properly; however, a short scram time is not essential for safe reactor operation due to the self-regulating nature of the TRIGA fuel.

A3.2.2 Measuring Channels

Operation of the measuring channels is essential to maintain reactor operation within all prescribed limits. The measuring channels operation is required for processing reactor power signals from the core instrumentation so that the safety channels function as designed.

A3.2.3 Safety Channels

The safety channels provide alarms or scrams which give assurance that the reactor is operated in a safe and controlled manner.

The linear safety channels initiate an automatic scram in the event the reactor power level reaches the LSSS, which gives assurance of fuel cladding integrity.

The period channel alarms when the power is rising too fast (a period of less than 3 seconds) to assure that the operator has full control of the reactor power level. Periods greater than 3 seconds assure a slow, controlled increase in the power level.

The pool water temperature alarm assures that fuel element cooling is adequate to insure cladding integrity. The departure from nucleate boiling (DNB) ratio for a power of 250 kW and a pool temperature of 60°C is approximately 5.2. The DNB ratio of 5.2 is an indication that the heat flux is

less than 20% of that required for film boiling. Damage to nuclear instrumentation occurs above 70°C. Damage to the water treatment resin may occur above 45°C.

The fission chamber high voltage monitor alarms if the voltage level drops to 90% of normal. The accuracy of measuring channels is maintained at voltages above 70% of normal.

A3.3 RADIATION MONITORING SYSTEMS

A3.3.1 Routine Radiation Monitoring Systems

The radiation monitoring systems warn personnel of above-normal radiation and airborne particulate activity levels in the reactor hall. The alarm levels will be set consistent with the practice of ensuring radiation exposure is kept as low as reasonably achievable (ALARA) and will give assurance that operator and radiography personnel exposure is less than the yearly allowable limits set by DOE Order 5480.1B, Chapter 11.

The stack samples yield data for historical radioactivity content of the reactor hall air effluent. In addition in the event of an accidental release they can provide release data.

The air monitors provide prompt warning of high concentrations. These air monitors are also supplemented by routine samples and surveys to determine the radiological status of the facility.

The Area Radiation Monitor normal alarm setting is 10 mR/hr. The Air Particulate Monitor (alpha) alarm is normally set at or below 40 MPC hours. The Air Particulate Monitor (beta-gamma) alarm is normally set at or below 4 MPC hours.

Operation with airborne concentrations within the TRIGA area affords no threat to the environment. This slightly contaminated air must pass through HEPA filters which would remove virtually all of the radioactive particles before release to the outside atmosphere.

A3.3.2 Radiation Monitoring Systems for Neutron Radiography of Irradiated Fuel

The high-range, gamma-sensitive radiation monitor located within the concrete shielded neutron radiography area alarm point will be set as low as reasonable but shall not exceed 3 R/hr. The purpose of the monitor is to provide an interlock which prevents opening of the rolling concrete door or movement of the cask cart when irradiated fuel is in the neutron radiography facility. The 3 R/hr limit is the practical setting for a radiation instrument having a log response with an upper range of 10^4 R/hr. The 3 R/hr limit is within the range of portable radiation survey instrumentation that is used when the door is opened and therefore is an acceptable limit.

A3.4 ENGINEERED SAFETY FEATURE

The ventilation system gives assurance that: 1) airborne radioactive particles are filtered out of the air before being exhausted to the environment; and 2) no unfiltered air leaks out of the reactor hall.

Two sets of ventilation equipment and two sources of power will minimize the possibility of a ventilation system failure. Each set of equipment is capable of maintaining a negative pressure in the reactor hall and filtering eight air changes per hour before exhausting the air to the environment. A roughing filter and two HEPA filters (minimum efficiency 99.95% each) will minimize the amount of airborne particulates exhausted to the environment.

Pressure instruments will monitor air filters, exhaust fans and room air pressure to ensure that the HVAC system is operating properly. Automatic alarms and switching to the secondary fans will occur if negative pressure is lost in the reactor hall.

A3.5 AUXILIARY SAFETY FEATURES

The auxiliary safety features provide controls which assure safe facility operation. The locks and interlocks assure that conditions are met which could degrade safety if not met.

The magnet power key lock gives assurance that only authorized (certified) personnel can start up the reactor.

The control rod pushbutton interlock prevents withdrawing more than one control rod at the same time to exceed the reactivity insertion limit (3.1.2). See A3.1.2 for the bases.

The shielding door scram interlock gives assurance that if the door is not fully closed the reactor will be shutdown so that no high radiation levels from the reactor will be present around the opening between the door and the rest of the shielding. Another interlock also prevents movement of the cask cart when the shield door is open. In addition, when a high radiation exists within the shielded enclosure as during the neutron radiography of irradiated fuel, a high-range, gamma-sensitive radiation monitor inside the enclosure in the alarm position prevents the door from being opened. Similarly, the interlock associated with the radiation monitor removes power from the cask cart to prevent its movement while irradiated components are present in the beam stop area, preventing exposure to operating personnel from an unshielded component.

The reactor pool level monitor warns personnel of high or low pool level. The high pool level alarm assures that personnel are aware of possible flooding from the reactor pool. The low level alarm is an indication that shielding by the water has been reduced and above-normal radiation levels may be present.

The "rod withdrawal prohibit" interlock prevents control rod withdrawal unless there is a reactor power (neutron flux) indication. This interlock

prevents a possible uncontrolled condition where the reactor could be put on a short period while the neutron flux is below the instrumentation threshold.

The manual scram bar allows the operator to quickly shut down the reactor due to any off-standard indication.

Loss of console power de-energizes all control rod magnets to assure that the reactor fails in a safe condition.

The remote scram switch provides the capability to shut down the reactor from a remote location in the event the reactor hall is inaccessible.

A3.6 REACTOR COOLANT

Experience has shown that similar purification equipment in use with other TRIGA reactors can easily maintain coolant conductivity levels of less than five micromhos per centimeter, and that no visible corrosion of fuel clad or other components will occur if the four-week average conductivity of the water does not exceed that value.

A3.7 LIMITATION ON EXPERIMENTS

Conduct of experiments within the limits of the technical specification requirements for experiments and by reference to further administrative control requirements provides a minimum of necessary steps to take to prevent an experiment from causing damage to reactor components and possible subsequent, release of radioactivity, or exposure of personnel or public to radiation by accident.

The basis for the 25 cent limit on experiments is detailed in Safety Analysis Report Supplement No. 1. If uncontrolled this reactivity would result in a maximum power level increase of 42 kW and a minimum reactor period of 25 seconds. The limit of 5 cents on pneumatic transfer, experiments with

rotating parts or other oscillatory reactivity insertion mechanisms is based upon a minimum positive period of 230 seconds and a maximum power level increase of 9 kW. A miscalculation of the reactivity worth of these experiments by a significant amount would not lead to reactor damage, significant personnel exposure or exceed the safety limit of 550°C.

Neutron radiography of irradiated fuel is limited by the radiation and heat rejection capabilities of the transfer cask and shielded enclosure over the reactor. These limits have been established at 5×10^4 curies of total fission product inventory and/or 120 Watts of heat generation, whichever is smaller.

The 5×10^4 curies of total fission product result in a radiation exposure rate of 6 mR/hr at the surface of the concrete shield beam stop and less than 100 mR/hr at the surface of the transfer cask. The 120 Watts of heat generation results in a maximum fuel pin temperature of 360°F, well within the fuel cladding limit of 1500°F.

Similarly, the surface dose rate at the centerline of the shipping cask shall not exceed 100 mR/hr. This limit provides assurance that irradiated components accepted for neutron radiography will not create excessive exposure rates to operating personnel while being transported in the transfer casks or being neutron radiographed.

Irradiated material accepted for neutron radiography shall be contained in a sealed metal container. This container must satisfactorily pass a standard helium leak test prior to use in the neutron radiography facility. This container provides a barrier for added assurance that gaseous fission products or particulate fuel pin contamination will not contaminate the neutron radiography facility if, for some reason, the primary containment barrier should fail.

A4.0 SURVEILLANCE REQUIREMENTS

A4.2.1 Linear Safety Channel Calibration

The annual calibration of the flux measuring safety channels gives assurance that the accuracy is adequate to ensure that the safety limits are not exceeded. The annual calibration period is the standard time between calibrations established by experience from over 50 reactor years of TRIGA operation. A channel test prior to each operating period gives assurance that the safety channels and trip settings are operating properly. |R

A4.3.1 Reactivity Surveillance

The core excess reactivity limit precludes the release of radionuclides due to a fuel failure caused by loss of reactor control. The FSAR analyses, of the maximum achievable steady state power (Section 5) and a step insertion (Section 10) of the maximum allowable core excess reactivity, result in a maximum fuel temperature (510°C) less than the safety limit of 550°C.

A4.3.2 Control and Safety System Surveillance

Surveillance of the control and safety system gives assurance that the reactor control and monitoring system operates as designed. The surveillance consists of both operational tests and calibrations. The surveillance period was established by considering the experience from over 50 reactor years of TRIGA operating using the same type of instrumentation. |R

A4.3.3 Radiation Monitoring System Surveillance

The radiation monitoring system surveillance consists of daily observation source tests, and calibrations which gives assurance that the systems operate as designed. The surveillance period was established by considering the instruments and experience at Hanford.

A4.3.4 Engineered Safety Feature Surveillance

Surveillance of the HVAC system operation gives assurance that the system provides pressure control as designed. It also assures that the alarms will function to alert operations personnel in the event of a system failure. Periodic testing of the HEPA filters gives assurance that the filters will serve their design function of preventing release of radioactive particulate material to the environment.

A4.3.5 Auxiliary Safety Feature Surveillance

Surveillance of auxiliary safety features consist of semiannual tests which assure that they perform as designed. The design specified reliable instrumentation, which gives assurance of reliable performance between tests.

A4.3.6 Coolant Conductivity Surveillance

Daily measurement and recording of coolant conductivity provides assurance that any changes in coolant conductivity will be promptly noted and investigated. Weekly monitoring during periods when the reactor is not operated provides sufficient information for the determination of long-term average conductivity.

A4.3.7 Experiment Surveillance

Requirement for every experiment to be reviewed prior to an operation provides a control method to ensure operation within authorized bounds and safety limits.

A4.4 MATERIAL AND EQUIPMENT CONTROLS

A4.4.1 Fissile Material Limitations

The storage of TRIGA fuel within the reactor in standard TRIGA fuel storage racks limit the k_{eff} of the stored fuel to less than 0.8. Driver and test

fuel pins associated with the neutron radiography may be used and stored within the NRF in batches not exceeding 45% of the minimum critical mass number. This limit prevents criticality from resulting should a double batch occur. WHC fissile material limitations are specified by the Criticality Safety Procedures WHAN-M-6.

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