TECHNICAL SPECIFICATIONS

FOR THE

PURDUE UNIVERSITY REACTOR, PUR-1

DOCKET NUMBER 50-182

FACILITY LICENSE NO. R-87

PREPARED BY:

C.H. Townsend

West Lafayette, IN 47907

October 2018

3. The reactor key shall be out of the key switch and under control of a licensed operator or locked in an approved location

4. No work shall be in progress involving core fuel, core structure, installed control rods, or control rod drives unless they are physically decoupled from the control rods

5. No experiments shall be moved or serviced that have, on movement, a reactivity worth exceeding the maximum value allowed for a single experiment

6. The control console is placed in a permissions status where the controls are not operable.

1.33 Reactor Shutdown - That subcritical condition of the reactor where the negative reactivity, with or without experiments in place, is equal to or greater than the shutdown margin.

1.34 Readily Available on Call - Readily available on call shall mean the licensed senior operator shall be within a reasonable driving time (1/2 hour) or less than 15 miles from the reactor building, and the operator on duty is currently informed, and can rapidly contact the senior reactor operator by phone.

1.35 Reference core condition - The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<0.003 $\Delta k/k$).

1.36 Removable Experiment - A removable experiment is any experiment, experimental facility, or component of an experiment, other than a permanently attached appurtenance to the reactor system, which can reasonably be anticipated to be moved one or more times during the life of the reactor.

1.37 Rod, control - A control rod is a device fabricated from neutron-absorbing material that is used to establish neutron flux changes and to compensate for routine reactivity losses. A control rod can be coupled to its drive unit allowing it to perform a safety function when the coupling is disengaged.

1.38 Rod, regulating - The regulating rod is a low worth control rod used primarily to maintain an intended power level that need not have scram capability. Its position may be varied manually or by a servo-controller.

1.39 Rod, Shim-Safety - The control rods used in PUR-1 as described in the definition for Rod, control.

1.40 Secured Experiment - Any experiment, experimental facility, or component of an experiment is deemed to be secured, or in a secured position, if it 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.

increased relative to transients previously reviewed, and assures reactor change rate of minimal magnitude such that the reactor may be shutdown without exceeding the safety limit.

Specification 3.1.e limits the reactivity worth of secured experiments to values of reactivity which, if introduced as a positive step change, are calculated not to cause fuel melting. This specification also limits the reactivity worth of unsecured and movable experiments to values of reactivity which, if introduced as a positive step change, would not cause the violation of a safety limit. The manipulation of experiments worth up to 0.003 $\Delta k/k$ will result in reactor change rates smaller than 12 percent per second. This change rate is sufficient to initiate a setback but not a scram. These change rates can be readily compensated for by the action of the safety system without exceeding any safety limits.

A limitation of 0.003 $\Delta k/k$ for the total reactivity worth of all movable and unsecured experiments provides assurance that a common failure affecting all such experiments cannot result in an accident of greater consequences than the maximum credible accident analyzed in the HSR.

Specification 3.1.g along with 3.1.a assures that the reactor is capable of being shut down in the event of a positive reactivity insertion caused by the flooding of an experiment.

3.2 **Reactor Safety System**

Applicability - This specification applies to the reactor safety system and other safety-related instrumentation.

Objective - The objective is to specify the lowest acceptable level of performance or the minimum number of acceptable components for the reactor safety system and other safety related instrumentation.

Specification – The two shim-safeties shall not be moved more than 6 cm from the fully inserted position unless the following conditions are met:

a. The reactor safety channels and safety-related instrumentation shall be operable in accordance with Tables I and II including the minimum number of channels and the indicated maximum or minimum set points.

b. Both shim-safety rods and the regulating rod shall be operable.

c. The time from the initiation of a scram condition in the scram circuit until the shim-safety rod reaches the rod lower limit switch shall not exceed one second.

d. The pool top radiation monitor shall be capable of indicating an alarm to off-site reactor staff when a high limit is reached and the reactor has been secured. The alarm may be out of service up to thirty days. Loss of functionality beyond thirty days shall require a visual pool level inspection in intervals of 24 hours, not to exceed 30 hours.

e. Building alternating current power must be supplied to the reactor Instrumentation and Control during normal operation. Loss of power shall require immediate shutdown by the operator to be completed within an interval of 15 minutes.

TABLE I. SAFETY CHANNELS REQUIRED FOR OPERATION

Channel	Minimum Number Required	Setpoint (c)(d)	Function
Log count rate and change rate	1[(a)]	2 cps or greater 8 %/s or less 15 %/s or less 6 %/s sec. or less	2 cps rod withdrawal interlock Setback Scram Rod withdrawal interlock
Log N and change rate	1[(b)]	8 %/s or less 15 %/s or less 6 %/s or less 12kW, 120% Operating power level, or less	Setback Scram Rod withdrawal interlock Scram
Linear	1	0% Selected Range, or greater 110% Selected Range or less 120% Selected Range or less	Setback Setback Scram
Safety	1[(b)]	11 kW, 110% Operating power level, or less 12 kW, 120% Operating power level, or less	Setback Scram
Manual Scram (console) (hallway)	 1 1		 Scram Scram

(a) Not required after Log N-Change Rate channel comes on scale.
(b) Required to be operable but not on scale at startup.
(c) All percentage based setpoints shall be tripped when the measured value is greater than or equal to the specified value. Counts per second (cps) setpoints are at values less than or equal to the specified value. Exception: Trip point for 0% shall happen as the value goes from the positive to negative value.
(d) Setbacks shall be set such that they will be initiated prior to a Scram

TABLE II. SAFETY-RELATED CHANNELS (AREA RADIATION MONITORS)

Channel	Minimum Number Required(e)	Setpoint	Function
Pool top monitor	1	50 mR/hr, 2x full power background, or less than either	Scram
Water process	1	7 ½ mR/hr or less	Scram
Console Monitor	1	7 ½ mR/hr or less	Scram
Continuous air sampler	1	Stated on sampler	Air sampling

(e) For periods of one week or for the duration of a reactor run, a radiation monitor may be replaced by a gamma sensitive instrument which has its own alarm and is observable by the reactor operator.

Bases - The neutron flux level scrams provide redundant automatic protective action to prevent exceeding the safety limit on reactor power, and the change rate scram conservatively limits the rate of rise of the reactor power to values which are manually controllable without reaching excessive power levels or fuel temperatures.

The rod withdrawal interlock on the Log Count Rate and Change Rate Channel assures that the operator has a measuring channel operating and indicating neutron flux levels during the approach to criticality.

The manual scram button and the "reactor on" key switch provide two methods for the reactor operator to manually shut down the reactor if an unsafe or abnormal condition should occur and the automatic reactor protection does not function.

The use of the area radiation monitors (Table II) will assure that areas of the Purdue University Reactor (PUR-1) facility in which a potential high radiation area exists are monitored. These fixed monitors initiate a scram whenever the preset alarm point is exceeded to avoid high radiation conditions as well as alert facility personnel when the reactor has been secured and an elevated radiation level exists. Use of more conservative values are permitted on the setpoint to allow greater safety margin.

Specifications 3.2.b and 3.2.c assure that the safety system response will be consistent with the assumptions used in evaluating the reactor's capability to withstand the maximum credible accident.

In specification 3.2.c. the rod lower limit switches are positioned to measure, as close as possible, the fully inserted position.

Shielding from radiation is one of the primary reasons for the pool's level. An offsite alarm from the pool top radiation monitor alerts facility staff of a rising radiation level which must be mitigated or otherwise addressed and this is addressed in 3.2.d.

The Instrumentation and Control system is designed to be capable of performing a normal shutdown in the event of a loss of off-site power. The time period to complete this shutdown is up to 15 minutes as that is well within the rating of the UPS units with a maximum power loading. Loss of off-site power starts the power draw from the UPS units which therefore starts the 15 minute timeframe. In this even, classified as an unscheduled shutdown, an SRO must be present for the subsequent restart.

3.3 **Primary Coolant Conditions**

Applicability - This specification applies to the limiting conditions for reactor operation for the primary coolant.

Objective - The objective is to assure a compatible environment, adequate shielding, and a continuous coolant path for the reactor core.

Specification –

a. The primary coolant conductivity shall be maintained at a value less than 3 $\mu Siemens/cm$.

b. The primary coolant shall be maintained at least 13 feet above the core whenever the reactor is operating. The primary coolant shall be maintained at least 13 feet above the top of the core or at a level sufficient for the pool top radiation monitor to indicate less than 1 mRem/hour during non-operational periods.

c. The primary coolant (bulk pool volume) shall be maintained at or below $30\,°C$ while the reactor is operating.

d. The primary coolant radiation levels shall not exceed the levels for water in 10 CFR 20 Appendix B, Table 2.

Bases - Experience at the PUR-1 and other facilities has shown that the maintenance of primary coolant system water quality in the ranges specified in specification 3.3.a will minimize the amount and severity of corrosion of the aluminum components of the primary coolant system and the fuel element cladding.

The height of water in specification 3.3.b is enough to furnish adequate shielding as well as to guarantee a continuous coolant path.

Maintaining the primary coolant temperature in Specification 3.3.c will ensure the margin to the onset of nucleate boiling is maintained and analyses shown in the Safety Analysis Report remain valid.

Limiting the amount of radioactivity in the primary coolant minimizes the health risk to the public as well as to facility personnel.

3.4 **Confinement**

Applicability - This specification applies to the integrity of the reactor room.

Objective - The objective is to limit and control the release of airborne radioactive material from the reactor room.

Specification -

a. During reactor operation and when radioactive material is being handled with potential for airborne release, the following conditions shall be met:

Objective - The objective is to assure that the reactor safety system is operable as required by Specification 3.2

Specification -

a. A channel calibration of the reactor safety channels as described in Table I shall be performed as follows:

    1. An electronic calibration shall be performed annually, with no interval to exceed 15 months. The electronic calibration may be deferred with CORO approval during periods of reactor shutdown, but shall be performed prior to startup.

    2. A power calibration by foil activation shall be performed annually, with no interval to exceed 15 months. The power calibration may be deferred with CORO approval during periods of reactor shutdown, but shall be performed prior to startup.

b. A channel check on the radiation monitoring equipment shall be completed daily during periods when the reactor is in operation. Calibration of the Safety-Related Channels specified in Table II and hand held radiation survey instruments shall be performed annually, with no interval to exceed 15 months. Calibration may be deferred with CORO approval during periods of reactor shutdown, but shall be performed prior to startup.

c. Shim-safety rod drop times shall be measured annually, with no measurement's interval to exceed 15 months. These drop times shall also be measured prior to operation following maintenance which could affect the drop time or cause movement of the shim-safety rod control assembly. Drop times may be deferred with CORO approval during periods of reactor shutdown, but shall be performed prior to startup.

d. A channel check of each of the Scram capabilities specified in Table I shall be performed prior to each day's startup.

e. A channel check of the pool top radiation monitoring equipment's off-site alarm capability shall be done biannually, not to exceed 7 ½ months.

f. A simulated loss of off-site power shall be performed annually with no interval to exceed 15 months to verify the UPS units are capable of providing Instrumentation and Control power for at least 30 minutes.

g. Appropriate surveillance testing on any technical specification required system shall be conducted after replacement, repair, or modification before the system is considered operable and returned to service.

Bases - A test of the safety system channels prior to each startup will assure their operability, and annual calibration will detect any long-term drift that is not detected by normal intercomparison of channels. The channel check of the neutron flux level channel will assure that changes in core-to-detector geometry or operating conditions will not cause undetected changes in the response of the measuring channels.

Area monitors will give a clear indication when they are not operating correctly. In addition, the operator routinely records the readings of these monitors and will be aware of any reading which indicates loss of function.

The area monitoring system employed at the PUR-1 has exhibited very good stability over its lifetime, and annual calibration is considered adequate to correct long-term drift.

The measured drop times of the shim-safety rods have been consistent since the PUR-1 was built. An annual check of this parameter is considered adequate to detect operation with materially changed drop times. Binding or rubbing caused by rod misalignment could result from maintenance; therefore, drop times will be checked after such maintenance.

A daily check of the scram functionality ensures functionality of the system.

Annual checks of the UPS unit functionality will verify the UPS units are capable of providing power for at least 30 minutes. Changes in battery functionality are expected to be nominal over a period of several years. Therefore the frequency of an annual check is sufficient to verify operability of the controlled shutdown condition during loss of off-site power.

Testing replaced, repaired, or otherwise modified systems shall be done to ensure their adequate performance with the integral reactor safety and control system. Appropriate surveillance testing is taken to mean actions which provide reasonable assurance it will provide any required protective function and not inhibit other systems from performing their respective functionality.

4.3 **Primary Coolant System**

Applicability - This specification applies to the average surveillance schedules of the primary coolant system.

Objective - The objective is to assure high quality pool water, adequate shielding, and to detect the release of fission products from fuel elements.

Specification -

a. The conductivity of the primary coolant shall be recorded monthly, not to exceed six weeks. This cannot be deferred during reactor shutdown.

b. The primary coolant shall be sampled monthly, not to exceed six weeks, and analyzed for gross alpha and beta activity. This cannot be deferred during reactor shutdown.

c. During reactor shutdown, the primary coolant level or radiation level shall be monitored monthly with an interval not to exceed six weeks. Primary coolant height shall be measured prior to reactor operation.

d. The Primary Coolant temperature shall be recorded in the log book at no interval to exceed four hours if any shim-safety or regulating rod is at a height greater than 6 cm.

Bases - Monthly surveillance of pool water quality provides assurance conductivity changes will be detected before significant corrosive damage could occur.

When the reactor pool water is at a height of 13 feet above the core, adequate shielding during operations is assured. Experience has shown that approximately 35-40 gallons of water will evaporate weekly and weekly water make-up is sufficient to maintain the reactor pool water height. Analysis has shown radiation levels to remain sufficiently low with excessive water loss during non-operational periods.

Analysis of the reactor water for gross alpha and beta activity assures against undetected leaking fuel assemblies.

4.4 **Confinement**

Applicability - This specification applies to the surveillance requirements for maintaining the integrity of the reactor room.

Objective - The objective is to assure that the integrity of the reactor room is maintained, by specifying average surveillance intervals.

Specification -

a. The negative pressure of the reactor room shall be recorded weekly.

b. Operation of the inlet and outlet dampers shall be checked semiannually, with no interval to exceed 7 1/2 months.

c. Operation of the air conditioner shall be checked semiannually, with no interval to exceed 7 1/2 months.

Bases - Specification a, b, and c check the integrity of the reactor room. Based upon past experience these intervals have been shown to be adequate for ensuring the operation of the systems affecting the integrity of the reactor room.

4.5 **Experiments**

Applicability - This specification applies to the surveillance of limitations on experiments.

Objective – To assure compliance with the provision of the utilization license, the Technical Specifications, and 10 CFR Parts 20 and 50.

Specification – No experiments shall be performed unless:

a. It is a tried experiment.

b. The experiment has been properly reviewed and approved according to Section 6 of the technical specifications.

   1. Proposed experiments shall be approved by the Committee on Reactor Operations

   2. Submitted proposed experiments shall provide a comprehensive list of steps to be performed, quantities to be measured, hazards to be considered, limiting initial conditions of the reactor, and required available personnel.

Bases - The basis for this specification is to ensure the safety of the reactor and associated components, personnel, and the public by verification of proper review and approval of experiments as specified in Section 6 of these technical specifications.

4.6 **Fuel Parameters**

Applicability - This specification applies to the surveillance requirements for fuel integrity.

Objective - The objective is to assure that the fuel clad remains unblemished and there has been no release of radioactivity to the reactor coolant or facility.

Specification - Representative fuel plates shall be inspected annually, with no interval to exceed 15 months through visual inspection of the assembly. Representative is set forth to mean at least one plate from the assembly expected to have the highest burn as well as a plate from one of the 12 remaining, non-control assemblies.

Bases - Specification 4.6 will ensure reactor fuel integrity is not compromised. The inspection period is set forth to verify the integrity of the fuel cladding thereby ensuring there are no unexpected releases of fission products exposing facility workers or members of the public. Inspection of an assembly from the highest power region (as outlined in the PUR-1 SAR) ensures those plates under the largest thermal stress are considered. Inspection of another assembly ensures that a single plate passing inspection does not provide a single false negative data point representing the entire core. Non-control assemblies are chosen to inhibit undue burden on the facility.

4.7 **Effluents**

Applicability - This specification applies to the surveillance requirements for radioactive effluents which may leave the facility through the confinement system.

Objective - The objective is to assure requirements set forth in 10 CFR 20.110(d) and 10 CFR 20.1301 are not exceeded and public safety is maintained.

Specification –

a. Dosimetry shall be placed at the following locations

    1. The location inside the reactor room which represents the hypothetical minimum distance a member of the public could reach to the reactor pool.

    2. At the exhaust location of the reactor facility which is representative of effluent release from the reactor facility.

b. Dosimetry shall be changed out according to the guidance of the Purdue Radiological Management on the same time period as facility personnel or semiannually, not to exceed 7 ½ months, whichever is lesser.

Bases - Specification 4.7 will ensure that the dose given to member of the public is measured to be below those set forth in 10 CFR 20.110(d) and 10 CFR 20.1301.