UNIVERSITY *of* MISSOURI

RESEARCH REACTOR CENTER

July 11, 2011

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

Reference: Docket 50-186
University of Missouri-Columbia Research Reactor
Amended Facility License R-103

On August 6, 2009 the University of Missouri-Columbia Research Reactor submitted a request to amend the Technical Specifications appended to Facility License R-103. Enclosed is our response to the U.S. Nuclear Regulatory Commission's most recent request for additional information regarding the proposed Amendment, dated July 1, 2011.

If you have any questions, please contact John L. Fruits, the facility Reactor Manager, at (573) 882-5319.

Sincerely,

Ralph A. Butler, P.E.
Director

RAB/djr

Enclosures

Christine M. Errante

CHRISTINE M. ERRANTE
Notary Public - Notary Seal
State of Missouri
Commissioned for Boone County
My Commission Expires: April 14, 2015
Commission Number: 11528381

A020
NRR

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RESEARCH REACTOR CENTER

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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
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REFERENCE: Docket 50-186
University of Missouri-Columbia Research Reactor
Amended Facility License R-103

SUBJECT: Written communication as specified by 10 CFR 50.4(b)(1) regarding the response to the "University of Missouri – Columbia – Request for Additional Information, Re: License Amendment, Center Test Hole (TAC No. ME1876)," dated July 1, 2011

By letter dated August 6, 2009, the University of Missouri-Columbia Research Reactor (MURR) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) to amend the Technical Specifications, which are appended to Facility License R-103, that would authorize the implementation of an engineered safety device that would prevent operation of the reactor unless the center test hole canister or strainer is inserted and latched onto the inner reactor pressure vessel. Approval of this Amendment would allow greater flexibility and capacity in the center test hole for the irradiation of high specific activity radioisotopes that are used for radiopharmaceutical research and cancer treatments.

By letter dated June 1, 2010, as part of the facility license renewal process, the NRC requested additional information and clarification regarding the proposed Amendment in the form of seven (7) questions. By letter dated August 31, 2010, the MURR responded to those questions.

By letter dated December 27, 2010, the NRC requested additional information and clarification regarding the proposed Amendment in the form of five (5) questions. By letter dated January 31, 2011, the MURR responded to those questions.

On July 1, 2011, the NRC requested additional information and clarification regarding the proposed Amendment in the form of four (4) questions. Those questions, and MURR's responses to those questions, are attached. If there are any questions regarding this response, please contact me at (573) 882-5319. I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

John L. Fruits
Reactor Manager

ENDORSEMENT:
Reviewed and Approved,

Ralph A. Butler, P.E.
Director

Christine M. Errante

CHRISTINE M. ERRANTE
Notary Public - Notary Seal
State of Missouri
Commissioned for Boone County
My Commission Expires: April 14, 2015
Commission Number: 11528381

1513 Research Park Drive Columbia, MO 65211 Phone: 573-882-4211 Fax: 573-882-6360 Web: www.murr.missouri.edu

Fighting Cancer with Tomorrow's Technology

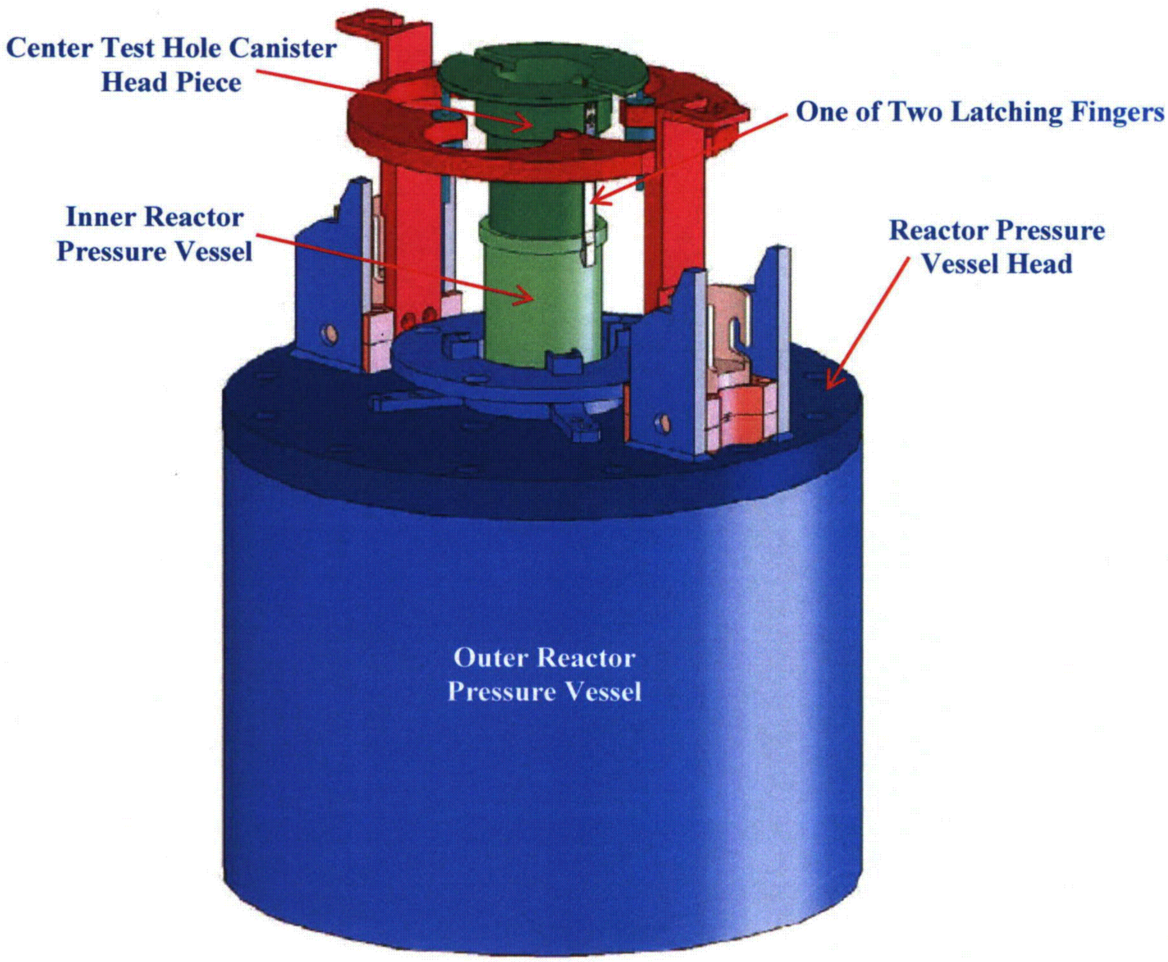
Attachments:
1. Operating Procedure EX-RO-105, "Reactor Irradiation Experiments"
2. Operating Procedure OP-RO-460, "Pool Coolant System - Two Pump Operation"
3. Operating Procedure OP-RO-461, "Pool Coolant System - One Pump Operation"
4. Administrative Procedure AP-RO-110, "Conduct of Operations"
5. Hazards Summary Report, Addendum 3, Section 3.5, "Analysis of Rapid Step Reactivity Insertions From Full Power in the MURR"
6. Compliance Check Procedure CP-36, "FIRST Scrams"
7. MURR Print No. 2712, "Flux-Trap Irradiations Reactivity Safety Trip," (3 Sheets)

xc: Reactor Advisory Committee
Reactor Safety Subcommittee
Dr. Robert Duncan, Vice Chancellor for Research
Mr. Craig Basset, U.S. NRC
Mr. Alexander Adams, U.S. NRC

1. *Failure of the latching mechanism for the Center Test Hole Canister could potentially result in a reactivity change of 0.011 delta k/k, which is an unanalyzed condition. Please provide information to the following questions:*

   a. *The center test hole canister is held in place by two Inconel metal latching fingers. In the event of the failure of one of the fingers, can a single finger hold the canister in place under normal operations conditions? Please provide details.*

The following is a description of the center test hole canister latching mechanism: When installed, the center test hole canister position is positively determined by a latching mechanism located at the top of the assembly. The latching mechanism consists of two Inconel metal fingers which secure the canister to the upper portion of the inner reactor pressure vessel. The fingers, which are attached to the upper section (head piece) of the canister by four (two per finger) countersunk, stainless steel screws, are positioned 180 degrees apart and are totally independent of one another. In order to provide additional vertical alignment and support, the canister base piece engages into a test hole slot which is welded to the reflector tank base flange. The center test hole canister latching mechanism and method of vertical alignment and support have not been modified or altered from its original design and no failures have occurred in the nearly 45 years of operation.



The condition of the latching fingers and stainless steel screws are closely inspected at least twice a week – first, when the canister is removed after the reactor is shutdown in order to retrieve the irradiated samples and second, before it is reinserted into the inner pressure vessel after new samples have been loaded into the canister.

In the extremely unlikely event of a failure of a single latching finger, the other finger can hold the canister in place under all operating conditions. One latching finger fully meets the intent of the definition of a Secured Experiment (MURR Technical Specification 1.24), which states, "A secured experiment is any experiment which is rigidly held in place by mechanical means with sufficient restraint to withstand any anticipated forces to which the experiment might be subjected."

Additionally, the overall length of the center test hole canister is 170.25 inches and it is positioned vertically within the 4.5-inch inside diameter inner reactor pressure vessel. The weight of the center test hole canister, gravity and a downward pool coolant flow rate of approximately 100 gallons per minute through the inner reactor pressure vessel collectively aid to provide additional downward force to maintain the canister in place under all operating conditions.

b. Is there a common failure that could effect both latching fingers? Please explain.

As described above, the center test hole canister latching fingers are positioned 180 degrees apart and are totally independent of one another. There is no common failure that could affect both latching fingers.

c. The application states that it is "highly unlikely" that an operator could inadvertently remove a fully loaded center test hole canister while at power. Please provide further justification and a description of controls to validate this conclusion, or provide justification and a description of controls to validate this conclusion, or provide an analysis that demonstrates that the reactor can be safely shutdown following a reactivity insertion from the removal of a fully loaded center test hole without violating the safety limit for power.

Administrative controls, the design of the center test hole canister and its latching mechanism and the proposed engineered safety device collectively serve to prevent an inadvertent removal or insertion of the center test hole canister while operating.

The following MURR Technical Specifications and administrative and operating procedures have been established regarding operation of the center test hole canister:

1. Technical Specification 3.6.e states, "Only movable experiments in the center test hole shall be removed or installed with the reactor operating. All other experiments in the center test hole shall be removed or installed only with the reactor shutdown. Secured experiments shall be rigidly held in place during reactor operation." Note: Center test hole movable experiments are restricted to the three smaller outer tubes of the six-tube center test hole canister and cannot exceed an absolute reactivity worth of 0.001 ΔK (Technical Specification 3.1.i).

2. Operating procedure EX-RO-105, "Reactor Irradiation Experiments" (Attachment 1), provides precautions and limitations and procedural guidance regarding operation of the center test hole canister (referred to as Flux Trap in the procedure). (See Section 4.0,

"Precautions and Limitations," Section 6.1, "Flux Trap - Secured Experiment, and Section 6.2, "Flux Trap - Movable Experiment.")

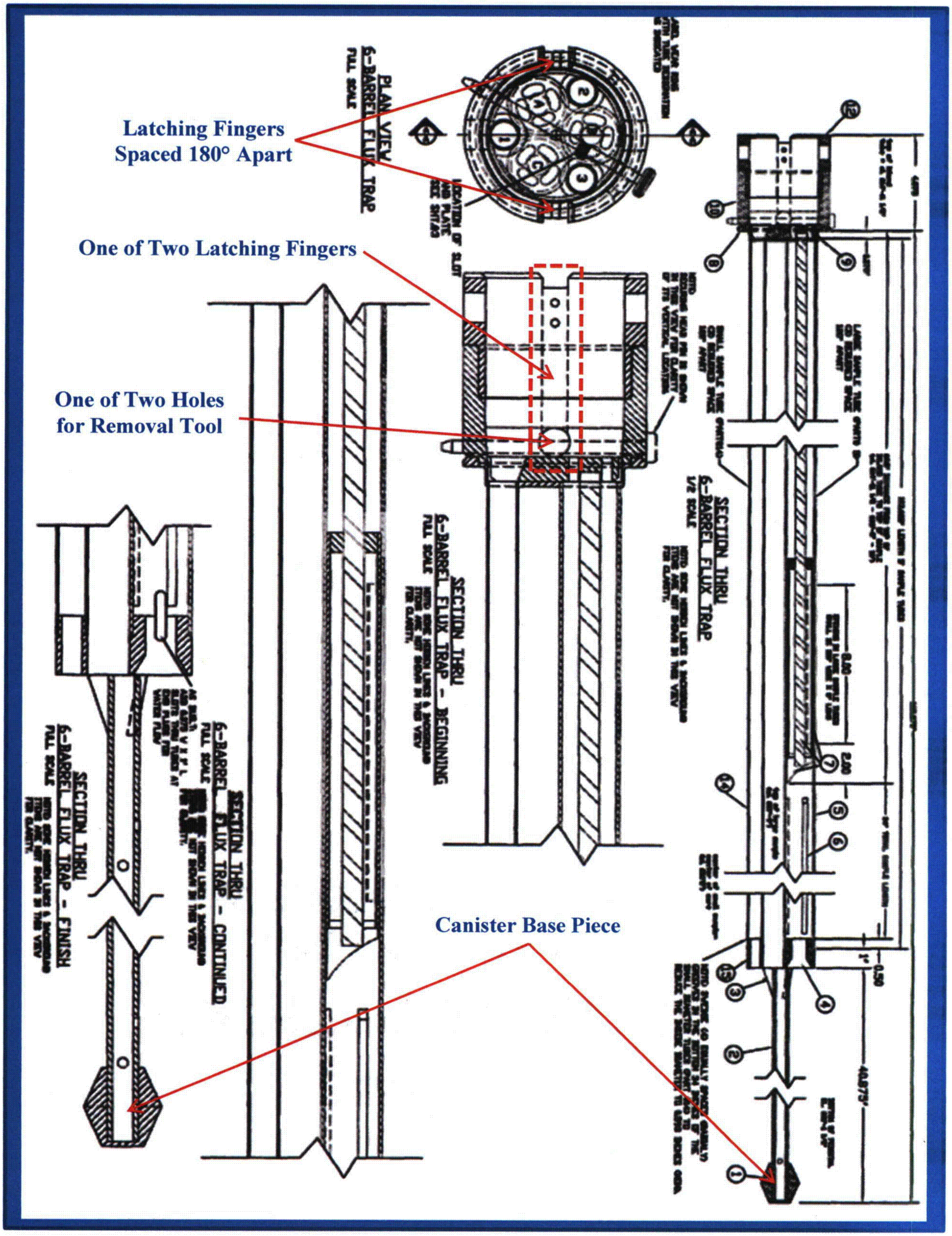
3. Operating procedures OP-RO-460, "Pool Coolant System - Two Pump Operation" (Attachment 2), and OP-RO-461, "Pool Coolant System - One Pump Operation" (Attachment 3), require that the center test hole canister (referred to as Flux Trap Sample Holder in the procedure) or the flux trap strainer must be installed when the reactor is operating. (See Section 4.0, "Prerequisites and Initial Conditions.")

4. Administrative procedure AP-RO-110, "Conduct of Operations" (Attachment 4), provides administrative requirements and instructions for the control room staff regarding experiments (See Section 6.9, "Experiments.")

The design of the center test hole canister latching mechanism is described in detail above. The latching mechanism, consisting of two separate, independent latching fingers, provides a redundant, positive latch of the center test hole canister to the inner reactor pressure vessel. Additionally, a special removal tool, with an overall length of approximately 20 feet, is required to unlatch and remove the center test hole canister from the inner pressure vessel. The head of the removal tool must be inserted into the center test hole canister wear ring in order to spread the latching fingers sufficiently to disengage the canister from the inner pressure vessel. Knowledge of the tool's operation, in addition to the skill that is required to operate the tool under nearly 17 feet of pool water, also helps to prevent the inadvertent removal of the center test hole canister while the reactor is operating.

Finally, the proposed Flux-Trap Irradiations Reactivity Safety Trip (FIRST) device would prevent the insertion of positive or negative reactivity from either the insertion or removal of the center test hole canister because (1) the reactor cannot be started up without the center test hole canister or strainer inserted and latched, and (2) removal of the center test hole canister while at power will cause a reactor scram. Because of the redundant FIRST device sensor switches, the reactor would immediately shutdown (less than 0.7 seconds for all four control blades to be inserted greater than 80% from their fully withdrawn positions – approximately 91% of the total blade worth is inserted at this level) if the center test hole canister moved outward less than ¼-inch (maximum travel of the sensor switches). It should also be noted that because of the positive void coefficient of the flux trap region (approximately $+0.865 \times 10^{-5}$ ΔK/K/cc void), removal of the center test hole canister would insert negative reactivity into the core.

Because of the FIRST device, insertion of positive or negative reactivity from either the insertion or removal of the center test hole canister while the reactor is operating is no longer considered a credible accident. The only credible accident is the failure of a single experiment in the center test hole. The worst case scenario is the sudden bursting of a sample can and the resulting discharge of its contents, with the possible damage to an adjacent sample can. Experiments in the center test hole will continue to be limited by Technical Specification 3.1.h such that the failure of any single experiment cannot introduce a reactivity change of greater than 0.006 ΔK. The transient analysis for 10-MW operation to determine the maximum safe step reactivity insertion is described in Section 3.5 of Addendum 3 to the Hazards Summary Report (Attachment 5). The analysis shows that the MURR can withstand a rapid step reactivity insertion of 0.007 ΔK with no core damage.

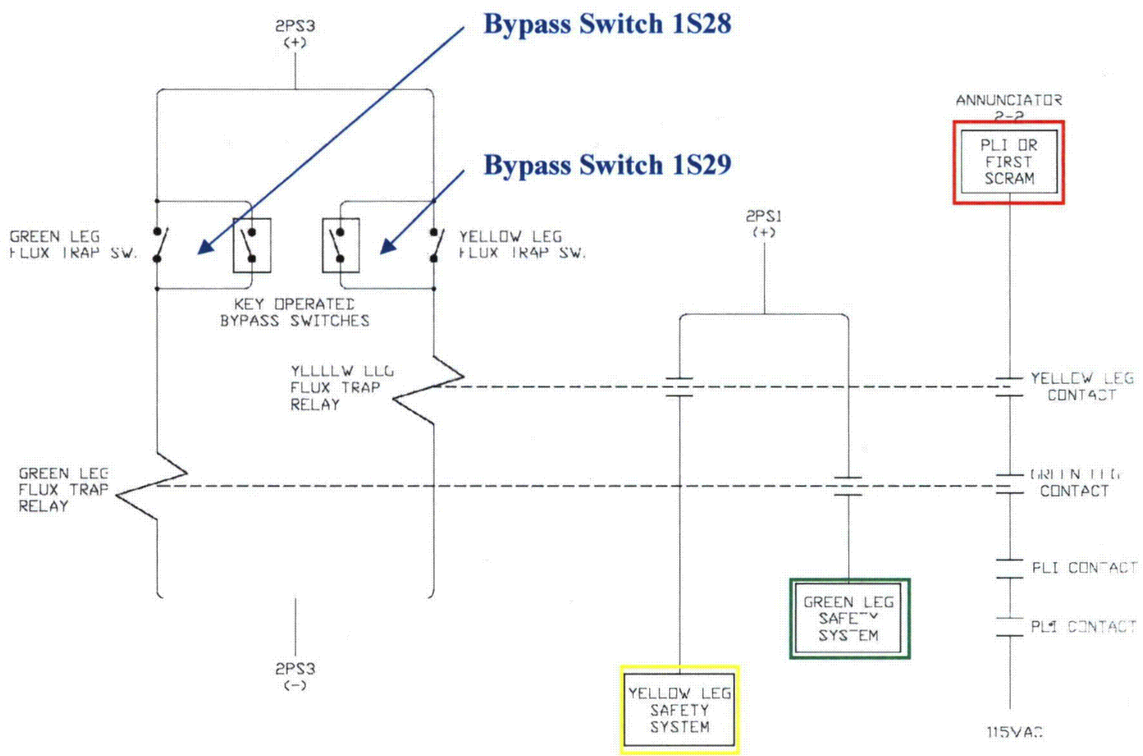


Six-Tube Center Test Hole Canister

2. *The bypass key circuit controlling the FIRST instrument channels provides a point of single failure. Please propose changes to address the single failure issue or provide justification as to why this condition is acceptable.*

While it was previously argued that the bypass key circuit controlling the FIRST instrument channels would not provide a point of single failure (Answer to RAI question No. 5, dated January 31, 2011), MURR is proposing the following change to further ensure that a single failure scenario cannot occur.

MURR will implement a second bypass key switch, identical to the original bypass key switch such that each of the two instrument channels will have an independent bypass switch. This second switch, designated 1S29, will be mounted on the reactor control console adjacent to the originally proposed switch, designated 1S28. Where the original 1S28 switch used two separate contact blocks, each switch will now use only one contact block.



Simplified Diagram of FIRST Wiring Scheme with Two Bypass Switches

The addition of a second bypass switch will not alter the way the instrument channels function electrically from what was originally proposed in the Amendment application. Additionally, the bypass switches will also provide the same following two functions as previously stated: (1) allow testing and troubleshooting capability, and (2) provide the use of both the proposed methodology and the current methodology for calculating the reactivity contribution of samples and the center test hole canister in the flux trap region. The bypass keys will be controlled administratively as previously described:

1. Administrative procedure AP-RO-110, "Conduct of Operations," requires permission from the Reactor Manager for operation of the reactor with any scram bypass switch in the "bypass" position.

2. Form FM-57, "Long Form Startup Checksheet," contains a step to ensure all bypass switch keys are removed prior to startup.

3. The key will not be present or accessible unless the Reactor Manager has granted permission for its use, as required by proposed TS 3.3 Footnote (6), and directed the channels to be placed in bypass.

Language referring to the FIRST Bypass Switch (1S28) and the FIRST Bypass key in documents such as the original Amendment application, subsequent responses to Requests for Additional Information, FIRST Modification Record and statements regarding Single Failure Criterion, Channel Independence, Indication of Bypasses and Access to Means for Bypassing should hereafter be considered to refer to the FIRST Bypass Switches (1S28 and 1S29) and the FIRST Bypass keys, respectively.

Statements in the above documents regarding the suitability and reliability of the proposed bypass switches should be considered to remain in place and unchanged, despite previous arguments regarding the use of a single switch.

A revised copy of Compliance Check Procedure CP-36, "FIRST Scrams," which will be used to test the operability of the FIRST system on a semiannual basis to ensure compliance with MURR Technical Specification 5.4.a., is attached (Attachment 6). Also included are the engineering prints (3 sheets) for the FIRST device (Attachment 7).

ATTACHMENT 1

EX-RO-105
Revision 14

MURR

OPERATING PROCEDURE

EX-RO-105

MASTER COPY
ISSUED DEC 0 1 2010

REACTOR IRRADIATION EXPERIMENTS

RESPONSIBLE GROUP: Reactor Operations

PROCEDURE OWNER: Ryan Lynn

APPROVED BY: Les P. Foyto _______________ Date 10-7-10

This procedure contains the following:

Pages	1	through	12
Attachments	1	through	7
Tables	None	through	
Figures	None	through	
Appendices	None	through	
Check-Off Lists	None	through	

TABLE OF CONTENTS

REACTOR IRRADIATION EXPERIMENTS

1.0 PURPOSE

1.1 Instructions for irradiating flux trap, graphite reflector and bulk pool samples.

2.0 SCOPE

2.1 Requirements, restrictions, and limitations applicable to the performance of *in-pool irradiations.*

3.0 DEFINITIONS

3.1 _AIMS_ - The computer based system used to track sample handling evolutions.

3.2 _In-Pool Irradiations_ - Samples that are irradiated in the:

- Flux Trap
- Graphite Reflector
- Bulk Pool

3.3 _Movable Experiment_ - A *movable experiment* is one that is designed with the intent that it may be moved into and out of the reactor while the reactor is operating. **(TS 1.11)**

3.4 _Secured Experiment_ - A *secured experiment* is any experiment that is rigidly held in place by mechanical means with sufficient restraint to withstand any anticipated forces to which the experiment might be subjected. **(TS 1.24)**

3.5 _Unsecured Experiment_ - An *unsecured experiment* is any experiment that is not secured as defined in TS 1.24, or the moving parts of *secured experiments* when they are in motion. **(TS 1.25)**

4.0 PRECAUTIONS AND LIMITATIONS

4.1 When the bridge area radiation monitor is in UPSCALE, closely monitor its indication. **(TS 3.4.a)**

4.2 With the exception of routine sample handling, no radioactive material will be moved in the pool that will cause a working area dose rate _greater than_ 100 mR/hr to any individual without direct monitoring by Reactor Health Physics (Reference 7.1). **(ALARA)**

4.0 PRECAUTIONS AND LIMITATIONS (CONT.)

4.3 Limitations as established by Technical Specification 3.1, "Reactivity," Sections 3.1.g through 3.1.k, and Technical Specification 3.6, "Experiments," Sections 3.6.b through 3.6.j, and 3.6.m.

4.4 *Unsecured experiments* that do not meet the criteria of *movable experiments*, which are to be irradiated in the center test hole, must be performed in accordance with Reactor Test Procedure RTP-26 (Reference 7.2).

4.4.1 Such *unsecured experiments* shall not have any wire, rope, or other lifting device attached in order to prevent their inadvertent removal.

4.4.2 Under no circumstances shall an *unsecured experiment* that does not meet the criteria of a *movable experiment* be installed or removed while the reactor is operating.

4.5 Unless specifically allowed by an approved Reactor Utilization Request (RUR), all samples to be irradiated in the reactor pool must be encapsulated in either a seal-welded or flooded aluminum can. A sample's primary encapsulation must be an aluminum can or a sealed quartz vial.

4.6 Samples must be weighted, if necessary, to ensure negative buoyancy, such that the samples sink.

4.7 When a Flux Trap sample holder is installed; it shall be securely latched in the center test hole. **(TS 1.24) (TS 3.6.e)**

4.8 Flux Trap sample holder large diameter tubes must be fully loaded with samples, water cans, or spacers.

4.9 The Flux Trap sample hold-down rod must be securely pinned in place. **(LER 82.11.17)**

4.10 Flux Trap sample cans must be seal-welded and leak checked.

4.11 Prior to loading a *movable experiment*, its reactivity worth must be summed with all other *movable experiments* located in the Small Flux Trap to verify that the total reactivity worth is within the limit established by the Small Flux Trap Tube Information Loading Sheet (Record 8.4).

4.12 Prior to removing a *movable experiment,* the reactivity worth of the *movable experiments* that are to remain in the Small Flux Trap must be summed to verify that the total reactivity worth will remain within the limit established by the Small Flux Trap Tube Information Loading Sheet (Record 8.4).

4.0 PRECAUTIONS AND LIMITATIONS (CONT.)

4.13 Removal of multiple sample holders from the reflector region during reactor operations lowers reflector differential pressure as read on PT-917. This could lead to a "Reflector HI-LO Diff Pressure Scram." Extra care must be taken, and PT-917 closely monitored to prevent reflector differential pressure from dropping below the scram setpoint when multiple sample holders are removed from the reflector while the reactor is operating.

5.0 PREREQUISITES AND INITIAL CONDITIONS

NOTE:	Approved RURs are maintained in the Document Control Center. RUR Summary Sheets are maintained in controlled manuals at the points of use.

5.1 *In-pool irradiations* must be performed in accordance with a Reactor Utilization Request (RUR) that is approved by the Reactor Manager.

NOTE:	For guidance in verifying the flux trap loading sheet, refer to Attachments 9.6 and 9.7.

5.2 The "Flux Trap Loading Sheet" (Record 8.3) must be approved by the Irradiations Section Leader (or designee).

2.5.1 The reactivity worth identified on the "Flux Trap Loading Sheet" (Record 8.3) and the accuracy of the loading sheet must be approved by the Reactor Manager (or an Assistant Reactor Manager) and have Lead Senior Reactor Operator (LSRO) concurrence.

5.3 The "Small Flux Trap Tube Information Loading Sheet" (Record 8.4) must be approved by the Irradiations Section Leader (or designee).

3.5.1 The reactivity worth identified on the "Small Flux Trap Tube Information Loading Sheet" (Record 8.4) must be approved by the Reactor Manager (or an Assistant Reactor Manager) and have LSRO concurrence.

6.0 PROCEDURE

NOTE: The Lead Senior Reactor Operator is responsible for the correct performance of all sample handling evolutions and their documentation.

NOTE: Sample run time is monitored using a dedicated computer system. The LSRO must ensure the computer accurately reflects and tracks the contents of the "Reflector Loading Sheet" (Record 8.1), "Run Sheet" (Record 8.2), "Gemstone Irradiation Sheet" (Record 8.5), and "Silicon Run Sheet" (Record 8.6).

NOTE: "Run Sheets" (Record 8.2) are kept in the control room as a record of the sample inventory and handling activities until the sample is released to Product and Service Operations (PSO).

6.1 REFLECTOR AND BULK POOL

NOTE: IF any problem is noted with an evolution in progress or previously performed, THEN STOP, place the evolution in a safe condition, and contact the LSRO for further guidance.

6.1.1 Both the Sample Handler and *AIMS* system operator shall be responsible for ensuring the evolution is completed properly and shall be in constant communication with one another.

NOTE: Sample evolutions must be performed within 2% of the setpoint. IF a sample is flipped early, THEN add the difference to the end of the run. Record early flips or pulls on the "Silicon Run Sheet" (Record 8.6).

When an *AIMS* "Sample On Delay" alert is received:

a) The Sample Handler(s) shall:

1) VERIFY the "Bridge Upscale Switch" is placed in the UPSCALE position.

6.0 PROCEDURE (CONT.)

CAUTION:	Care must be taken while handling samples in the reflector area to avoid hitting the control rod drives and offset mechanisms.

CAUTION:	Removal of multiple sample holders from the reflector region during reactor operations lowers reflector differential pressure as read on PT-917. This could lead to a "Reflector HI-LO Diff Pressure Scram." Extra care must be taken, and PT-917 closely monitored to prevent reflector differential pressure from dropping below the scram setpoint when multiple sample holders are removed from the reflector while the reactor is operating.

NOTE:	ENSURE the necessary protective gear is used to perform the evolution.

2) VERIFY the evolution to be performed by checking the *AIMS* computer and sample record sheets. IF loading a new sample, OR handling an in process sample, THEN perform the evolution identified on "Reflector Loading Sheet" (Record 8.1), "Run Sheet" (Record 8.2), "Gemstone Irradiation Sheet" (Record 8.5), or "Silicon Run Sheet" (Record 8.6).

3) VERIFY new sample identification number and position.

4) ENSURE in process samples are visually checked for identification number, position, and orientation as they are being removed from the sample holder. This information shall be communicated to the *AIMS* operator who will verify it is in accordance with the *AIMS* computer and the sample record sheets.

b) The *AIMS* operator shall:

1) VERIFY the *AIMS* computer is properly updated in accordance with the sample record sheets.

2) Alert the sample handler when the sample evolution is to be performed.

6.0 PROCEDURE (CONT.)

3) MAINTAIN communications with the sample handler and VERIFY actions are in accordance with the *AIMS* computer and the appropriate sample record sheets.

4) Make any necessary changes to the *AIMS* computer and sample record sheets.

5) Alert the sample handler of **any** discrepancies.

6.1.2 Upon completion of the evolution the sample handler shall:

a) INSPECT all sample positions, reach rods, cables, and rotators to ensure proper operation.

b) Perform a brief inspection of the bridge area for cleanliness and stowage.

c) Remove any protective gear and frisk as necessary.

d) VERIFY the "Bridge" Area Radiation Monitor is reading below its alarm set point and place the "Bridge Upscale Switch" in the NORMAL position.

e) VERIFY the *AIMS* operator has properly updated the *AIMS* computer and the appropriate sample record sheets.

6.1.3 Report any unresolved discrepancies to the LSRO.

6.2 FLUX TRAP - SECURED EXPERIMENT

CAUTION:	The Flux Trap sample holder SHALL NOT, under any circumstances, be unlatched while the reactor is operating. **(TS 1.24) (TS 3.6.e)**

NOTE:	Prior to loading the Flux Trap sample holder, the "Flux Trap Loading Sheet" must be approved by the Reactor Manager (or an Assistant Reactor Manager) and LSRO.

NOTE:	The Flux Trap sample holder must be Danger Tagged as "uninstalled" any time it is not loaded with an approved loading.

6.2.1 Place "Bridge Upscale Switch" to UPSCALE.

6.0 PROCEDURE (CONT.)

NOTE:	A Senior Reactor Operator must supervise the removal of the Flux Trap sample holder. **(HSR 8.2)**

6.2.2 IF Flux Trap sample holder is installed in center test hole, THEN unlatch Flux Trap sample holder using pressure vessel head lifting tool, AND place in Flux Trap sample unloader.

6.2.3 VERIFY "Flux Trap Loading Sheet" (Record 8.3) indicates: **(LER 80.07.07) (LER 82.11.17)**

- 34 inches of samples in each large diameter tube of the 6-Barrel Flux Trap Sample Holder **(LER 98.02)**, or
- 30 inches of samples in each tube of the 3-Barrel Flux Trap Sample Holder.

6.2.4 Load Flux Trap sample holder in accordance with "Flux Trap Loading Sheet (Record 8.3).

6.2.5 Following loading of each tube, VERIFY: **(LER 80.07.07) (LER 82.11.17)**

- 34 inches of samples in each large diameter tube of the 6-Barrel Flux Trap Sample Holder **(LER 98.02),** or
- 30 inches of samples in each tube of the 3-Barrel Flux Trap Sample Holder.

6.2.5.1 VERIFY the required sample length by lifting the unloading rod to the prescribed mark, AND OBSERVE that the top of the highest sample is in line with or above the unloading door. **(LER 80.07.07)**

NOTE:	A Senior Reactor Operator must visually verify that the Flux Trap sample hold-down rod pin is inserted and that the pin is secured in place. **(LER 05.02)**

6.2.6 ENSURE that the Flux Trap sample hold-down rod is fully inserted and install the pin and secure in place. **(LER 05.02)**

6.0 PROCEDURE (CONT.)

NOTE:	A Senior Reactor Operator must visually verify that the Flux Trap sample holder is latched during insertion into the center test hole. **(HSR 8.2)**

6.2.7 Insert Flux Trap sample holder in center test hole, AND ENSURE Flux Trap sample holder is latched. **(LER 71.11.22) (LER 77.12.08) (LER 98.02)**

6.2.8 RECORD sample loading information on "Run Sheet" (Record 8.2).

6.2.9 Update sample irradiation information on AIMS.

6.2.10 Place "Bridge Upscale Switch" to NORMAL.

6.3 SMALL FLUX TRAP - MOVABLE EXPERIMENT

CAUTION:	While the reactor is operating, the Small Flux Trap *movable experiments* can only be inserted or removed one at a time.

NOTE:	Only an SRO, RO or RO Trainee under the direct supervision of an SRO or RO can remove or insert a *movable experiment* in the Small Flux Trap sample holder while the reactor is operating.

NOTE:	Prior to the insertion or removal of a *movable experiment*, the experiment holder's identification must be verified against that as identified on Record 8.4.

6.3.1 Place "Bridge Upscale Switch" to UPSCALE.

6.3.2 IF reactivity worth of sample being inserted is positive, THEN position Regulating Blade to greater than 15.6 inches.

6.3.3. IF reactivity worth of sample being inserted is negative, THEN position Regulating Blade to less than 10.0 inches.

6.3.4 IF reactivity worth of sample being removed is positive, THEN position Regulating Blade to less than 10.0 inches.

6.3.5 IF reactivity worth of sample being removed is negative, THEN position Regulating Blade to greater than 15.6 inches.

6.0 PROCEDURE (CONT.)

6.3.6 Slowly remove or install sample while allowing Regulating Blade movement to stabilize.

6.3.7 Update sample irradiation information on dedicated computer system.

6.3.8 RECORD sample irradiation information on "Run Sheet" (Record 8.2).

6.3.9 Place "Bridge Upscale Switch" to NORMAL.

6.4 <u>SMALL FLUX TRAP - UNSECURED EXPERIMENT</u>

6.4.1 An unsecured experiment that does not meet the criteria of a movable experiment MUST be performed in accordance with Reactor Test Procedure RTP-26 (Reference 7.2).

7.0 REFERENCES

7.1 RP-HP-137, "Handling Radioactive Material in the Reactor Pool"

7.2 RTP-26, "Unsecured Experiment in Flux Trap Procedure"

8.0 RECORDS

8.1 "Reflector Loading Sheet"

8.2 RXS-ISO FORM 20-3, "Run Sheet"

8.3 "Flux Trap Loading Sheet"

8.4 "Small Flux Trap Tube Information Loading Sheet"

8.5 FM-9, "Gemstone Irradiation Sheet"

8.6 "Silicon Run Sheet"

9.0 ATTACHMENTS

9.1 "Reflector Loading Sheet"

9.2 RXS-ISO FORM 20-3, "Run Sheet"

9.3 "Flux Trap Loading Sheet"

9.0 ATTACHMENTS (CONT.)

9.4 FM-9, "Gemstone Irradiation Sheet"

9.5 "Silicon Run Sheet"

9.6 "Guidance for Verifying the Flux Trap Loading Sheet – Operations Management Responsibilities"

9.7 "Guidance for Verifying the Flux Trap Loading Sheet – Lead Senior Reactor Operator (LSRO) Responsibilities"

______ Loading Sheet Page 1 of 1

Load samples and spacers according to diagrams. See runsheet for the individual can for any additional information for that sample.

Can #:	Please load at time on date	Timer: ______	☐ Run sample for ______ hours.	☐ Pull sample at ______ on ______ regardless of runtime.
Can #:	Please load at time on date	Timer: ______	☐ Run sample for ______ hours.	☐ Pull sample at ______ on ______ regardless of runtime.
Can #:	Please load at time on date	Timer: ______	☐ Run sample for ______ hours.	☐ Pull sample at ______ on ______ regardless of runtime.
Can #:	Please load at time on date	Timer: ______	☐ Run sample for ______ hours.	☐ Pull sample at ______ on ______ regardless of runtime.

Position	Can 1	Can 2	Can 3	Can 4	Can 5
32–28	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
28–24	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
24–20	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
20–18	**Can #** Pull at Time on Date	Spacer-2"	Spacer-4"	Spacer-4"	Spacer-4"
18–16	**Can #** **Irradiation hours**	**Can #** **Irradiation hours**			
16–12	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
12–8	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
8–4	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"
4–0	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"	Spacer-4"

Loading Created By: ______________________ (Initial and Date) Verified By: ______________________ (Initial and Date) Irradiations Loading #: ____________

CAN #: HE35 MURR ID #: 15903 Stored Position

Company: RPG/Ehrhardt/Cutler

Material Ruthenium 0.00296g

Projected Pull Date 09/03/2002

Special Instructions

Run For 155 Hours.

Facility: Flux Trap

RUR: 209

Position	Start of Irradiation			End of Irradiation			Hours
	Date	Time	Totalizer	Date	Time	Totalizer	

SAMPLE

Run Sheet; RXS-ISO FORM 20-3

Flux Trap Loading Sheet
For 05/23/2005
Sheet # 1110

TUBE A

Pull at Shutdown
74, 76

Pull to Storage	Position
70	
13	
71	
4K2	

Reloads (from cask)
76

New Loads
94, 3, 3" H2O Spacer
2" H2O Spacer, 92

position		Sample #	
29 - 30, 28 - 29, 27 - 28	30	92 BaCO$_3$ 30-May	N
26 - 27, 25 - 26	27	2"-H$_2$O Spacer	N
24 - 25, 23 - 24, 22 - 23	25	3"-H2O Spacer	N
21 - 22, 20 - 21, 19 - 20	22	76	R
18 - 19, 17 - 18	19	5 (s) 13-Jun	
16 - 17, 15 - 16	17	15 (s) 30-May	
14 - 15, 13 - 14	15	3 (s) 20-Jun	N
12 - 13, 11 - 12	13	1K2 Spacer	
10 - 11, 9 - 10	11	2K2 Spacer	
8 - 9, 7 - 8, 6 - 7	9	3"-Ti Spacer	
5 - 6, 4 - 5, 3 - 4	6	94 BaCO$_3$ 30-May	N
2 - 3, 1 - 2, 0 - 1	3	3"-H2O Spacer	

☐ Check

TUBE B

Pull at Shutdown

Pull to Storage	Position
12	
72	
18 to C	

Reloads (from cask)

New Loads
97, 10
2" H2O Spacer

position		Sample #	
29 - 30, 28 - 29, 27 - 28, 26 - 27	30	4"-H2O Spacer	
25 - 26, 24 - 25, 23 - 24	26	7 P-33	
22 - 23, 21 - 22, 20 - 21	23	37 P-33	
19 - 20, 18 - 19	20	2"-H$_2$O Spacer	N
17 - 18, 16 - 17	18	8 (s) 13-Jun	
15 - 16, 14 - 15	16	16 (s) 06-Jun	
13 - 14, 12 - 13	14	10 (s) 20-Jun	N
11 - 12, 10 - 11	12	2"-H$_2$O Spacer	
9 - 10, 8 - 9	10	5K2 Spacer	
7 - 8, 6 - 7	8	3K2 Spacer	
5 - 6, 4 - 5, 3 - 4	6	97 BaCO$_3$ 30-May	N
2 - 3, 1 - 2, 0 - 1	3	3"-H2O Spacer	

☐ Check

TUBE C

Pull at Shutdown
54, 6, 91, 31

Pull to Storage	Position
77	

Reloads (from cask)
6

New Loads
99, 39, 18(from b)
54

position		Sample #	
29 - 30, 28 - 29, 27 - 28, 26 - 27	30	4"-H2O Spacer	
25 - 26, 24 - 25, 23 - 24	26	54	N
22 - 23, 21 - 22, 20 - 21	23	98 P-33	
19 - 20, 18 - 19, 17 - 18	20	6	R
16 - 17, 15 - 16	17	14 (s) 30-May	
14 - 15, 13 - 14	15	18 (s) 06-Jun	from b
12 - 13, 11 - 12, 10 - 11	13	39 Microsph. 30-May	N
9 - 10, 8 - 9	10	2"-H$_2$O Spacer	
7 - 8, 6 - 7	8	2"-H$_2$O Spacer	
5 - 6, 4 - 5, 3 - 4	6	99 BaCO$_3$ 30-May	N
2 - 3, 1 - 2, 0 - 1	3	3"-H2O Spacer	

☐ Check

Page 1 of 3

Totalizer to Zero ☐

Flux Trap Loading Sheet
For 05/23/2005
Sheet # 1110

Type Worth Loading Sheet					
loading A	type worth A	loading B	type worth B	loading C	type worth C
BaCO	1.90E-05	H2O	0.00E+00	H2O	0.00E+00
BaCO	1.90E-05	H2O	0.00E+00	H2O	0.00E+00
BaCO	1.90E-05	H2O	0.00E+00	H2O	0.00E+00
H2O	0.00E+00	H2O	0.00E+00	H2O	0.00E+00
H2O	0.00E+00	P-33(H2O	1.00E-05	Al-4hole	1.90E-05
H2O	0.00E+00	P-33(H2O	1.00E-05	Al-4hole	1.90E-05
H2O	0.00E+00	P-33(H2O	1.00E-05	Al-4hole	1.90E-05
H2O	0.00E+00	P-33(H2O	1.00E-05	P-33(H2O	1.00E-05
Al-4hole	1.90E-05	P-33(H2O	1.00E-05	P-33(H2O	1.00E-05
Al-4hole	1.90E-05	P-33(H2O	1.00E-05	P-33(H2O	1.00E-05
Al-4hole	1.90E-05	H2O	0.00E+00	Al-4hole	1.90E-05
Sulfur	1.00E-05	H2O	0.00E+00	Al-4hole	1.90E-05
Sulfur	1.00E-05	Sulfur	1.00E-05	Al-4hole	1.90E-05
Sulfur	1.00E-05	Sulfur	1.00E-05	Sulfur	1.00E-05
Sulfur	1.00E-05	Sulfur	1.00E-05	Sulfur	1.00E-05
Sulfur	1.00E-05	Sulfur	1.00E-05	Sulfur	1.00E-05
Sulfur	1.00E-05	Sulfur	1.00E-05	Sulfur	1.00E-05
KCl-F	-4.00E-05	Sulfur	1.00E-05	Al-4hole	1.90E-05
KCl-F	-4.00E-05	H2O	0.00E+00	Al-4hole	1.90E-05
KCl-F	-4.00E-05	H2O	0.00E+00	Al-4hole	1.90E-05
KCl-F	-4.00E-05	KCl-F	-4.00E-05	H2O	0.00E+00
Ti-Spacer	-3.50E-05	KCl-F	-4.00E-05	H2O	0.00E+00
Ti-Spacer	-3.50E-05	KCl-F	-4.00E-05	H2O	0.00E+00
Ti-Spacer	-3.50E-05	KCl-F	-4.00E-05	H2O	0.00E+00
BaCO	1.90E-05	BaCO	1.90E-05	BaCO	1.90E-05
BaCO	1.90E-05	BaCO	1.90E-05	BaCO	1.90E-05
BaCO	1.90E-05	BaCO	1.90E-05	BaCO	1.90E-05
H2O	0.00E+00	H2O	0.00E+00	H2O	0.00E+00
H2O	0.00E+00	H2O	0.00E+00	H2O	0.00E+00
H2O	0.00E+00	H2O	0.00E+00	H2O	0.00E+00

Page 2 of 3

Flux Trap Loading Sheet
For 05/23/2005
Sheet # 1110

Position	Importance Function	Reactivity Worth A	Reactivity Worth B	Reactivity Worth C
29 - 30	0.695002	0.0000132	0.0000000	0.0000000
28 - 29	0.695002	0.0000132	0.0000000	0.0000000
27 - 28	1.257649	0.0000239	0.0000000	0.0000000
26 - 27	1.257649	0.0000000	0.0000000	0.0000000
25 - 26	2.342793	0.0000000	0.0000234	0.0000445
24 - 25	2.342793	0.0000000	0.0000234	0.0000445
23 - 24	3.843365	0.0000000	0.0000384	0.0000730
22 - 23	3.843365	0.0000000	0.0000384	0.0000384
21 - 22	5.713510	0.0001086	0.0000571	0.0000571
20 - 21	5.713510	0.0001086	0.0000571	0.0000571
19 - 20	7.673323	0.0001458	0.0000000	0.0001458
18 - 19	7.673323	0.0000767	0.0000000	0.0001458
17 - 18	9.273694	0.0000927	0.0000927	0.0001762
16 - 17	9.273694	0.0000927	0.0000927	0.0000927
15 - 16	10.024821	0.0001002	0.0001002	0.0001002
14 - 15	10.024821	0.0001002	0.0001002	0.0001002
13 - 14	9.637917	0.0000964	0.0000964	0.0000964
12 - 13	9.637917	-0.0003855	0.0000964	0.0001831
11 - 12	8.135472	-0.0003254	0.0000000	0.0001546
10 - 11	8.135472	-0.0003254	0.0000000	0.0001546
9 - 10	5.855333	-0.0002342	-0.0002342	0.0000000
8 - 9	5.855333	-0.0002049	-0.0002342	0.0000000
7 - 8	3.393624	-0.0001188	-0.0001357	0.0000000
6 - 7	3.393624	-0.0001188	-0.0001357	0.0000000
5 - 6	1.472149	0.0000280	0.0000280	0.0000280
4 - 5	1.472149	0.0000280	0.0000280	0.0000280
3 - 4	0.458439	0.0000087	0.0000087	0.0000087
2 - 3	0.458439	0.0000000	0.0000000	0.0000000
1 - 2	0.121561	0.0000000	0.0000000	0.0000000
0 - 1	0.121561	0.0000000	0.0000000	0.0000000

Individual Tube Worth	-0.0006761	0.0001415	0.0017291
Three tube total	0.0011944		
Ft Holder	0.0036000		
Total Large FT	0.0047944 **		

** Administrative total reactivity worth approved by Reactor Manager or Designee

Loading Created and Approved By: ______________________

Loading Verified By: ______________________

Reactivity Approved By: ______________________

Can Length Verified by: __________ / __________

LSRO Concurrence: ______________________

Page 3 of 3

RUR No. ___________

GEMSTONE IRRADIATION SHEET

Irradiation Position: ______________________ TOTAL Run Time (hours): ______________________

Can Number: ______________________

MURR ID: ______________________ Reactivity Worth: ______________________

Set Point Hours	Date Start	Time	TOTALIZER	Date End	Time	TOTALIZER	Event

Comments: ______________________

____

____

HP Dose Rate @ Receipt Survey: ___________ mR/hr

Page 1 of 1

FM-09
Revision 3

Silicon Run Sheet

IRRADIATION POSITION : B5B LOT : 140-619-1

Delay Counts: 5 Detector : BOT Scale : 2.E-06

CAN #	FLIP COUNT	DATE START	TIME START	START TOTALIZER	FLIP TOTALIZER	COUNTS @ FLIP	NOTES	DATE STOP	TIME STOP	STOP TOTALIZER	COUNTS @ PULL	APPROX. HRS.	NOTES
B000	588											15.6	
B001	588											15.6	
B002	589											15.6	
B003	590											15.6	

LOT TOTAL APPROX. HRS : 62.4

NOTES	
1	Handled early/late due to AIMS
2	Handled early/late due to other evolution in progress
3	Handled early/late due to ALARA (<2%)
4	Rotator malfunction (not rotating)
5	Rotator not in correct position
6	Holder height not correct
7	Sample interrupted by reactor shutdown
8	
9	

Guidance for Verifying the Flux Trap Loading Sheet

Operations Management Responsibilities

1. General

    a. Verify the FT Loading Number is correct (with respect to the previous loading sheet).

    b. Verify the FT Loading Date information provided is correct.

2. Irradiation Cans

    a. Verify the accuracy of the individual sample type worth values used to estimate the total flux trap reactivity worth.

    b. Verify the total length of the cans pulled/stored is the same as the total length of the cans loaded/reloaded.

3. Reactivity

    a. Verify the FT holder reactivity listed is the appropriate value for that holder.

    > NOTE: Currently used values are:
    >
    > Empty 3-Barrel FT holder worth: 0.0036 Δk
    > Empty 6-Barrel FT holder worth: 0.0050 Δk

    b. Verify that absolute individual tube (worth) is less than 0.006 Δk.

    c. Verify that total reactivity worth for the entire loading (3 or 6 tubes + holder) is less than the currently established administrative limit. Write this limit in the space provided.

    > NOTE: Current Administrative limit for the total flux trap reactivity worth is 0.0050 Δk.

    > NOTE: While verifying the values, consider only four (4) decimal places. More digits are carried in the EXCEL spreadsheet only to avoid excessive rounding errors.

    d. After verification, sign at the bottom of the FT loading sheet at the appropriate location.

Guidance for Verifying the Flux Trap Loading Sheet

LSRO Responsibilities

1. <u>General</u>

   a. Verify the FT Loading Number is correct (with respect to the previous loading sheet).

   b. Verify the FT Loading Date information provided is correct.

2. <u>Irradiation Cans</u>

   a. Verify the new can numbers and can lengths are correct.

   b. Verify the accuracy of the paperwork supplied for the new cans.

   c. Verify the total length of the cans pulled/stored is the same as the total length of the cans loaded/reloaded.

   d. Verify the cans pulled are also indicated on the separate sample "Pull Sheet" provided.

3. <u>Reactivity</u>

   a. Verify the FT holder reactivity worth listed is the appropriate value for that holder.

   > <u>NOTE</u>: Currently used values are:
   >
   > Empty 3-Barrel FT holder worth: 0.0036 Δk
   > Empty 6-Barrel FT holder worth: 0.0050 Δk

   b. Verify that <u>absolute</u> individual tube (worth) is less than 0.006 Δk.

   c. Verify that total reactivity worth for the entire loading (3 or 6 tubes + holder) is less than the administrative limit assigned by the Assistant Reactor Manager.

   > <u>NOTE</u>: While verifying the values, consider only four (4) decimal places. More digits are carried in the EXCEL spreadsheet only to avoid excessive rounding errors.

   d. After verification, sign at the bottom of the FT loading sheet at the appropriate location.

ATTACHMENT 2

OP-RO-460
Revision 12

MURR

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OPERATING PROCEDURE

OP-RO-460

POOL COOLANT SYSTEM - TWO PUMP OPERATION

RESPONSIBLE GROUP: Reactor Operations

PROCEDURE OWNER: Sean Schaefer

APPROVED BY: Les Foyto Date: 8-16-10

This procedure contains the following:

Pages	1	through	6
Attachments	1	through	1
Tables	None	through	
Figures	None	through	
Appendices	None	through	
Check-Off Lists	None	through	

TABLE OF CONTENTS

POOL COOLANT SYSTEM - TWO PUMP OPERATION

1.0 PURPOSE

1.1 Instructions for starting up and shutting down the Pool Coolant System in a two pump operating mode.

2.0 SCOPE

2.1 Pool Coolant System startup and shutdown using detailed valve and switch positioning.

3.0 PRECAUTIONS AND LIMITATIONS

3.1 Failure to perform an Area Radiation and Contamination Survey of Room 114 prior to entry, could result in a worker receiving an unanticipated radiation exposure or becoming contaminated. (ALARA) (HSR 10.3)

3.2 The pumps of the Pool Coolant System shall be instrumented and connected so as to permit safe operation at five or ten megawatts on either pump or both pumps operating simultaneously. **(TS 4.4.d)**

4.0 PREREQUISITES AND INITIAL CONDITIONS

NOTE:	Normal Pool Coolant System operation consists of two operating pumps. At the discretion of the Reactor Manager, operation with one pump can be performed in accordance with Reference 7.7.

4.1 No Pool Coolant System maintenance has been performed since the last shutdown of the pool system, or

4.1.1 If maintenance has been performed on the system, ensure that all affected components are in their normal positions (Attachment 9.1).

4.1.2 The Lead Senior Reactor Operator (LSRO) must determine if a valve line-up checksheet needs to be completed (Attachment 9.1).

4.2 A Room 114 Area Radiation and Contamination Survey has been completed, or

4.2.1 Perform a Room 114 Unscheduled Entry procedure (Reference 7.6).

4.0 PREREQUISITES AND INITIAL CONDITIONS (CONT.)

4.3 The following systems are in the proper line-up:

- Valve Operation Air System (Reference 7.5)
- Drain Collection System (Reference 7.4)
- Reactor Demineralizer System (Reference 7.3)

4.4 Power available to Pool Coolant Pumps P-508A and P-508B, and Pool Demineralizer Pump P-513B.

4.5 Pool level is 29'-4" to 29'-10". The pool coolant system may be operated with pool level lowered to below the refuel bridge to perform RTP-21.

4.6 When the reactor is operating, the Flux Trap Sample Holder <u>or</u> Flux Trap Strainer must be <u>installed</u>. When the reactor is shutdown, this requirement is at the discretion of the LSRO.

4.7 Pool Coolant Temperature Controller S-2 temperature demand SET at <u>100 °F</u>.

4.8 S-2 electro-hydraulic motor power local switch is <u>ON</u>.

5.0 PROCEDURE (STARTUP)

5.1 <u>PREPARE SYSTEM FOR STARTUP:</u>

5.1.1 ENSURE Pool Coolant Flow Recorder is <u>ON</u>.

5.1.2 ENSURE Pool Coolant Temperature Recorder is <u>ON</u>.

5.1.3 ENSURE Primary & Pool Coolant Demineralizer Flow Recorder is <u>ON</u>.

5.1.4 ENSURE Pool Coolant Flow Bypass Switch 2S40 in '<u>10 MW</u>' position.

5.1.5 Place Master Control Switch 1S1 to '<u>Test</u>' position.

5.2 <u>SYSTEM STARTUP:</u>

5.2.1 Place Pool Coolant Isolation Valve 509 switches to '<u>Manual/Open</u>' positions.

5.2.2 START Pool Coolant Pump P-508A.

5.2.3 START Pool Coolant Pump P-508B.

5.0 PROCEDURE (STARTUP)

5.2.4 ENSURE flow is between <u>1,100 gpm and 1,300 gpm</u>.

5.2.4.1 IF flow adjustment is required, THEN adjust flow using Pool HX-521 Outlet Valve 600A.

5.2.5 START Pool Demineralizer Pump P-513B, AND ENSURE flow <u>greater than</u> 42.5 gpm.

5.2.6 ENSURE all applicable valve position indication lights are <u>lit</u>.

5.2.7 Place Valve 509 switches to '<u>Auto/Close</u>' positions.

5.2.8 Master Control Switch 1S1 may be placed to <u>ON</u> as compliance check or startup checksheet requires.

5.2.9 Calculate the pool system input potentiometer setting after secondary system has been placed in operation (2 pumps). Use the formula (average pool flow / 1400) AND adjust as necessary.

6.0 PROCEDURE (SHUTDOWN)

6.1 <u>SYSTEM SHUTDOWN:</u>

CAUTION:	The Pool Coolant System must be operated for <u>greater than</u> 5 minutes following a reactor shutdown from full power to allow for the removal of decay heat.

6.1.1 Place Master Control Switch 1S1 to '<u>Test</u>' position.

<u>NOTE</u>:	Pool Coolant Pumps P-508A and P-508B must be secured <u>at the same time</u> to prevent check valve slam and potential valve damage.

6.1.2 STOP Pool Coolant Pumps P-508A <u>and</u> P-508B <u>at the same time</u>.

6.1.3 VERIFY Pool Coolant Isolation Valve 509 <u>CLOSES.</u>

6.1.4 VERIFY Pool Demineralizer Pump P-513B shuts <u>OFF</u>.

6.1.5 Place Valve 509 switches to '<u>Manual/Close</u>' positions.

6.1.6 Place Pump P-513B switch to '<u>Off</u>' position.

6.0 PROCEDURE (SHUTDOWN)

6.1.7 ENSURE all applicable valve position indication lights are lit.

6.1.8 Place Master Control Switch 1S1 to 'Off' position.

7.0 REFERENCES

7.1 MURR Dwg. 156, "Piping & Instrument Diagram"

7.2 MURR Dwg. 41, Sh. 1 of 3, "Process Instrumentation Control and Interlock"

7.3 RM-RO-405, "Reactor Demineralizer System"

7.4 OP-RO-532, "Drain Collection System"

7.5 OP-RO-516, "Valve Operation Air System"

7.6 RP-HP-135, "Room 114 Entry - Self Monitored"

7.7 OP-RO-461, "Pool Coolant System - One Pump Operation"

8.0 RECORDS

8.1 Reactor Startup Checksheet - Full Power Operation

9.0 ATTACHMENTS

9.1 Pool Coolant System Valve Line-up Checksheet

Date:______________________

POOL COOLANT SYSTEM VALVE LINE-UP

This checksheet will be completed when required by the Lead Senior Reactor Operator (LSRO). The operators performing the check will independently verify the position of each valve and indicate the verification by initialing the checksheet. Where appropriate, the positions of throttled valves are shown on a permanent tag secured to the valve. Note the throttled valve's position on the checksheet. Under the direction of the LSRO, a valve may be positioned other than listed on this checksheet. If this is required, the operators must ensure that the valve is in the desired position and indicate this position on this checksheet. If this change of position is not covered by a procedure in use, for example an RTP, SMP, or Work Package, which would return the valve to the normal operating position, then the LSRO will issue and place a Danger Tag on the valve for the duration of time the valve is in the out-of-normal position.

LOCATION: ROOM 114

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
568F	FT-912C Valve Manifold	HP/LP Open; Equalizer Closed		
599AE	FT-912C QDF Isolation	Closed		
599AD	FT-912C QDF Isolation	Closed		
515AY	Conductivity Cell 932B Isolation	Open		
515AZ	Conductivity Cell 932D Isolation	Open		
514E	P-508B Suction	Open		
514F	P-508B Discharge	Open		
515AI	P-508B Drain	Closed		
518AC	P-508B Gauge Isolation	Open		
518AD	P-508B Gauge Isolation	Open		
595J	Pool Cleanup Effluent to Sample Station	Open		
515X	P-513B Bypass	Closed		
515N	P-513B Discharge	Open		
518G	P-513B Gauge Isolation	Open		
518H	P-513B Gauge Isolation	Open		
595K	Vent (Cleanup Influent)	Closed		

Date:______________________

POOL COOLANT SYSTEM VALVE LINE-UP (Cont.)

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
595G	Pool Influent to Sample Station	Open		
514C	P-508A Suction	Open		
514D	P-508A Discharge	Open		
515AH	P-508A Drain	Closed		
518I	P-508A Gauge Isolation	Open		
518J	P-508A Gauge Isolation	Open		
522C	Pool Drain/Fill	Closed		
522B	Pool Drain	Closed		
515M	Cleanup Suction from Pool	Closed		
515P	Cleanup Return to Pool	Open		
515Q	Cleanup Return to Loop	Closed		
515T	Cleanup Suction from Loop	Open		
599J	PS-947 Isolation	Open		
518V	Vent (Common Pump Discharge Line)	Closed		
518W	Vent (Downstream Y-Strainer)	Closed		
518AG	Y-Strainer 597B Drain	Closed		
568C	FT-912D Valve Manifold	HP/LP Open; Equalizer Closed		
599N	FT-912D QDF Isolation (Downstream Y-Strainer)	Closed		
599Q	FT-912D QDF Isolation (LP)	Closed		
599P	FT-912D QDF Vent (LP)	Closed		
599R	FT-912D QDF Vent (HP)	Closed		
568D	FT-912F Valve Manifold	HP/LP Open; Equalizer Closed		
599S	FT-912F QDF Isolation (HP)	Closed		
599T	FT-912F QDF Isolation (LP)	Closed		

Date:________________________

POOL COOLANT SYSTEM VALVE LINE-UP (Cont.)

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
599U	FT-912F QDF Vent (LP)	Closed		
599X	FT-912F QDF Vent (HP)	Closed		
518U	T_H Vent	Closed		
518N	HUT Vent Isolation	Open		
518K	HUT Vent	Closed		
515R	HUT Drain	Locked Closed		
514B	HUT Outlet	Open		
514G	HX-521 Inlet	Open		
518Z	Y-Strainer 597D Drain	Closed		
515Z	HX-521 Drain	Closed		
518AJ	HX-521 Vent	Closed		
600A	HX-521 Outlet	Throttled		
518AL	PI-927 Isolation	Open		
518AK	Vent (Capped)	Closed		
518Q	Loop Drain (Tunnel)	Closed		
518R	Loop Drain (Tunnel)	Closed		
514A	V-509 Isolation	Open		
568G	PT-917 Isolation	Open		
599Z	PT-917 Vent	Closed		
515AC	Spool-piece to WT System (DI Room)	Closed		

Comments:

MURR

OPERATING PROCEDURE

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OP-RO-461

POOL COOLANT SYSTEM - ONE PUMP OPERATION

RESPONSIBLE GROUP: Reactor Operations

PROCEDURE OWNER: Rich Smith

APPROVED BY: Les Foyto Date: 11-15-10

This procedure contains the following:

Pages	1	through	7
Attachments	1	through	1
Tables	None	through	
Figures	None	through	
Appendices	None	through	
Check-Off Lists	None	through	

TABLE OF CONTENTS

POOL COOLANT SYSTEM - ONE PUMP OPERATION

1.0 PURPOSE

1.1 Instructions for starting up and shutting down the Pool Coolant System in a one pump operating mode.

2.0 SCOPE

2.1 Pool Coolant System startup and shutdown using detailed valve and switch positioning.

3.0 PRECAUTIONS AND LIMITATIONS

3.1 Failure to perform an Area Radiation and Contamination Survey of Room 114 prior to entry could result in a worker receiving an unanticipated radiation exposure or becoming contaminated. **(ALARA) (HSR 10.3)**

3.2 The pumps of the Pool Coolant System shall be instrumented and connected so as to permit safe operation at five or ten megawatts on either pump or both pumps operating simultaneously. **(TS 4.4.d)**

4.0 PREREQUISITES AND INITIAL CONDITIONS

4.1 Obtain the Reactor Manager's permission for one Pool Coolant Pump operation.

4.2 No Pool Coolant System maintenance has been performed since the last shutdown of the pool system, or

4.2.1 If maintenance has been performed on the system, ensure that all affected components are in their normal positions (Attachment 9.1).

4.2.2 The Lead Senior Reactor Operator (LSRO) must determine if a valve line-up checksheet needs to be completed (Attachment 9.1).

4.3 A Room 114 Area Radiation and Contamination Survey has been completed, or

4.3.1 Perform a Room 114 Unscheduled Entry procedure (Reference 7.6).

4.4 The following systems are in the proper line-up:

- Valve Operation Air System (Reference 7.5)
- Drain Collection System (Reference 7.4)
- Reactor Demineralizer System (Reference 7.3)

4.0 PREREQUISITES AND INITIAL CONDITIONS (CONT.)

4.5 Power available to Pool Coolant Pump P-508A or P-508B, and Pool Demineralizer Pump P-513B.

4.6 Pool level is 29'-4" to 29'-10". The Pool Coolant System may be operated with pool level lowered to below the refuel bridge to perform RTP-21.

4.7 When the reactor is operating, the Flux Trap Sample Holder or Flux Trap Strainer must be installed. When the reactor is shutdown, this requirement is at the discretion of the LSRO.

4.8 Pool Coolant Temperature Controller S-2 temperature demand SET at 100 °F.

4.9 S-2 electro-hydraulic motor power local switch is ON.

5.0 PROCEDURE (STARTUP)

5.1 PREPARE SYSTEM FOR STARTUP:

5.1.1 IF Pool Coolant System is running in two pump operation, THEN shutdown Pool Coolant System (Reference 7.7).

5.1.2 Isolate one Pool Coolant Pump:

- Tag OPEN breaker for non-operating Pool Coolant Pump P-508A or P-508B.
- Depress, AND lock out non-operating Pool Coolant Pump P-508A or P-508B 'Stop' button.
- CLOSE AND Tag-Out non-operating pump Suction Valve 514C (P-508A) or 514E (P-508B).
- CLOSE AND Tag-Out non-operating pump Discharge Valve 514D (P-508A) or 514F (P-508B).

5.1.3 ENSURE operating pump Suction Valve 514C (P-508A) or 514E (P-508B) is OPEN.

5.1.4 ENSURE operating pump Discharge Valve 514D (P-508A) or 514F (P-508B) is OPEN.

5.1.5 OPEN Pool HX-521 Outlet Valve 600A.

5.1.6 ENSURE Pool Coolant Flow Recorder is ON.

5.0 PROCEDURE (STARTUP) (CONT.)

5.1.7 ENSURE Pool Coolant Temperature Recorder is ON.

5.1.8 ENSURE Primary & Pool Coolant Demineralizer Flow Recorder is ON.

5.1.9 ENSURE Pool Coolant Flow Bypass Switch 2S40 in '10 MW' position.

5.1.10 Place Master Control Switch 1S1 to 'Test' position.

5.2 SYSTEM STARTUP:

5.2.1 Place Pool Coolant Isolation Valve 509 switches to 'Manual/Open' positions.

5.2.2 START Pool Coolant Pump P-508A or P-508B.

5.2.3 ENSURE flow is between 1,150 gpm and 1,250 gpm.

- IF flow adjustment is required, THEN adjust flow using Pool Hx-521 Outlet Valve 600A.

5.2.4 START Pool Demineralizer Pump P-513B AND ENSURE flow greater than 42.5 gpm.

5.2.5 ENSURE all applicable valve position indication lights are lit.

5.2.6 Place Valve 509 switches to 'Auto/Close' positions.

5.2.7 Master Control Switch 1S1 may be placed to ON as compliance check or startup checksheet requires.

5.2.8 Calculate the pool system input potentiometer setting after secondary system has been placed in operation (2 pumps). Use the formula (average pool flow / 1400) AND adjust as necessary.

5.2.9 RECORD Single Pool Coolant Pump operation in Console Log Book.

6.0 PROCEDURE (SHUTDOWN)

6.1 SYSTEM SHUTDOWN:

CAUTION:	The Pool Coolant System must be operated for greater than 5 minutes following a reactor shutdown from full power to allow for removal of decay heat.

6.1.1 Place Master Control Switch 1S1 to 'Test' position.

6.1.2 STOP Pool Coolant Pump P-508A or P-508B.

6.1.3 VERIFY Pool Coolant Isolation Valve 509 CLOSES.

6.1.4 VERIFY Pool Demineralizer Pump P-513B shuts OFF.

6.1.5 Place Valve 509 switches to 'Manual/Close' positions.

6.1.6 Place Pump 513B switch to 'Off' position.

6.1.7 ENSURE all applicable valve position indication lights are lit.

6.1.8 Place Master Control Switch 1S1 to 'Off' position.

7.0 REFERENCES

7.1 MURR Print 156, "Piping & Instrument Diagram"

7.2 MURR Print 41, Sh. 1 of 3, "Process Instrumentation Control and Interlock"

7.3 RM-RO-405, "Reactor Demineralizer System"

7.4 OP-RO-532, "Drain Collection System"

7.5 OP-RO-516, "Valve Operation Air System"

7.6 RP-HP-135, "Room 114 Entry – Self Monitored"

7.7 OP-RO-460, "Pool Coolant System - Two Pump Operation," Step 6.1, System Shutdown

8.0 RECORDS

8.1 Reactor Startup Checksheet - Full Power Operation

9.0 ATTACHMENTS

9.1 Pool Coolant System – One Pump Operation Valve Line-up Checksheet

Date:______________________

POOL COOLANT SYSTEM – ONE PUMP OPERATION
VALVE LINE-UP CHECKSHEET

This checksheet will be completed when required by the Lead Senior Reactor Operator (LSRO). The operators performing the check will independently verify the position of each valve and indicate the verification by initialing the checksheet. Where appropriate, the position of throttled valves are shown on a permanent tag secured to the valve. Note the throttled valve's position on the checksheet. Under the direction of the LSRO, a valve may be positioned other than listed on this checksheet. If this is required, the operators must ensure that the valve is in the desired position and indicate this position on this checksheet. If this change of position is not covered by a procedure in use, for example an RTP, SMP, or Work Package, which would return the valve to the normal operating position, then the LSRO will issue and place a Danger Tag on the valve for the duration of time the valve is in the out-of-normal position.

LOCATION: Room 114

WITH P-508A RUNNING ONLY

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
514C	P-508A Suction	Open		
514D	P-508A Discharge	Open		
514E	P-508B Suction	Tagged Closed		
514F	P-508B Discharge	Tagged Closed		

WITH P-508B RUNNING ONLY

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
514C	P-508A Suction	Tagged Closed		
514D	P-508A Discharge	Tagged Closed		
514E	P-508B Suction	Open		
514F	P-508B Discharge	Open		

POOL COOLANT SYSTEM – ONE PUMP OPERATION
VALVE LINE-UP CHECKSHEET (Cont.)

WITH P-508A OR P-508B RUNNING

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
568F	FT-912C Valve Manifold	HP/LP Open; Equalizer Closed		
599AE	FT-912C QDF Isolation	Closed		
599AD	FT-912C QDF Isolation	Closed		
515AY	Conductivity Cell 932B Isolation	Open		
515AZ	Conductivity Cell 932D Isolation	Open		
515AI	P-508B Drain	Closed		
518AC	P-508B Gauge Isolation	Open		
518AD	P-508B Gauge Isolation	Open		
595J	Pool Cleanup Effluent to Sample Station	Open		
515X	P-513B Bypass	Closed		
515N	P-513B Discharge	Open		
518G	P-513B Gauge Isolation	Open		
518H	P-513B Gauge Isolation	Open		
595K	Vent (Cleanup Effluent)	Closed		
595G	Pool Influent to Sample Station	Open		
515AH	P-508A Drain	Closed		
518I	P-508A Gauge Isolation	Open		
518J	P-508A Gauge Isolation	Open		
522C	Pool Drain/Fill	Closed		
522B	Pool Drain	Closed		
515M	Cleanup Suction from Pool	Closed		
515P	Cleanup Return to Pool	Open		
515Q	Cleanup Return to Loop	Closed		

Date:________________________

POOL COOLANT SYSTEM – ONE PUMP OPERATION
VALVE LINE-UP CHECKSHEET (Cont.)

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
515T	Cleanup Suction from Loop	Open		
599J	PS-947 Isolation	Open		
518V	Vent (Common Pump Discharge Line)	Closed		
518W	Vent (Downstream Y-Strainer)	Closed		
599AA	Vent (Common Pump Discharge Line)	Closed		
518AG	Y-Strainer 597B Drain	Closed		
568C	FT-912D Valve Manifold	HP/LP Open; Equalizer Closed		
599N	FT-912D QDF Isolation (HP)	Closed		
599Q	FT-912D QDF Isolation (LP)	Closed		
599P	FT-912D QDF Vent (LP)	Closed		
599R	FT-912D QDF Vent (HP)	Closed		
568D	FT-912F Valve Manifold	HP/LP Open; Equalizer Closed		
599S	FT-912F QDF Isolation (HP)	Closed		
599T	FT-912F QDF Isolation (LP)	Closed		
599U	FT-912F QDF Vent (LP)	Closed		
599X	FT-912F QDF Vent (HP)	Closed		
518U	T_H Vent	Closed		
518N	HUT Vent Isolation	Open		
518K	HUT Vent	Closed		
515R	HUT Drain	Locked Closed		
514B	HUT Outlet	Open		
518Z	Y-Strainer 597D Drain	Closed		
514G	HX-521 Inlet	Open		

Date:________________________

POOL COOLANT SYSTEM – ONE PUMP OPERATION
VALVE LINE-UP CHECKSHEET (Cont.)

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER
515Z	HX-521 Drain	Closed		
518AJ	HX-521 Vent	Closed		
600A	HX-521 Outlet	Throttled		
518AL	PI-927 Isolation	Open		
518AK	Vent (Capped)	Closed		
518Q	Loop Drain (Tunnel)	Closed		
518R	Loop Drain (Tunnel)	Closed		
514A	V-509 Isolation	Open		
568G	PT-917 Isolation	Open		
599Z	PT-917 Vent	Closed		
515AC	Spool-piece to WT System (DI Room)	Closed		

Comments:

ATTACHMENT 4

AP-RO-110
Revision 15

MURR

OPERATING

AP-RO-110

CONDUCT OF OPERATIONS

MASTER COPY
ISSUED OCT 27 2009

RESPONSIBLE GROUP: Reactor Operations

PROCEDURE OWNER: John Fruits

APPROVED BY: Les Foyto ________ Date: 9-25-09

This procedure contains the following:

Pages	1	through	25
Attachments	1	through	2
Tables	1	through	2
Figures	None	through	
Appendices	None	through	
Check-Off Lists	None	through	

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CONDUCT OF OPERATIONS

1.0 PURPOSE

1.1 To establish administrative requirements for the Control Room and the operation of the reactor and associated systems to ensure safe and reliable operation of the University of Missouri Research Reactor (MURR).

2.0 SCOPE

2.1 Contains administrative requirements and instructions for Control Room Staffing and the operation of the reactor and associated systems.

3.0 DEFINITIONS

3.1 _Combustible liquids_ - Any *liquid* having a *flashpoint* at or above 140°F (60°C).

3.2 _Corrosive chemicals_ - Materials that are chemically incompatible with reactor system components.

3.3 _Flammable classifications_ - classified as follows:

a. Class I - those *liquids* having *flashpoints* below 100°F (37.8°C) and may be subdivided.

b. Class II - those *liquids* having *flashpoints* at or above 100°F (37.8°C) and below 140°F (60°C).

c. Class III - all *combustible liquids*.

3.4 _Flammable liquids_ - Any *liquid* having a *flashpoint* below 140°F (60°C) and a vapor pressure not exceeding 40 psia at 100°F (37.8°C).

3.5 _Flashpoint_ - The temperature at which a *liquid* gives off vapor sufficient to form an ignitable mixture with the air near the surface of the *liquid* or within an encapsulation vessel.

3.6 _Foreign material_ – Any material that is introduced into a system or component that was not a part of its original design or intended use. This includes unexpected dirt and debris, tools, badges, pens, gloves, towels, unapproved chemicals, wire, fasteners, paint chips, grinding particles, sealing compounds or any other item or residue which if left inside the system, could adversely affect its operation, chemistry, components or radiation levels.

3.7 _Hot reactor startup_ - A startup in which restart capability is in doubt.

3.0 DEFINITIONS (CONT.)

3.8 *Independent verification* - The process wherein a tag-out or valve line-up is performed by one person and then independently checked by another. This shall not be interpreted to allow the two individuals to perform the checks together.

3.9 *Knowledgeable person* - A Reactor Operator Trainee who has successfully completed a 50% board.

3.10 *Liquid* - Any material which has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM Test for Penetration for Bituminous Materials, D-5-65.

3.11 *Normal reactor startup* - A startup after any shutdown in which restart capability is not in doubt.

3.12 *Standard working hours* - Monday through Friday from 0730 to 1730.

3.13 *Toxic materials* - Any material listed as *toxic* (Reference 7.18) or any material not previously approved for use.

3.14 *Unscheduled shutdown* - Any unplanned automatic shutdown of the reactor, that occurs after all 'Blade Full-In Lights' have cleared, that is the result of an equipment actuation, Operator error, or equipment malfunction, or any unplanned manual shutdown that is an immediate response to conditions that could adversely affect safe operation. Immediate as used in this definition means that there is no time for evaluation, discussion, or planning and continued operation for a short time is not an option. A shutdown that is not immediate and is due to a problem or equipment failure that can be evaluated, discussed, and planned, will not be classified as an *unscheduled shutdown*.

4.0 RESPONSIBILITIES

4.1 The responsibilities of the Reactor Operations Control Room staff shall include, but is not limited to, the following:

4.1.1 Reactor Operator (RO) shall:

a. Operate the reactor controls and facility equipment in accordance with approved facility documents.

b. Diligently monitor reactor indications and control reactor parameters and promptly act to determine the causes and correct abnormal conditions.

c. Ensure all shift members are aware of changes in plant conditions.

d. Safely and accurately perform assigned tasks.

4.0 RESPONSIBILITIES (CONT.)

4.1.2 Senior Reactor Operator (SRO), in addition to the duties of the RO shall:

a. Ensure facility equipment is operated in accordance with approved facility documents.

b. Direct the license related activities of licensed operators.

4.1.3 Lead Senior Reactor Operator (LSRO), in addition to the duties of the SRO shall:

a. Act as the direct representative of Operations Management for the conduct of operations at MURR.

b. Have the responsibility and authority to direct activities to:

- Protect the health and safety of the public and the environment
- Ensure the reactor is operated in compliance with the conditions of the facility license and all applicable regulatory requirements and commitments
- Prevent injury to personnel
- Prevent damage to MURR structures, systems and components
- Keep radiation dose ALARA

c. Ensure the safe and reliable operation of the reactor.

d. Ensure Control Room distractions are kept to a minimum, especially during reactivity manipulations.

e. Keep Operations Management informed of facility conditions and personnel issues.

f. Ensure evolutions are performed in accordance with approved procedures.

g. Be cognizant of evolutions performed at MURR during the shift.

h. Ensure samples are run as scheduled.

i. Ensure system specialist duties assigned to the crew are performed.

j. Ensure machinery history and turnover note are up to date and accurate.

k. Ensure operators on shift are fit for duty.

l. Be responsible for the training, qualification and requalification of the crew.

m. Review Routine Patrol Checksheet after each patrol. **(CAP 01-0012)**

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Cryogenic *liquids* shall not be used in any experiment within the reactor pool.

5.2 *Flammable* and *combustible* materials are allowed in the containment building only with specific written authorization of the Reactor Manager (Reference 7.18).

5.3 Storage of *flammable* or *combustible liquids* is prohibited in the containment building without specific written authorization of the Reactor Manager (Reference 7.18).

5.4 *Toxic materials* are allowed in the containment building only with specific written authorization of the Reactor Manager (Reference 7.18).

5.5 *Corrosive chemicals* are allowed for use in reactor systems only with specific written authorization of the Reactor Manager.

5.6 Placing any material in any reactor experimental position without an approved Reactor Utilization Request (RUR) is prohibited.

5.7 The amount of H-3 shall be less than 10 mCi and all other activities shall be less than 2 mCi before pumping the waste tank to the sanitary sewer. The Reactor Manager may authorize discharge to the sanitary sewer if these limits are exceeded (Reference 7.20).

5.8 All switch manipulations shall be deliberate and expected responses shall be verified by self- checking using the principles of STAR (Stop, Think, Act, Review).

5.9 Do not key 2-way radios in the vicinity of the instrument panels.

5.10 Do not place your hand or any other item near an electronic meter, especially meters that not only provide indication but also scram functions, to prevent any inadvertent meter movement caused by static electricity. **(CAP 06-0024)**

5.0 PRECAUTIONS AND LIMITATIONS (CONT.)

5.11 To ensure continued safe and reliable operation of the facility, take proper precautions when working on or near systems or components where *foreign material* could be introduced. This includes but is not limited to: **(CAP 05-0094)**

- Keeping the general area clear of loose materials.
- Ensuring all badges and EPDs are secure when working near the pool.
- Ensuring tools are properly controlled through the use of lanyards.
- Ensuring the flux trap holder or strainer is installed when performing work above the core.
- Ensuring the vessel top hat is installed when performing work directly over the core if the pressure vessel head is removed.
- Ensuring all *foreign material* created in the work area is captured, contained and removed from the area.
- Being cognizant of any materials that may inadvertently be knocked or dropped into the pool.
- Informing Operations Management of any *foreign material* that is introduced into a system or component that has not been retrieved.

6.0 PROCEDURE

6.1 <u>ADMINISTRATIVE POLICIES</u>:

6.1.1 The reactor shall be operated under conditions and limitations required by the Technical Specifications. **(MURR License R-103, Appendix A)**

6.1.2 No experiments or tests will be performed on the reactor or reactor control systems while the reactor is critical without permission from the Reactor Manager or his designee.

6.1.3 Supervisory Authority:

a. The importance of a single point of authority and accountability for all reactor activities is recognized for safe and effective control of reactor operation.

b. The Reactor Manager has authority over all activities related to reactor operation.

c. The Lead Senior Reactor Operator (LSRO) is the Reactor Manager's delegated representative on shift and is given the authority to direct licensed and unlicensed activities related to reactor operation during his duty shift.

6.0 PROCEDURE (CONT.)

6.1.4 Safety:

a. Safe operation of the reactor MUST take precedence over all other considerations.

6.1.5 Radiation Safety:

a. Each indoctrinated individual working at MURR is responsible for maintaining his or her radiation exposure As Low As is Reasonably Achievable (ALARA).

b. Each indoctrinated individual working at MURR is responsible for being aware of the radiation conditions in the area where they are working. This awareness is achieved by reading the posted survey maps and signs in the area or at the entrance to the area.

c. No barrels, radiologically hazardous containers or materials which are in required locked storage may be moved from behind locked areas without HP approval.

6.1.6 Physical Protection of Special Nuclear Materials:

a. Government regulations require special provisions to safeguard Special Nuclear Material. The safeguards provided and the procedures applicable to maintaining the security of Special Nuclear Materials are contained in the facility Security Plan and Security Procedures. **(10 CFR 73)**

6.1.7 *Independent Verification*:

a. All tag-outs and valve line-ups require *independent verification*. **(LER 02-02)**

b. All tag-outs and valve line-ups MUST be performed by operations personnel. The LSRO may authorize a person from the Electronics Shop to perform the *independent verification* on an electrical tag-out.

6.1.8 Relaxing Containment Integrity:

a. Prior to relaxing containment integrity, the LSRO and the individual designated by the LSRO to relax containment integrity will perform an *independent verification* to ensure that the reactor is secured as defined by Technical Specification 1.20. **(CAP 06-0071)**

b. Requirement (d) of Technical Specification 1.20 is interpreted to mean that the Control Rod Drive Mechanisms must all be installed prior to relaxing containment integrity. Having been removed, or removing a Control Rod Drive mechanism means "work is in progress" as defined by Operations Management. **(CAP 06-0071)**

6.0 PROCEDURE (CONT.)

6.2 AUTHORIZATIONS:

6.2.1 Any maintenance performed on the reactor, systems, and equipment covered by Technical Specifications MUST be reviewed by the LSRO to verify operability of the affected systems and equipment prior to reactor operation.

6.2.2 The Reactor Manager's permission MUST be obtained prior to performing the following:

- Lowering the pool level greater than 2 feet below the Reactor Refuel Bridge
- Restarting the reactor after a shutdown for which the cause cannot be determined
- Removing a control rod offset mechanism from its installed position
- Any change to a beamport status or experiment

6.2.3 Any fuel element determined to be damaged will not be loaded into the core without a written evaluation by the Assistant Reactor Manager-Physics.

6.3 PROCEDURE CHANGES:

6.3.1 Any procedure change which has safety significance MUST be reviewed by the Reactor Procedure Review Subcommittee (RPRS) prior to its use. Changes to a procedure that are editorial and have no safety significance may be made by the Reactor Manager, Assistant Reactor Manager – Operations, or the LSRO. Temporary changes may be made to a procedure with the approval of the LSRO and another licensed operator.

6.3.2 All deviations from an approved procedure MUST be documented on a Deviation from Procedure Report (Attachment 9.1) and subsequently reviewed by the RPRS.

6.4 STANDING ORDERS:

6.4.1 A Standing Order is a special instruction relating to reactor or facility operation.

a. Standing Orders MUST be approved by the Reactor Manager <u>or</u> his designee.

b. Standing Orders are maintained in the Standing Order book located in the Control Room.

c. Standing Orders MUST be cancelled by the Reactor Manager <u>or</u> his designee.

d. Standing Orders shall be cancelled once they are incorporated into Operations procedures or the condition which caused the Standing Order to be issued no longer exists.

6.0 PROCEDURE (CONT.)

6.5 DAILY OPERATIONS:

6.5.1 OPERATING CREWS

a. The minimum staffing level for reactor operations will be 2 licensed operators, one of whom will be licensed as a Senior Reactor Operator.

b. In the case of an emergency, the level of staffing may be reduced to one Senior Reactor Operator and one *knowledgeable person.* This reduced staffing level shall be documented in the Console Logbook and the time minimized by calling in an additional licensed operator. The Reactor Manager or Assistant Reactor Manager – Operations shall be informed of this situation as soon as possible (Record 8.1).

6.5.2 SHIFT TURNOVER

a. Personnel shall not assume operational duties unless they are physically and mentally fit.

b. Shift turnover will provide oncoming operators with an accurate description of the overall facility status, emphasizing any work in progress or abnormal situations.

c. Oncoming personnel shall conduct a comprehensive review of the console log, shift turnover sheet, control panels, records, and status boards. **(LER 00-02) (LER 00-04)**

d. Both the oncoming and the outgoing LSROs shall independently ensure the sample irradiation sheets are up-to-date and correct.

e. At a time when facility conditions are stable, the off-going LSRO shall brief the oncoming shift concerning:

- Reactor plant and facility conditions
- Turnover note items
- Abnormal conditions
- Upcoming activities

6.0 PROCEDURE (CONT.)

6.5.3 CONTROL ROOM OCCUPANCY

a. The Control Room MUST be occupied by one licensed Operator having the ability to communicate with a second licensed Operator within the facility whenever:

- The reactor is in operation. **(TS 1.17)**

  OR

- The key is in the Master Control Switch.

  OR

- Maintenance is in progress on reactor instrumentation and control.

b. A licensed Operator will sign in the Console Watch Log as the Console Watch and MUST remain in the Control Room until:

- Properly relieved by another licensed Operator.

  OR

- A shutdown checksheet has been performed (if leaving the Control Room unoccupied for greater than 8 hours).

  OR

- The conditions of Step 6.5.3.a **DO NOT** require the Control Room to be occupied. Then the Control Room boundary may be expanded to include the Reactor Bridge.

c. The Console Watch is responsible for operating all instrumentation and controls within the Control Room.

d. In the case of an emergency (as with 6.5.1 (b)), the Control Room MUST be occupied by one licensed Senior Reactor Operator having the ability to communicate with a second *knowledgeable person*.

e. Only those persons authorized by the Reactor Manager or LSRO will have access to the control room during reactor operation.

6.5.4 OPERATING PARAMETERS

a. The reactor will be operated in Mode I only.

b. Mode I normal operating parameters are shown in Table 10.1.

c. Mode I alarm, rod run-in, and scram trip set points are shown in Table 10.2.

6.0 PROCEDURE (CONT.)

6.5.5 CONSOLE LOG **(TS 6.1.g (1)-(6))** (Record 8.1)

a. The Console Log will be maintained by the Console Watch and it will provide a detailed diary of reactor operation including but not limited to:

- Maintenance operations involving substitution or replacement of reactor equipment or components
- Records of experiments, tests and measurements
- Routine Patrols and Security Routines
- Reactor Startup information
- Power level changes
- Abnormal Conditions
- Completion of Compliance procedures, evolutions fulfilling Technical Specification requirements, and Preventative Maintenance items
- Reactor Shutdowns

b. Console Log wording will be at the discretion of the operator as long as the entry contains all necessary information.

6.5.6 OPERATING LOGS – STEADY STATE OPERATION

a. A complete set of Nuclear Data will be taken every hour (Reference 7.1, Record 8.2).

b. A complete set of Process Data will be taken every 2 hours (Reference 7.1, Record 8.2).

c. Startup Nuclear Data entries (Power level, Date, Time Arrival and Time Departure) will be taken every day (Reference 7.2, Record 8.3).

d. All operating logs shall be independently reviewed for completeness, accuracy and for the emergence of trends.

e. The LSRO MUST be notified of all out-of-spec conditions or parameters.

6.5.7 ROUTINE PATROL (Reference 7.3, Record 8.4)

a. While the reactor is <u>operating</u>, a routine patrol of the facility should be completed every 4 hours.

b. The LSRO MUST be notified of all out-of-spec conditions or parameters.

6.0 PROCEDURE (CONT.)

6.5.8 SECURITY ROUTINE

NOTE: Security Routines shall NOT be conducted at the same times every day in order to maintain randomness.

NOTE: Security Routines are not required during *standard working hours*.

a. A security routine of the facility shall be completed every 4 hours.

b. When the reactor is operating, a security routine of the facility shall be completed every 4 hours alternating with the routine patrol.

c. A security routine shall be completed prior to shift turnover after *standard working hours*.

6.5.9 CORRECTIONS TO A RECORD

6.5.9.1. Corrections to document entries should be made as follows:

a. Corrections to Nuclear Data, Process Data and Routine Patrol operating logs should be made as follows:

- Draw a single line through the incorrect entry
- Initial the lineout
- Write the correct entry

b. Corrections to all other document entries should be made as follows:

- Draw a single line through the incorrect entry
- Initial the lineout and include the time and date the correction was made
- Write the correct entry

6.5.9.2 Corrections to late (original) entries in the console logbook should be made as follows:

- Enter the current time
- On the text line write "LATE ENTRY (time and date of original event occurrence)"
- Write the text of the entry

6.0 PROCEDURE (CONT.)

6.5.10 REACTOR POOL BRIDGE RADIATION MONITOR

a. The Reactor Pool Bridge Radiation Monitor Upscale Switch may be temporarily set upscale during periods of maintenance and sample handling. During this period the indication MUST be closely monitored. **(TS 3.4.a.2)**

6.5.11 POST MAINTENANCE VALVE LINE-UPS **(LER 04-01)**

a. To prevent breaches in configuration control due to valve mis-positioning errors and to enhance equipment and personnel safety, valve line-up checksheets will be performed on all systems as part of equipment post maintenance testing. This includes all activities controlled by Compliance Procedures, Preventative Maintenance Procedures, Modification Records, and any Corrective Maintenance Procedure or Sequence (i.e., Work Packages).

b. Systems, Compliance Procedures, and Preventative Maintenance Procedures for which formal valve line-up checksheets have not yet been created, the Lead Senior Reactor Operator will use FM-93 (Reference 7.21, Record 8.10) and complete the valve number, description, and position sections. The position section will state the NORMAL operating position of the valve.

c. It is up to the discretion of the Lead Senior Reactor Operator to what extent a valve line-up checksheet should be completed, but at a minimum, shall include all valves that were manipulated during the maintenance or modification task.

6.6 REACTOR STARTUP:

6.6.1 PROCEDURES

a. Startup of the reactor will be in accordance with approved procedures.

- OP-RO-210, "Reactor Startup – Normal" (Reference 7.4)
- OP-RO-211, "Reactor Startup Procedure – Hot" (Reference 7.5)
- OP-RO-212, "Reactor Startup – Recovery from Temporary Power Reduction" (Reference 7.6)

6.0 PROCEDURE (CONT.)

6.6.2 REACTOR STARTUP CHECKSHEETS (Reference 7.7 and 7.8)

a. A Long Form Startup Checksheet MUST be completed before operation of the Reactor under the following circumstances (Record 8.5):

1. After any refueling evolution.

   OR

2. After any shutdown period of at least 8 hours.

   OR

3. After a Shutdown Checksheet has been completed (Reference 7.9).

   OR

4. If the LSRO determines its necessity.

b. A Short Form Startup Checksheet may be used and MUST be completed before operation of the Reactor under the following circumstances (Record 8.6):

1. A Long Form Startup Checksheet has been completed within the past 8 hours OR the Reactor has been operating at power within the past 8 hours.

   AND

2. The LSRO has determined that Systems and Instrumentation NOT covered by the Short Form have NOT been adversely affected during the shutdown.

c. A Startup Checksheet is NOT required to be completed before operation of the Reactor under the following circumstances:

1. The startup is a return to power within 2 hours of a shutdown.

   AND

2. The LSRO has determined that Systems and Instrumentation covered by the Long Form Startup Checksheet have NOT been adversely affected during the Shutdown.

6.0 PROCEDURE (CONT.)

6.6.3 REACTOR STARTUP CHECKSHEETS – TIME LIMIT REQUIREMENTS

a. If a Long Form Startup Checksheet is required:

1. The checks MUST be completed within 8 hours of starting, or a new Checksheet MUST be started.

   AND

2. A Reactor Startup MUST be commenced within 8 hours of the start of a Long Form Startup Checksheet. The time limit for the commencement of the Startup may be extended (one time) an additional 4 hours at the discretion of the LSRO by the completion of a Short Form Startup Checksheet.

6.6.4 NUCLEAR INSTRUMENTATION – STARTUP

a. The minimum nuclear instrumentation required to perform a reactor startup shall be the following: **(TS 3.3.a, 3.4.a, 3.4.c)**

- One Source Range channel
- Two Intermediate Range channels, each with period trips
- Three Power Range channels, each with high power trips

6.6.5 ESTIMATED CRITICAL POSITION (ECP)

a. Assistant Reactor Manager will provide an uncorrected ECP.

b. The LSRO shall ensure the provided uncorrected ECP is reliable, based on 1/M calculation.

c. A 1/M criticality calculation shall be performed for all *normal reactor startups*.

d. Any startup in which the reactor is not critical within ECP limits MUST be discontinued according to Reactor Startup procedures (Reference 7.4 and 7.5) AND:

- Notify the Assistant Reactor Manager – Physics
- Resolve any discrepancy between the ECP and the 1/M predicted critical position
- Obtain permission to continue startup from the Reactor Manager or Assistant Reactor Manager

6.0 PROCEDURE (CONT.)

6.6.6 CONTROL BLADE OPERATION

a. Control Blades will not be moved in gang control with the reactor critical except to perform the following:

- Reduce power
- Reactor Shutdown
- *Hot Reactor Startup*

b. Ganged Control Blades, or any single Control Blade, will not be withdrawn at the same time as the Regulating Blade.

c. Above 100 kilowatts, the reactor shall be operated so that the maximum distance between the highest and lowest shim blade shall not exceed 0.90 inches.

6.6.7 STARTUP FOLLOWING EXPERIMENT CHANGES – RADIATION MONITORING

> NOTE: Reactor Health Physics MUST monitor Beamport or other reactor experiments during a reactor startup when changes to Beamport or other experiments could result in an undefined radiation hazard.

a. Establish and maintain communications between the Control Room and Reactor Health Physics prior to commencing and during the startup. If communications are lost or not acknowledged, then the reactor MUST be maintained at a steady power level until communications are reestablished.

b. NOTIFY Reactor Health Physics at the following levels:

1. During a *Normal Reactor Startup*:
   - 50 kW
   - 5 MW
   - 10 MW
2. During a *Hot Reactor Startup*:
   - 5 MW
   - 10 MW

c. Health Physics shall inform the Control Room of the completed survey results at the final power level.

6.0 PROCEDURE (CONT.)

6.6.8 STARTUP FOLLOWING AN *UNSCHEDULED SHUTDOWN*

a. The reactor will not be started up following an *unscheduled shutdown* until the cause of the *unscheduled shutdown* has been determined, and safe corrective action taken. If, after thorough investigation, the cause cannot be determined and all systems are normal, the reactor may be started up with the approval of the Reactor Manager.

6.6.9 *HOT REACTOR STARTUP* (Reference 7.5)

a. A *Hot Reactor Startup* shall be performed by a Senior Reactor Operator <u>or</u> Reactor Operator under the direct supervision of a Senior Reactor Operator.

6.6.10 OPERATOR CHANGE DURING A STARTUP OR POWER TRANSIENT

a. Transfer of control of the reactor during a reactor startup <u>MUST be completed</u> with the control rods <u>at least 2" below</u> the ECP, unless prior approval is received from the Reactor Manager.

b. Control of the reactor will <u>not</u> be transferred from one operator to another during a power transient.

6.7 <u>FULL POWER OPERATION</u>:

6.7.1 NUCLEAR INSTRUMENTATION – STEADY STATE OPERATION

a. Power Range Monitor Channels 4, 5, and 6 indication shall be maintained between 100% and 105%.

b. The minimum nuclear instrumentation shall be the following: **(TS 3.3.a, 3.4.c)**

- Two Intermediate Range channels, each with period trips
- Three Power Range channels, each with high power trips

6.7.2 POWER MANAGEMENT

<u>NOTE</u>: If the Primary Power Calculator is operating and indicating accurately, it can be used for all power calculations. Manual power calculation by heat balance is always acceptable.

a. Full power steady-state operating level should be maintained between 9.90 MW and 10.0 MW.

b. ENSURE steady-state operating power level <u>does not</u> exceed 10.0 MW.

6.0 PROCEDURE (CONT.)

NOTE: The primary/pool system manual heat balance calculation is performed by: [(total average primary flow of each loop – primary demineralizer flow)$(T_h - T_c)_{primary}$ + (average pool flow)$(T_h - T_c)_{pool}$] 0.000144

NOTE: The secondary system manual heat balance calculation is performed by: [(secondary flow) $(T_h - T_c)_{secondary}$] 0.0292

c. Power levels MUST be calculated for any steady-state power operation of greater than 1 MW.

d. Any difference between the primary and secondary heat balance that is greater than 5 % (0.5 MW), should be investigated.

e. The reactor shall not be operated at a power level that generates a secondary heat balance of greater than 10.5 MW.

NOTE: When adjusting Power Range Monitor Level indication, it is preferable to have indicated power equal to or slightly greater than the manually calculated power.

f. The LSRO has the discretion to adjust Power Range Monitor Level indication to agree with a manually calculated power level by heat balance. Power Range Monitor Level indication may be adjusted when an accurate heat balance is not obtainable – due to changing temperatures – only during or immediately following a reactor startup.

6.8 REACTOR SHUTDOWN:

6.8.1 Shutdown of the reactor will be in accordance with approved procedure OP-RO-220, "Reactor Shutdown or Power Reduction" (Reference 7.10).

6.8.2 A console logbook entry will be made stating that the reactor is shutdown.

6.8.3 A Form FM-19, "Unscheduled Power Reduction Report" (Reference 7.11, Record 8.7), and a Corrective Action Program (CAP) (Record 8.8) entry MUST be completed for any *unscheduled shutdown* or unplanned rod run-in.

6.8.4 Entry into Room 114 following a reactor shutdown shall be preceded by a Reactor Health Physics radiation survey or be in accordance with RP-HP-135, "Room 114 Entry – Self Monitored" (Reference 7.12). **(ALARA) (HSR 10.3)**

6.0 PROCEDURE (CONT.)

6.8.5 A Reactor Shutdown Checksheet (Reference 7.9, Record 8.9) MUST be performed if the Control Room or expanded Control Room boundary will be unattended.

6.9 EXPERIMENTS:

6.9.1 EXPERIMENT EVALUATION

a. All experimental programs that will be run in the reactor will be evaluated by the Reactor Manager and approved under a Reactor Utilization Request (RUR).

b. Experimenters requesting irradiation of material previously not run at MURR shall complete a RUR form. This request MUST be reviewed and approved by the Reactor Manager.

c. Experimenters requesting the use of Beamport experiments shall complete an Experiment Authorization request or be approved to work under an existing Experiment Authorization. This request MUST be reviewed by the Reactor Health Physics Manager and Reactor Manager.

d. Experimenters MUST complete an indoctrination training course covering the relationship between their experiment and reactor operations, emergency procedures, and radiation safety.

6.9.2 EXPERIMENT OPERATION

a. The insertion and removal of experiments in the center test hole position shall be done with the reactor shutdown. Small Flux Trap samples may be inserted and removed with the reactor in operation in accordance with EX-RO-105, "Reactor Irradiation Experiments." **(T.S. 3.6.e)**

b. Experimenters MUST inform the Control Room of an activity that may affect reactor operation.

c. Beamport shutters will be operated only with authorization from the Control Room.

d. Any change to the Beamport liner status should be made after the reactor has been shutdown for <u>greater than</u> 8 hours. Any deviation from this requirement MUST be authorized by the Reactor Manager. **(LER 75-01)**

e. Health Physics MUST monitor Beamport <u>or</u> other reactor experiments during a reactor startup, when changes to Beamport or other experiments could result in an undefined radiation hazard.

6.0 PROCEDURE (CONT.)

6.10 MODIFICATION RECORDS: (Reference 7.13)

a. Any change to reactor license related systems as described in the Hazards Summary Report MUST have a modification evaluation completed prior to the modification.

b. The modification record MUST include the bases for the modification and a 10 CFR 50.59 screen or evaluation.

6.11 OPERATOR AIDS:

a. An Operator Aid is a set of instructions or information posted at or near a piece of equipment that will give the user additional information on how to operate equipment or interpret equipment or system condition.

b. Operator Aids will be labeled and treated as controlled documents.

6.12 RADIATION WORK PERMIT: (Reference 7.14)

6.12.1 A Radiation Work Permit (RWP) will be completed as determined by the LSRO and for any non-routine work that could result in the following:

- Radiation exposure rate of greater than 100 mR/hr
- Potential to release radioactive airborne contamination or produce unusual surface contamination.

6.13 REACTOR OPERATOR LICENSE MAINTENANCE:

6.13.1 Each licensed person will complete the training requirements of the MURR Licensed Operator Requalification Program.

6.13.2 To maintain active status, each licensed operator will assume the duties of RO or SRO, as applicable, for a minimum of eight consecutive hours per calendar quarter. The watch shall include a shift turnover and the performance of a Reactor Routine Patrol or Long Form Startup Checksheet.

6.13.3 Failure to complete any of the Requalification Program requirements within the specified time will result in the individual's license becoming administratively inactive.

6.13.4 Individuals without an active license may not assume any licensed duties.

6.0 PROCEDURE (CONT.)

6.13.5 To reactivate the individual's license, the Reactor Manager MUST certify that:

a. A minimum score of 70% on each section of the previous Biennial Requalification Examination has been obtained.

b. Previous years Annual On-The-Job Requirements / Checklist (Reference 7.15) <u>and</u> Annual Operating Test Records (Reference 7.16) are complete.

c. The licensee has completed <u>at least</u> six hours of under instruction watch and <u>at least</u> 8 hours of licensed Reactor Operator or Lead Senior Reactor Operator duties (Reference 7.17).

7.0 REFERENCES

7.1 FM-43, "Nuclear and Process Data"

7.2 FM-55, "Startup Nuclear Data"

7.3 FM-56, "Reactor Routine Patrol"

7.4 OP-RO-210, "Reactor Startup – Normal"

7.5 OP-RO-211, "Reactor Startup – Hot"

7.6 OP-RO-212, "Reactor Startup – Recovery from Temporary Power Reduction"

7.7 FM-57, "Long Form Startup Checksheet"

7.8 FM-58, "Short Form Startup Checksheet"

7.9 FM-11, "Reactor Shutdown Checksheet"

7.10 OP-RO-220, "Reactor Shutdown or Power Reduction"

7.11 FM-19, "Unscheduled Power Reduction Report"

7.12 RP-HP-135 "Room 114 Entry- Self Monitored"

7.13 AP-RO-115, "Modification Records"

7.14 AP-HP-105, "Radiation Work Permit"

7.15 MURR Operator Requalification Program, Appendix A, "Annual On-The-Job Requirements/Checklist"

7.0 REFERENCES (CONT.)

7.16 "Annual Operating Test Records"

7.17 FM-61, "MURR Operator Active Status Log"

7.18 FM-33, "Containment Building Restricted Materials"

7.19 EX-RO-105, "Reactor Irradiation Experiments"

7.20 OP-RO-741, "Waste Tank System Operation"

7.21 FM-93, "Post Maintenance Valve Line-Up Checksheet"

8.0 RECORDS

8.1 Reactor Control Room Console Logbook

8.2 FM-43, "Nuclear and Process Data"

8.3 FM-55, "Startup Nuclear Data"

8.4 FM-56, "Reactor Routine Patrol"

8.5 FM-57, "Long Form Startup Checksheet"

8.6 FM-58, "Short Form Startup Checksheet"

8.7 FM-19, "Unscheduled Power Reduction Report"

8.8 Corrective Action Program (CAP)

8.9 FM-11, "Reactor Shutdown Checksheet"

8.10 FM-93, "Post Maintenance Valve Line-Up Checksheet"

9.0 ATTACHMENTS (Obtain "Controlled" copy from MURR Intranet)

9.1 FM-18, "Deviation From Procedure Report"

9.2 FM-93, "Post Maintenance Valve Line-Up Sheet"

10.0 TABLES

10.1 Normal Reactor Operating Parameters

10.2 Nominal Alarm, Rod Run-In, And Scram Trip Setpoints (10 MW)

DEVIATION FROM PROCEDURE REPORT

Date:______________________

1. Procedure Number, Title, Revision Number, and Section:__________________________

____

2. Reason for deviation from procedure:____

____

____

____

____

____

Submitted by:

____

Lead Senior Reactor Operator / Licensed Operator (temporary change)

Reviewed by:

____

Reactor Manager

☐ Reviewed by Reactor Procedures Review Subcommittee (RPRS)

_______________ _______________
Date Initials

Disposition recommended by RPRS:

☐ Procedure Revision Required

☐ Procedure Revision Not Required

FM-93
Revision 2

POST MAINTENANCE VALVE LINE-UP CHECKSHEET

This checksheet will be completed when required by the Lead Senior Reactor Operator (LSRO). The operators performing the check will independently verify the position of each valve and indicate the verification by initialing the checksheet. Where appropriate, the positions of throttled valves are shown on a permanent tag secured to the valve. Note throttled valve's position on the checksheet.

Date Performed:________________

VALVE	VALVE DESCRIPTION	POSITION	PERFORMER	VERIFIER

COMMENTS:____

____

____

____

____

Page ____ of ____

Reset Form

NORMAL REACTOR OPERATING PARAMETERS

NORMAL OPERATING RANGES (10 MW)

PARAMETERS	NORMAL OPERATING RANGE	UNITS
Thermal Power	9.5 to 10.0	MW
Primary Coolant Flow	3750 to 3850	gpm
Pool Coolant Flow	1150 to 1250	gpm
Pressurizer Pressure	66 to 74	psig
Pressurizer Level	-6 to +2	inches
Pool Level	29′ 4″ to 29′ 10″	feet-inches

NORMAL OPERATING VALUES (10 MW)

PARAMETERS	NORMAL OPERATING VALUE	UNITS
Reactor Coolant Outlet Temperature	136	°F
Reactor Coolant Inlet Temperature	120	°F
Pool Outlet Temperature	106	°F
Pool Inlet Temperature	100	°F
Primary Coolant Temperature Controller S-1 Demand Set	120	°F
Pool Coolant Temperature Controller S-2 Demand Set	100	°F

NOMINAL ALARM, ROD RUN-IN, AND SCRAM TRIP SETPOINTS (10 MW)

	SCRAM	ROD RUN-IN	ALARM	UNITS
Short Period	9	11		seconds
Low Count Rate			20	cps
High Power	119	114		% full power
RC Inlet High Temp (TE-901A)			140	°F
RC Outlet High Temp (TE-901B)	168		160	°F
RC Sys Low Flow (FT-912 A/E)	[1]1725		[1]1800	gpm
RC Sys Low Flow (FT-912 G/H)	[1]1725		[1]1800	gpm
RC HX High Temp (TE-980A/B)	[1]148			°F
RC Sys Low Pressure (PT-944 A/B)	[2]63			psig
RC Sys Low Pressure (PT-943)	[2]63			psig
Core Low ΔP (DPS-929)	[3]3400			gpm
Pressurizer Low Level (LC-935)	13-14 below CL		10 below CL	inches
Pressurizer High Level			12-15 above CL	inches
Pressurizer Low Pressure (PS-938)	63		65	psig
Pressurizer High Pressure (PS-939)	78		75	psig
Pool Sys Low Flow (FT-912 D/F)	[1]980		[1]1060	gpm
Pool Sys High Temperature (TE-901C)			115	°F
RC Demin Low Flow (FT-912B)			42.5	gpm
PC Demin Low Flow (FT-912C)			42.5	gpm
RC HighConductivity			2	µS
PC High Conductivity			2	µS
High Reflector ΔP (PT-917)	7			psi
Low Reflector ΔP (PT-917)	3			psi
Nitrogen Sys Low Pressure			110-115	psig
Seal Trench Low Level			5	feet

[1]Alarm and / or Scram received from either loop
[2]Pressurizer pressure with normal primary system flow
[3]ΔP corresponding to this flow value

Table 10.2

NOMINAL ALARM, ROD RUN-IN, AND SCRAM TRIP SETPOINTS (10 MW)

	SCRAM	ROD RUN-IN	ALARM	UNITS
High/Low Tank T-300 Level			6200 / 2500	gallons
High/Low Tank T-301 Level			6000 / 100	gallons
Off-Gas High Activity			CP-29 / 31 Data	cpm
Anti-Siphon Line High Level		≤ 6 above valves		inches
Pool Low Level	> 24	> 28		feet
Regulating Blade		≤ 10% or bottomed	<20% or >60%	% withdrawn
Vent Tank Low Level (LC 925A/B)		7 to 11 Below CL		inches
Secondary Coolant Low Flow			9×10^5	lb/hr
Secondary Coolant High Temp			115	°F
Channel 4, 5, or 6 Downscale			< 95	% of full-scale
Valve 546 A or B			off closed	
Valve 509	off open			
Valve 547			off open	
Valve 507 A or B	off open		closed with Pump P-501 on	
Valve S-1			80% open or 80% closed	
Nuclear Instrument	[4] anomaly			
Anti-Siphon System Low Pressure			30	psig
Anti-Siphon System High Pressure			40	psig
Thermal Column Door			open	
Truck Entry Door		seal deflated		
Evacuation Reactor Isolation	manual manual / auto			

[4] Any channel will scram on NI anomaly except WRM

3.5 Analysis of Rapid Step Reactivity Insertions from Full Power in the MURR

Previous studies (1,2) have evaluated extensively the expected results of a sudden positive step insertion of reactivity in the MURR. Addendum II to the Hazards Summary Report (2) concluded that the MURR could withstand a positive step insertion of 0.008 ΔK without fuel damage. This study was based on an initial power level of 10 MW, nominal flow, pressure, and reactor temperature conditions and the calculated core temperature and void coefficients of -7×10^{-5} $\Delta K/K/^{\circ}F$ and -2×10^{-3} $\Delta K/\%$ void respectively. During the initial startup and calibration of the MURR, these two parameters were observed to differ from the calculated values, and the MURR technical specifications were changed to require these numbers to be more negative than -3×10^{-5} $\Delta K/K/^{\circ}F$ and -1.2×10^{-3} $\Delta K/\%$ void respectively. Core voiding and temperature increase are the two major negative reactivity feedback mechanisms which halt the rapid power escalation following a positive step reactivity insertion, therefore it was concluded that the maximum tolerable step insertion and hence the maximum experiment worth, should be reduced to $+0.004$ ΔK.

During the low power testing program for the MURR's 6.2 kilogram uranium-aluminide core, the temperature and void coefficients were carefully remeasured and found to be very close to the original calculated values. The quantities observed were -7.0×10^{-5} $\Delta K/K/^{\circ}F$ and 2.51×10^{-3} $\Delta K/\%$ void respectively (3).

As part of the safety evaluation for power upgrade to 10 mw, a third study was undertaken to determine the maximum step reactivity insertion the MURR can withstand with no core damage. The MURR was modeled with a transient code ideally suited for this type of study; the Chic-Kin (4) computer code originating at Bettis Atomic Power Laboratory. This code combines hydraulic and heat transfer analysis with reactor kinetics to predict the power, temperature and pressure changes during reactor transients for either pin or plate type fuel. Rather than considering transients from nominal conditions, for this study the reactor was modeled with all critical parameters set to their scram values, i.e., the worst possible conditions for full power operation of the MURR (5). From previous work (6), the most conservative steady state power level at which burnout could occur was determined to be 25.23 mw. Therefore for a power transient starting from 11 mw, fuel plate failure would be conservatively predicted at steady state operation with power increased to a factor of 2.3 of its initial value. Figure 3.5.1 presents the normalized power increase factor versus time after the step insertion from the Chic-Kin code. Consistent with previous studies (1,2), it may be assumed that the MURR fuel can withstand the prompt power burst, since it is of such short time duration, and that fuel failure will occur at the hot spot only when the reactor continues in sustained operation with a normalized power increase factor greater than or equal to 2.3.

Figure 3.5.1 thus indicates that the MURR can withstand a positive step insertion of 0.006 ΔK. Experimental evidence indicates that one of the two short period trip circuits or one of three high power trips in the MURR safety system will initiate a scram within at least 115 milliseconds. Sufficient redundancy certainly exists to ensure that a post burst scram will occur. Experimentally observed (7) rod worth data and rod drop times enabled the modeling of a scram at 150 milliseconds after the step insertion by the Chic-Kin code. Figure 3.5.2 presents the expected reactivity insertion rate versus time after initiation of the scram. Figure 3.5.1 demonstrates that such a scram will safely shut the reactor down with no fuel damage.

Assumed parameters for this study are a core temperature and void coefficient of -6.0×10^{-5} ΔK/°F and -2.0×10^{-3} ΔK/% void. Experimental results have shown (3) that the MURR 6.2 kilogram core has temperature and void coefficients more negative than those cited. In summary, under the worst possible conditions, the MURR reactor can withstand a positive step insertion of +0.006 ΔK reactivity without core damage.

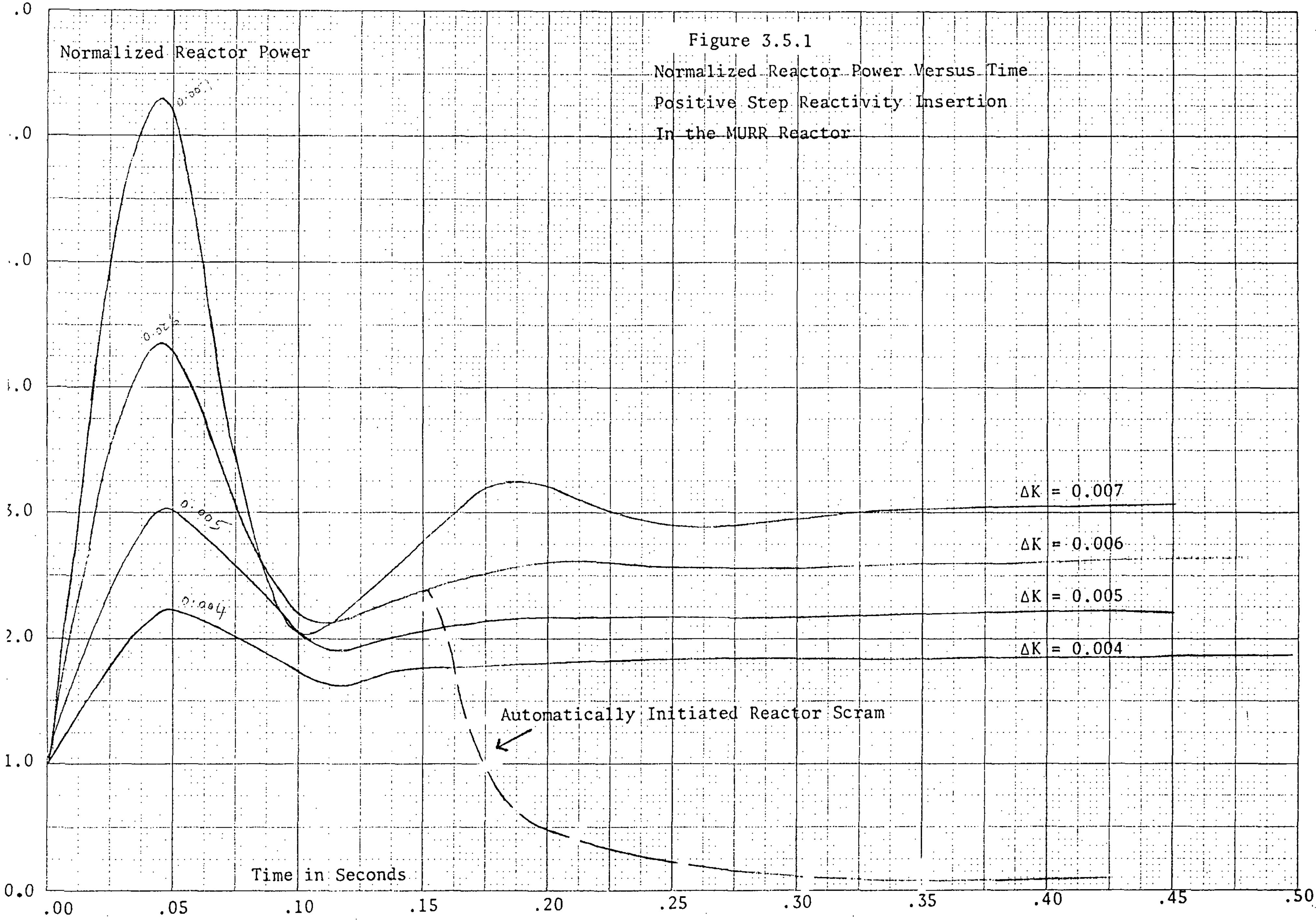
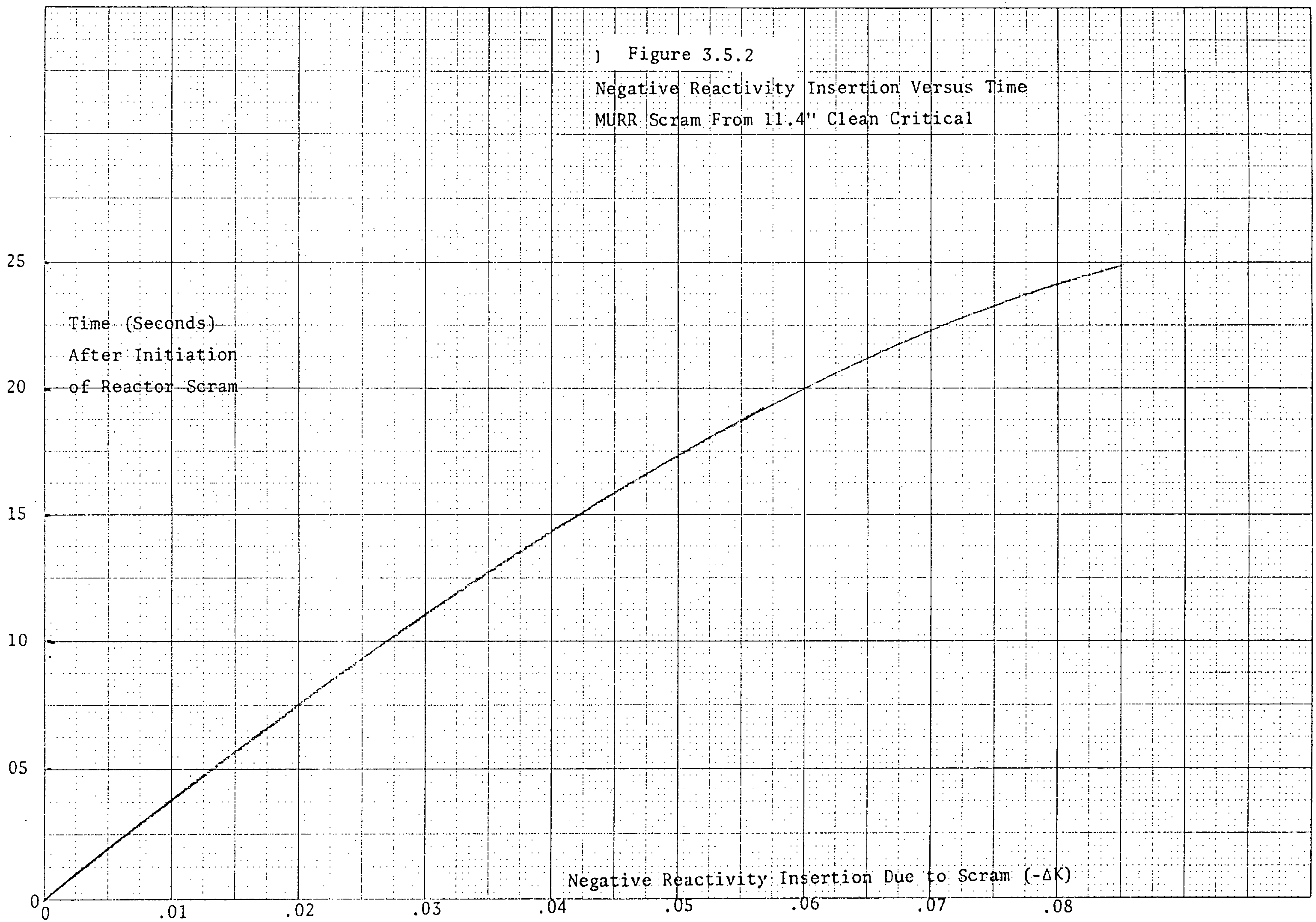


Figure 3.5.1
Normalized Reactor Power Versus Time
Positive Step Reactivity Insertion
In the MURR Reactor
Normalized Reactor Power
Time in Seconds
ΔK = 0.007
ΔK = 0.006
ΔK = 0.005
ΔK = 0.004
Automatically Initiated Reactor Scram
0.0
1.0
2.0
3.0
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50

Figure 3.5.2

Negative Reactivity Insertion Versus Time

MURR Scram From 11.4" Clean Critical



References

1. Hazards Summary Report, Addendum One, pp 53-79.
2. Hazards Summary Report, Addendum Two, pp 23-58.
3. Low Power Testing Program for the Missouri University Research Reactor 6.2 Kilogram Core, p 74.
4. JA Redfield, CHIC-KIN - A Fortran Program for Intermediate and Fast Transients in a Water Moderated Reactor, United States Atomic Energy Commission Report WAPD-TM-479 (1965).
5. Section 3.9, this report.
6. Section 3.2, this report.
7. Low Power Testing, Op. Cit., p 49.

ATTACHMENT 6

Compliance Check FIRST Scrams	**Frequency:** Semi-annually
Plant Conditions Reactor Shutdown Primary System Secured Pool System Secured FIRST Rig Installed Strainer Installed	**Number of Men Needed:** 2 **Estimated Time:** 30 minutes

Test Equipment, Tools and Materials
1. Jumpers
2. Shorted Relays
3. Bypass Key
4. Dummy Load Test Connector

References
Technical Specifications 3.1.g and 3.1.h
Print No. 139

Procedure

<u>FIRST - Scram (Yellow Leg)</u>

___1. Install Dummy Load Test Connector.
___2. Install jumper G-3 (bypass green leg of safety system).
___3. Install jumper Y-2 (reactor loop 'B1' low flow FT-912G).
___4. Install jumper Y-3 (Valve 509 off open).
___5. Install jumper Y-4 (reactor outlet low press PT-944A).
___6. Install jumper Y-5 (power level interlock).
___7. Remove relay K-25 (pressurizer low press PS-938) and install shorted relay in K-25 position.
___8. Remove relay K-30 (reactor loop 'A1' low flow FT-912A) and install shorted relay in K-30 position.
___9. Remove relay K-31 (pool loop low flow FT-912F) and install shorted relay in K-31 position.
___10. Place Master Control Switch 1S1 to '<u>ON</u>' position.
___11. Place Magnet Current Switch 1S14 to '<u>ON</u>' position.
___12. Reset scram TAAs.
___13. Remove strainer.
___14. VERIFY scram TAA's and magnet current to zero________________.
___15. Place FIRST Bypass Key Switch 1S29 to '<u>BYPASS</u>' position.
___16. Reset scram TAAs.
___17. Place FIRST Bypass Key Switch 1S29 to '<u>OFF</u>' position AND remove key.
___18. VERIFY scram TAAs and magnet current to zero________________.
___19. Install strainer.
___20. Place Magnet Current Switch 1S14 to '<u>OFF</u>' position.
___21. Place Master Control Switch 1S1 to '<u>OFF</u>' position.
___22. Remove jumper Y-5.
___23. Remove jumper Y-4.
___24. Remove jumper Y-3.

APPROVED:______________________________
Reactor Manager

___25. Remove jumper Y-2.
___26. Remove jumper G-3.
___27. Remove shorted relay from K-31 position and install relay K-31.
___28. Remove shorted relay from K-30 position and install relay K-30.
___29. Remove shorted relay from K-25 position and install relay K-25.

FIRST - Scram (Green Leg)

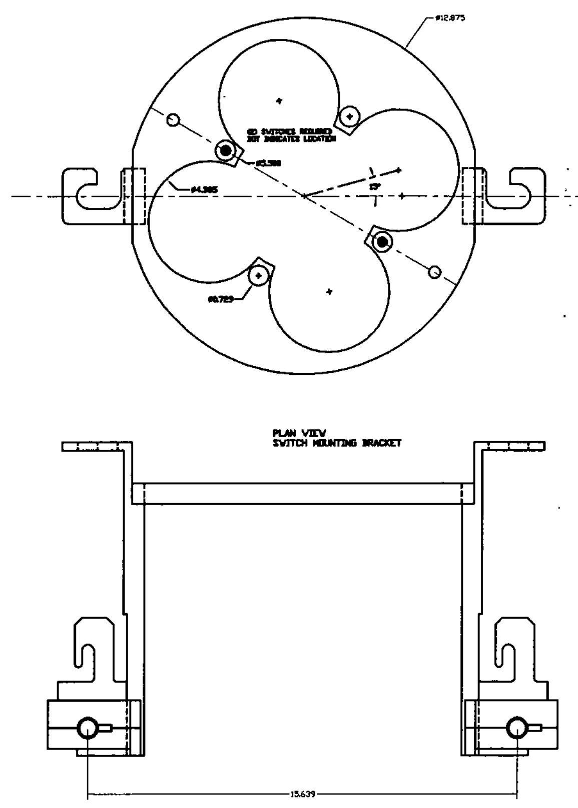
___30. Install jumper Y-1 (bypass yellow leg of safety system).
___31. Install jumper G-5 (power level interlock).
___32. Install jumper G-9 (reactor loop low press PT-943).
___33. Install jumper G-10 (reactor outlet low press PT-944B).
___34. Install jumper G-11 (reactor loop 'B2' low flow FT-912H).
___35. Install jumper G-27 (Reflector D/P PT-917).
___36. Remove relay K-26 (pressurizer high press PS-939) and install shorted relay in K-26 position.
___37. Remove relay K-37 (pool loop low flow FT-912D) and install shorted relay in K-37 position.
___38. Remove relay K-38 (reactor loop 'A2' low flow FT-912E) and install shorted relay in K-38 position.
___39. Place Master Control Switch 1S1 to 'ON' position.
___40. Place Magnet Current Switch 1S14 to 'ON' position.
___41. Reset scram TAAs.
___42. Remove strainer.
___43. VERIFY scram TAAs and magnet current to zero________________.
___44. Place FIRST Bypass Key Switch 1S28 to 'BYPASS' position.
___45. Reset scram TAAs.
___46. Place FIRST Bypass Key Switch 1S28 to 'OFF' position and remove key.
___47. VERIFY scram TAAs and magnet current to zero________________.
___48. Place Magnet Current Switch 1S14 to 'OFF' position.
___49. Place Master Control Switch 1S1 to 'OFF' position.
___50. Remove jumper G-27.
___51. Remove jumper G-11.
___52. Remove jumper G-10.
___53. Remove jumper G-9.
___54. Remove jumper G-5.
___55. Remove jumper Y-1.
___56. Remove shorted relay from K-38 position and install relay K-38.
___57. Remove shorted relay from K-37 position and install relay K-37.
___58. Remove shorted relay from K-26 position and install relay K-26.
___59. ENSURE all jumpers, shorted relays and bypass keys have been removed.
___60. Remove Dummy Load Test Connectors and connect control rod drive mechanism cables.
___61. Log CP completed in the Console Log Book and Maintenance Day Book.

Date Completed:____________________

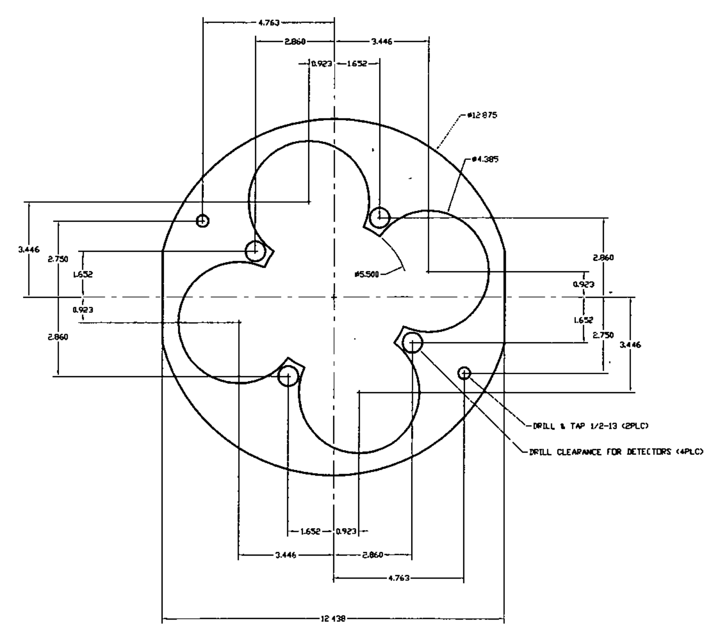
LSRO Signature:____

ATTACHMENT 7

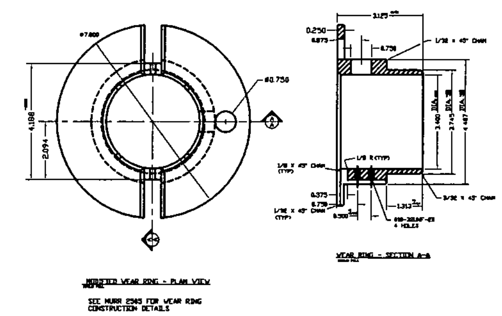
The limit switches that will be used on the flux trap modification were purchased from Seacon Advanced Products LLC, Bellville, TX. The part number is AU-LS-SD-C (MCR) and these are molded to a 50 foot cable.

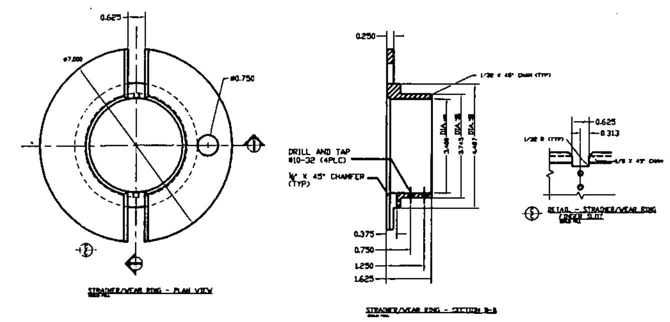


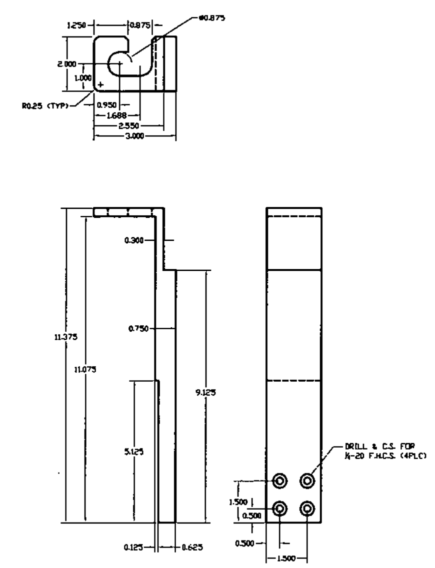
PLAN VIEW
SWITCH MOUNTING BRACKET



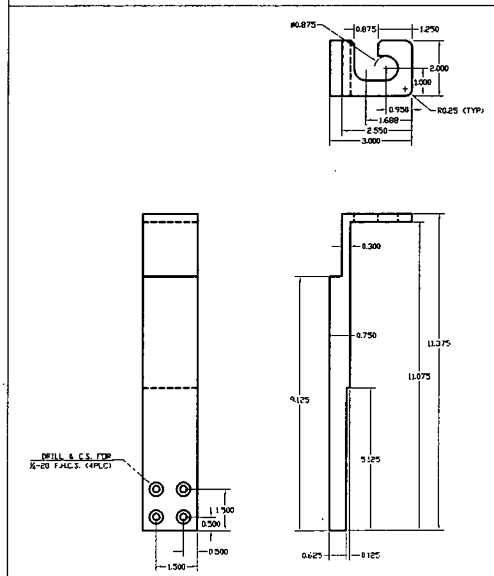
PART #1: SAFETY RIG SWITCH PLATE



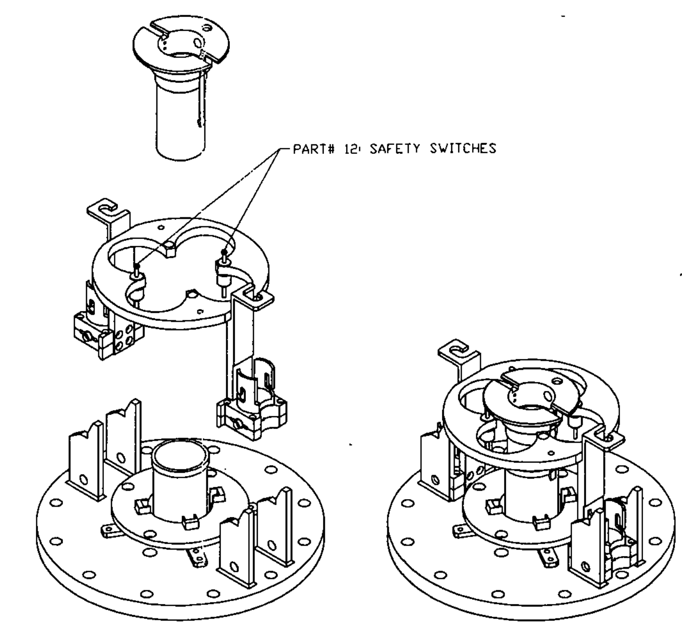


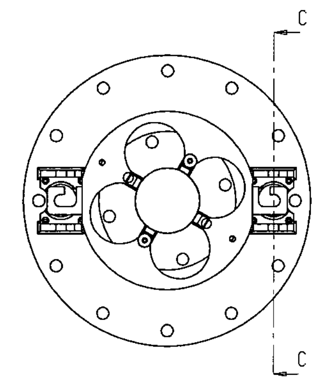


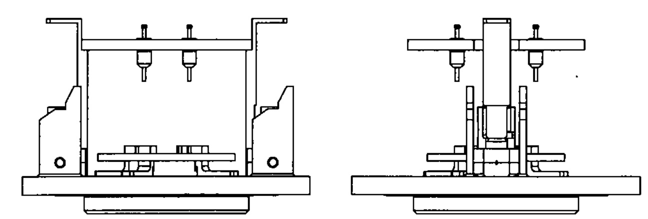
PART# 2: SAFETY RIG SUPPORT LEG #1

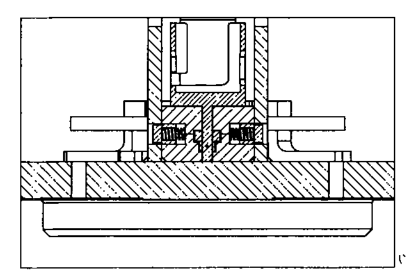


PART# 3: SAFETY RIG SUPPORT LEG #2









SECTION C-C

NO.	ITEM	DESCRIPTION	MATERIAL	NO. REQ'D.
12	SAFETY SWITCH	AU-LS-SD-C (MCR)	-	2
11	ENGAGEMENT PIN HOUSING (UPPER)	1" X 3 3/8" X 4 1/4" PLATE	ALUM. 6061-T6	2
10	ENGAGEMENT PIN HOUSING (LOWER)	1" X 3 3/8" X 4 1/4" PLATE	ALUM. 6061-T6	2
9	ENGAGEMENT PIN	O.D.: 3/4" X 0.85 LG	STAINLESS STEEL	4
8	ENGAGEMENT PIN GEAR RACK #2	BERG# R4-5	STAINLESS STEEL	2
7	ENGAGEMENT PIN GEAR RACK #1	BERG# R4-5	STAINLESS STEEL	2
6	ENGAGEMENT PIN SPRING	BERG# SPR1-8	STAINLESS STEEL	4
5	ENGAGEMENT PIN SPUR GEAR	BERG# P24S34-20	STAINLESS STEEL	2
4	ENGAGEMENT PIN KNOB	O.D.: 2 3/4" X 5" LG	ALUM. 6061-T6	2
3	SAFETY RIG SUPPORT LEG #2	2" X 3" X 12" STOCK	ALUM 6061-T6	1
2	SAFETY RIG SUPPORT LEG #1	2" X 3" X 12" STOCK	ALUM. 6061-T6	1
1	SAFETY RIG SWITCH PLATE	13" X 13" X 3/4" PLATE	ALUM 6061-T6	1

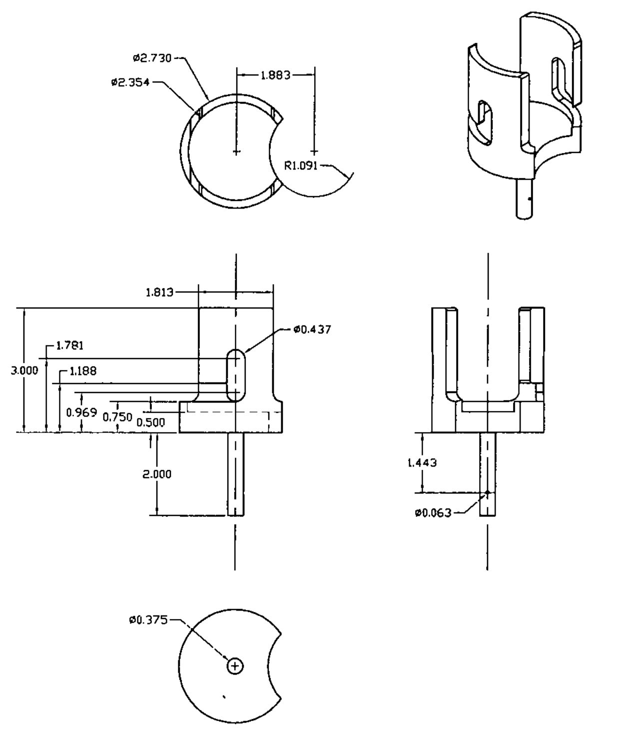
DATE: 11/20/2008
DRAWN BY: d.g.n.
CHECKED BY: ENGINEER:
CODE:
REVISION NUMBER: 0
REVISION DATE:

UNIVERSITY OF MISSOURI-COLUMBIA
REACTOR & FACILITIES OPERATIONS
research reactor facility

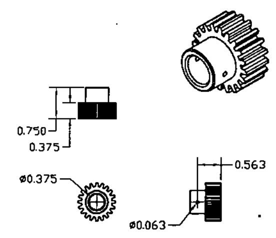
FLUX-TRAP IRRADIATIONS REACTIVITY SAFETY TRIP

MURR NUMBER: 2712

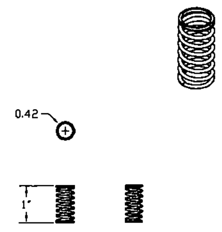
SHEET 1 OF 3



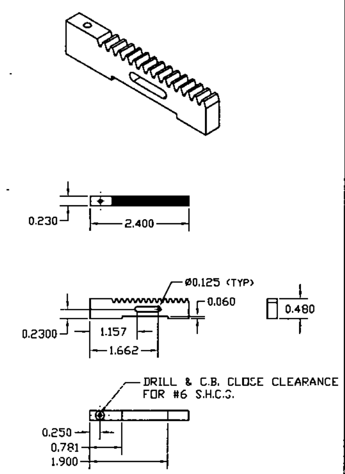
PART # 4: ENGAGEMENT CUPS
DETAILS



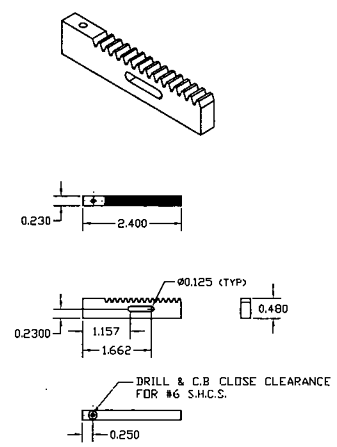
PART #5: ENGAGEMENT PIN PINION GEAR
DETAILS (BERG# P24S34-20)



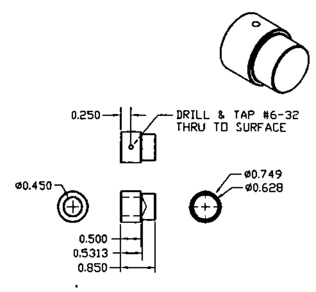
PART #6: ENGAGEMENT PIN SPRING
DETAILS (BERG# SFR1-8)



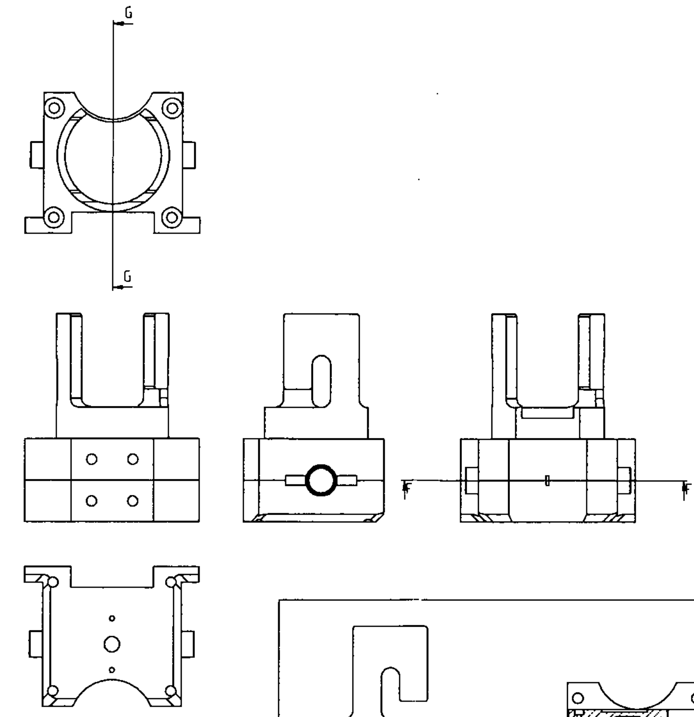
PART #7: ENGAGEMENT PIN RACK GEARS
DETAILS (BERG #R4-5)

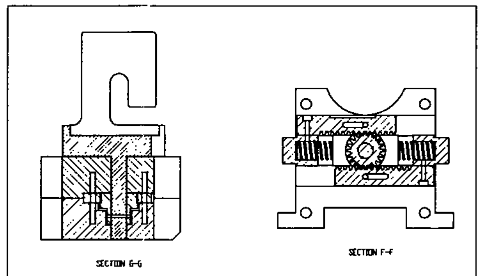


PART #8: ENGAGEMENT PIN RACK GEARS
DETAILS (BERG# R4-5)

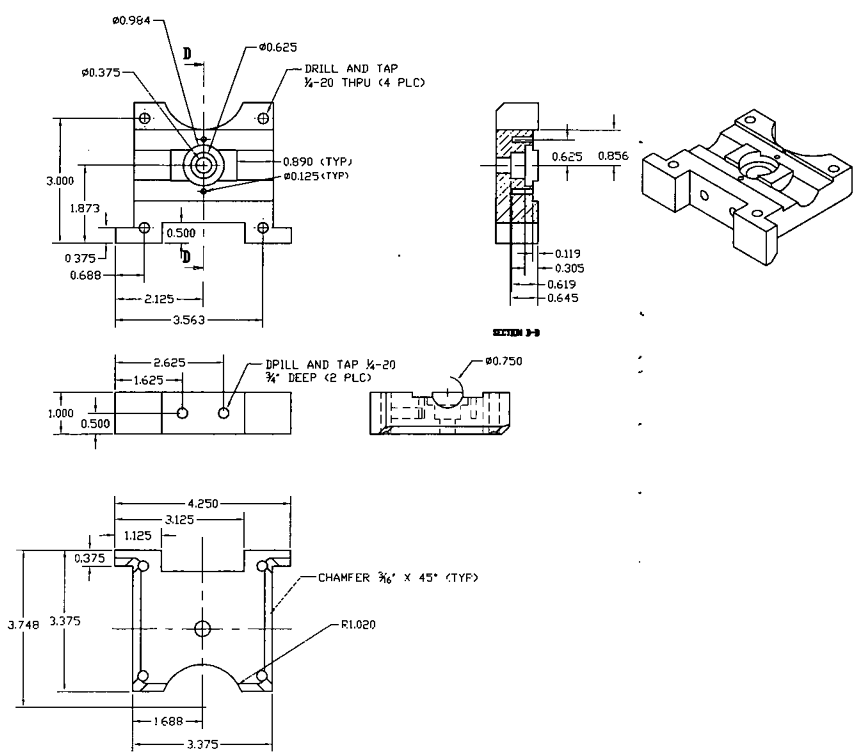


PART #9: ENGAGEMENT PIN

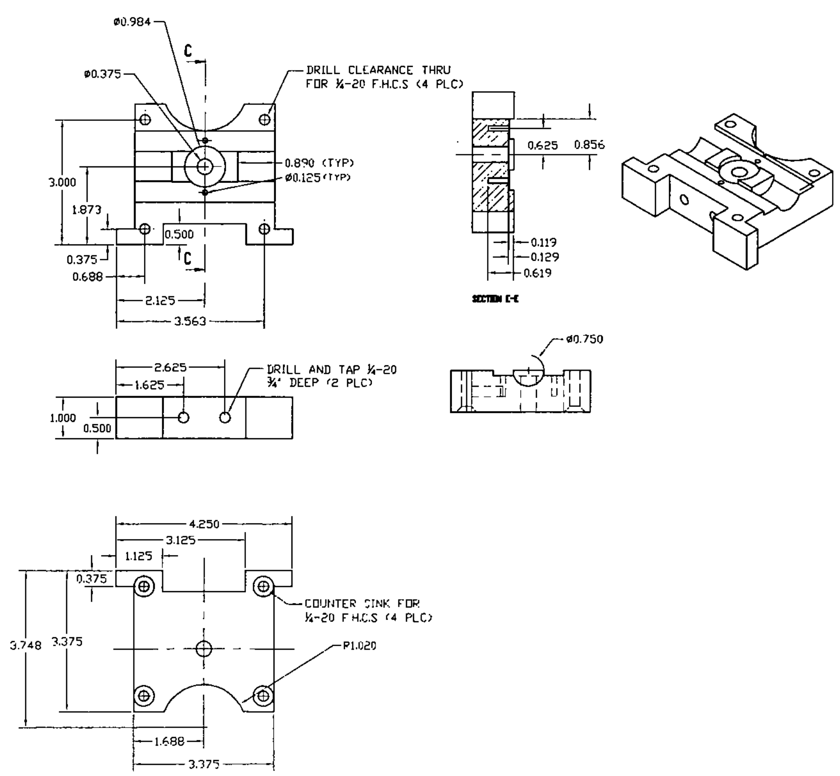




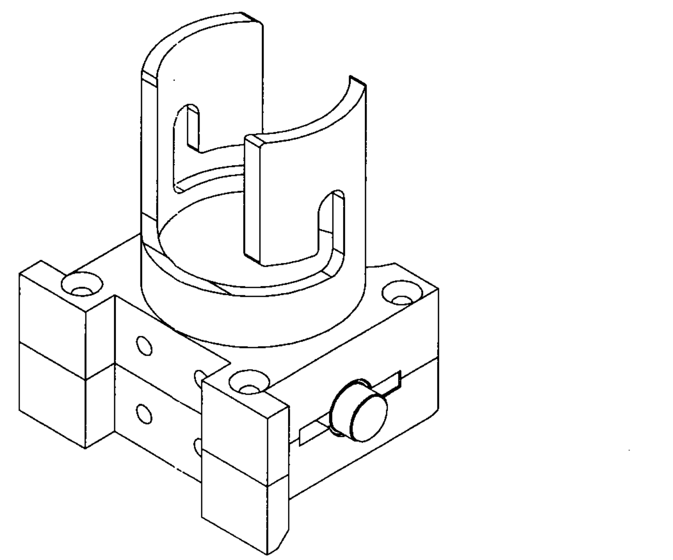
ENGAGEMENT PIN HOUSING
SECTIONS



PART #10: ENGAGEMENT PIN HOUSING
BOTTOM HALF DETAILS



PART #11: ENGAGEMENT PIN HOUSING
TOP HALF DETAILS



ENGAGEMENT PIN HOUSING
ASSEMBLY

seal

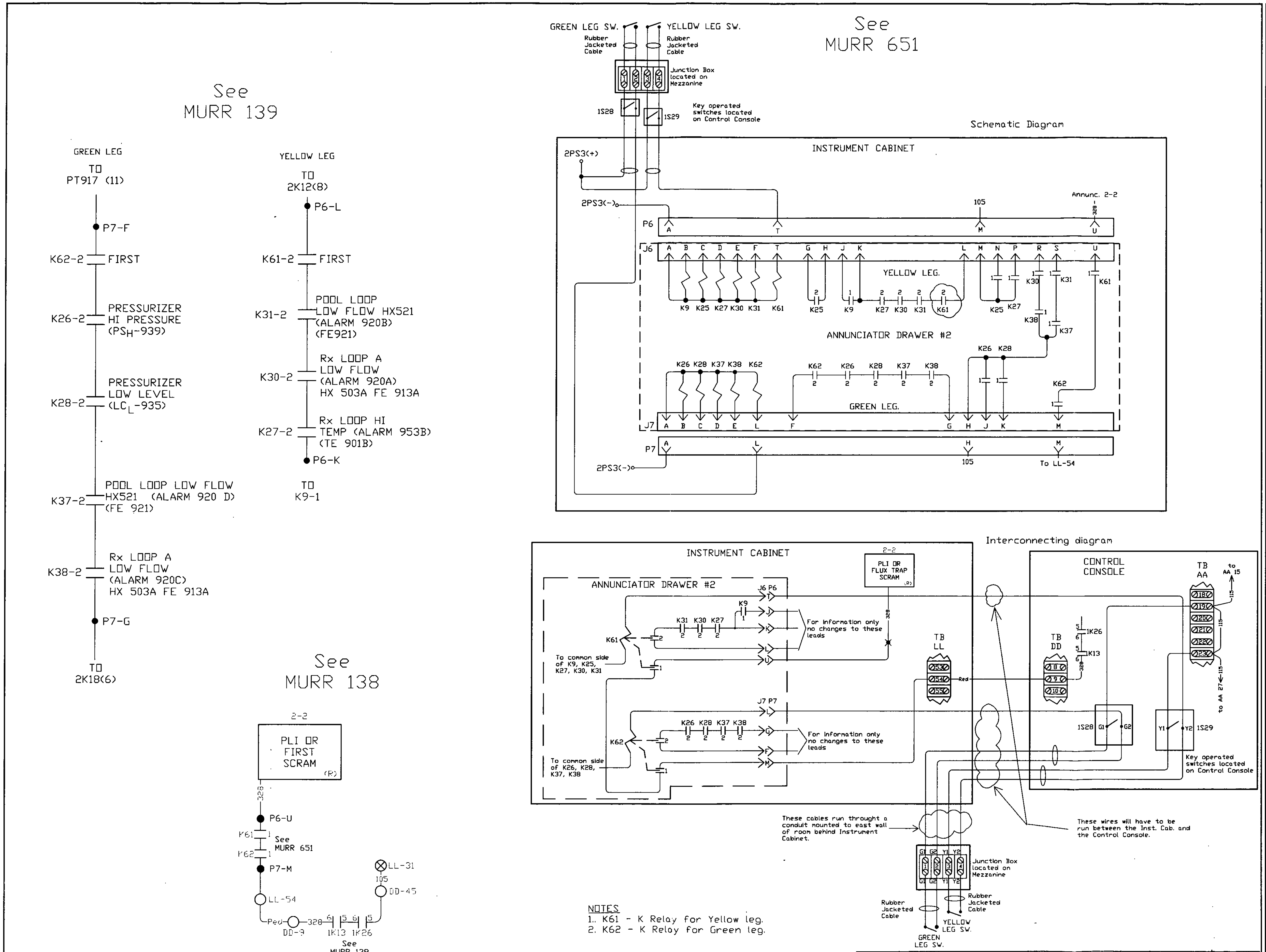
DATE: 11/20/2008
DRAWN BY:
d.g.n.
CHECKED BY:
ENGINEER:
CODE:
REVISION NUMBER:
0
REVISION DATE:

UNIVERSITY OF MISSOURI-COLUMBIA
REACTOR & FACILITIES OPERATIONS
research reactor facility

FLUX-TRAP IRRADIATIONS REACTIVITY
SAFETY TRIP

MURR NUMBER:
2712

SHEET
2 OF 3



NOTES
1. K61 - K Relay for Yellow leg.
2. K62 - K Relay for Green leg.

REV. NO	DESCRIPTION	DRAWN BY	DATE
Orig	Mod. Pkg.	THS	07/07/11

DATE: 07/07/11
DRAWN BY: T. Seeger
CHECKED BY: ENGINEER
CODE:
REVISION NUMBER:
REVISION DATE:

UNIVERSITY OF MISSOURI-COLUMBIA
REACTOR & FACILITIES OPERATIONS
research reactor facility

Flux-trap Irradiations Reactivity Safety Trip

MURR NUMBER: 2712

SHEET 3 OF 3