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June 28, 2005

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

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

Subject: Written communication as required by Missouri University Research Reactor Technical Specification 6.1.h (2) regarding a deviation from Technical Specification 3.6.e

The attached document provides the Missouri University Research Reactor (MURR) Licensee Event Report (LER) for an event that occurred on June 6, 2005, that resulted in a deviation from MURR Technical Specification 3.6.e.

Please contact Les Foyto, Reactor Manager, at 573-882-5276 if you have questions regarding this report.

Sincerely,

Ralph A. Butler, P.E.
Director

DIANE PURCELL
Notary Public - State of Missouri
County of Boone
My Commission Expires Jan. 31, 2006

RAB/djr

Enclosures

xc: Mr. Alexander Adams, Jr., U.S. NRC
Mr. Craig Bassett, U.S. NRC Region II
Dr. James S. Coleman, Vice Provost of Research, University of Missouri
MURR Reactor Advisory Committee
MURR Reactor Safety Subcommittee

IE22
A020

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Attachment
U.S. Nuclear Regulatory Commission
June 28, 2005

Licensee Event Report No. 05-02 – June 6, 2005
University of Missouri Research Reactor

Introduction

On June 6, 2005 during a normally scheduled reactor shutdown, it was discovered that the head pin, which secures the hold-down rod assembly for the three-tube flux trap sample holder, had been improperly installed during the previous reactor shutdown, May 30, 2005. Failure to have the head pin properly installed resulted in a deviation from Technical Specification (TS) 3.6.e; one of fifteen (15) Limiting Conditions for Operation regarding experiments.

TS 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 shut down. Secured experiments shall be rigidly held in place during reactor operation." Additionally, TS definition 1.24 for a secured experiment 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." Failure to have the head pin properly installed resulted in a component of a secured experiment, which was installed in the center test hole, not being rigidly held in place during reactor operation.

It should be noted that the flux trap sample holder itself was at all times rigidly held in place while inserted into the reactor. As described in the Safety Analysis section of this report, the reactivity worth of the sample holder is approximately 75% of the total reactivity worth of the experiment. The reactivity worth of all of the samples and spacers in the holder was only 0.00114 ΔK – slightly greater than the TS limit for a movable experiment. The reactivity that could have been introduced by movement of these samples and spacers in all three tubes was only 0.00037 ΔK, less than the limit for a movable experiment. Furthermore, any potential movement of samples or spacers was confined within the sample holder. Therefore, no reactor safety hazard existed with the flux trap sample holder pin improperly installed during reactor operation.

Description of Flux Trap and Sample Holder

The flux trap at the Missouri University Research Reactor (MURR) is that portion of the reactor through the high flux ($\sim 6 \times 10^{14}$ n/cm^2-sec) center of the core which is bounded by the 4.5-inch inside diameter inner pressure vessel and which extends 15-inches above and below the core centerline. The center test hole, by definition, is that volume in the flux trap that is occupied by the removable sample holder (experiment test tubes).

The number and the volume of samples that can be irradiated in the center test hole are limited mechanically by the design of the removable flux trap sample holder. Three

sample holders are designed and approved for use at the MURR, those being a six-tube, a three-tube, and a single-tube.

The three-tube sample holder consists of three aluminum tubes, each being 10 feet 2-inches long with an inside diameter (I.D.) of 1.334-inches. The tubes are arranged in a cloverleaf pattern and spot-welded together to form a single assembly. Stainless steel bands wrapped around the aluminum tubes provide redundancy for the spot-welds. The tubes, each with a vertical irradiation capacity of 30-inches, are clearly identified as A, B, and C, both physically on the sample holder and on all sample loading documentation. A support rod and base piece are attached to the bottom of the tube assembly. The overall length of the sample holder is 14 feet and 2 ½-inches.

The six-tube sample holder is similar in design to that of the three-tube with a few exceptions. There is an added four (4) vertical inches of irradiation capacity in the three 1.334-inch I.D. tubes and the addition of three smaller diameter irradiation tubes (0.68-inch I.D.). The small tubes are designed to allow movable and unsecured experiments to be irradiated in the flux trap. The small diameter holes are clearly identified as 1, 2, and 3, both physically on the sample holder and on all sample loading documentation.

The experimental volume of the larger diameter tubes of both the three- and six-tube sample holders is filled with either spacers or experiment capsules (samples). The samples and spacers are maintained in position by a hold-down rod assembly (Page 5 of 7), which is secured at the top of the sample holder by a 0.313-inch diameter head pin and hairpin keeper (Page 6 of 7). A 1/16-inch annulus exists between the samples and the internal wall of the sample tubes to provide cooling. The small diameter tubes may or may not contain samples during operation.

The sample holder is loaded vertically into the center test hole and is secured to the upper portion of the inner reactor pressure vessel by two stainless steel latching fingers. To provide additional vertical alignment and support, the base piece engages into a test hole slot welded to the reflector tank base flange. The sample holder top is designed to preclude the possibility of foreign objects entering the center test hole while the sample holder is in place. To remove the sample holder, a remote-operated tool engages the holder, expanding the latching fingers. The sample holder is then removed from the center test hole and handled in the reactor pool by a nylon rope.

A single-tube sample holder is also designed for use in the center test hole. It was used during initial operation of the MURR and replaced by the three-tube assembly when an increase in material irradiation capacity was required.

Event description

On June 6, 2005, the reactor was shutdown at 03:00 for the normally scheduled maintenance day activities. In attempting to remove the three-tube flux trap sample holder, the operator on the reactor bridge ascertained that he could not insert the remote-

operated removal tool far enough into the sample holder to expand the stainless steel latching fingers. After a few additional attempts, a second, slightly longer, remote-operated removal tool was used without success. After visually inspecting and verifying proper operation of both remote-operated removal tools, a viewing window and binoculars were used to inspect the upper section of the sample holder. It was determined that the head pin, which secures the hold-down rod assembly, had been inserted into two larger holes (0.75-inch diameter) that are 3.328-inches – hole centerline-to-centerline – above the correct pinning location thus preventing proper engagement of the removal tool. The larger holes are used to attach the nylon rope to the sample holder. The flux trap was eventually removed by pulling the hairpin keeper from the head pin and extracting the pin using a long remote tool. This allowed the flux trap sample holder to be unlatched and removed with its normal remote-operated removal tool.

Safety Analysis

Examination of the construction prints for the three-tube sample holder indicated that the head pin was inserted in a position that would have allowed the hold-down rod assembly a maximum upward travel distance of 3.58-inches (Page 7 of 7). Although no free space existed in the irradiation tubes because of the weight of the aluminum hold-down rod assembly on top of the samples and spacers, the possibility of upward travel did exist for all three irradiation tubes if some initiating mechanism could have caused the hold-down rod assembly to be pushed up against the combined forces of gravity and the downward flow of pool coolant. Not having the head pin in its correct location resulted in a deviation from TS 3.6.e, which requires secured experiments to be rigidly held in place during reactor operation.

The reactor operated from 12:33 on May 30, 2005 to 0:300 on June 6, 2005, or a period of 158.4 hours, with the flux trap samples not rigidly held in place. A conservative calculation of a 4-inch outward travel of all samples and spacers in all three tubes would have resulted in a net reactivity change of only 0.00037 $\Delta K/K$ (negative) – less than the TS reactivity limit of 0.001 ΔK for a movable experiment. The change in reactivity is due to the redistribution of the void areas and the absorption cross sections of the sample material in the high flux region. Forces due to the weight of the hold-down rod assembly, gravity, and the downward flow of pool coolant through the center test hole held the samples and spacers tight against the bottom of the flux trap tubes.

The basis for TS 3.6.e is to limit the experiments that can be moved in the center test hole while the reactor is operating, to those that will not introduce reactivity transients more severe than one that can be controlled without initiating safety system action. No credible mechanism is known that could cause all three tubes of samples and spacers to move simultaneously upwards 3.58-inches against the weight of the hold-down rod assembly, gravity, and the downward flow of pool coolant. In the still highly unlikely but slightly more credible event that only one tube of samples moved outward 3.58-inches against the same downward forces, the most positive reactive tube would have

resulted in a net reactivity change of only 0.00048 ΔK/K – still much less than the TS reactivity limit for a movable experiment.

Therefore, if either scenario had occurred, no safety system action would have been initiated. In the latter case, a positive reactivity insertion of 0.00048 ΔK would have resulted in the regulating blade being driven inward approximately 3.5-inches while in the automatic control mode, well within the normal operating range.

The reactivity worth of experiments in the center test hole is limited by TS 3.1.h (0.006 ΔK) such that the introduction of the maximum worth of all experiments would not result in damage to the fuel plates. This implies that the reactivity worth not only includes the samples and spacers, but the flux trap sample holder itself. On this occasion, the total reactivity worth of the samples and spacers was 0.00114 ΔK (positive) – slightly greater than the TS limit for a movable sample and only about 25% of the total worth of the experiment. The reactivity worth of the three-tube flux trap sample holder when it is empty is 0.0036 ΔK. Therefore, no reactor safety hazard existed with the flux trap sample holder pin improperly installed during this period of reactor operation.

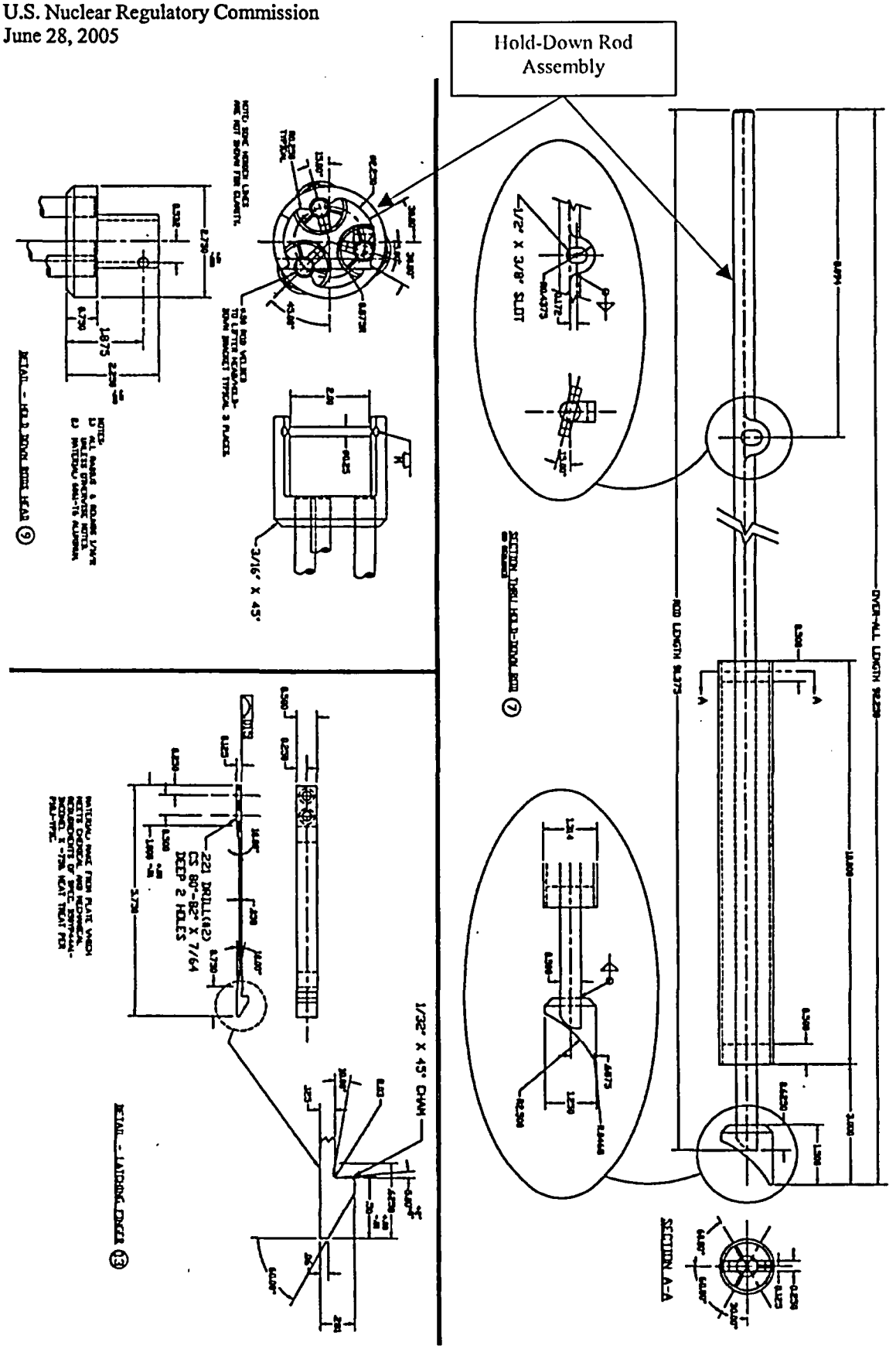
Corrective Actions

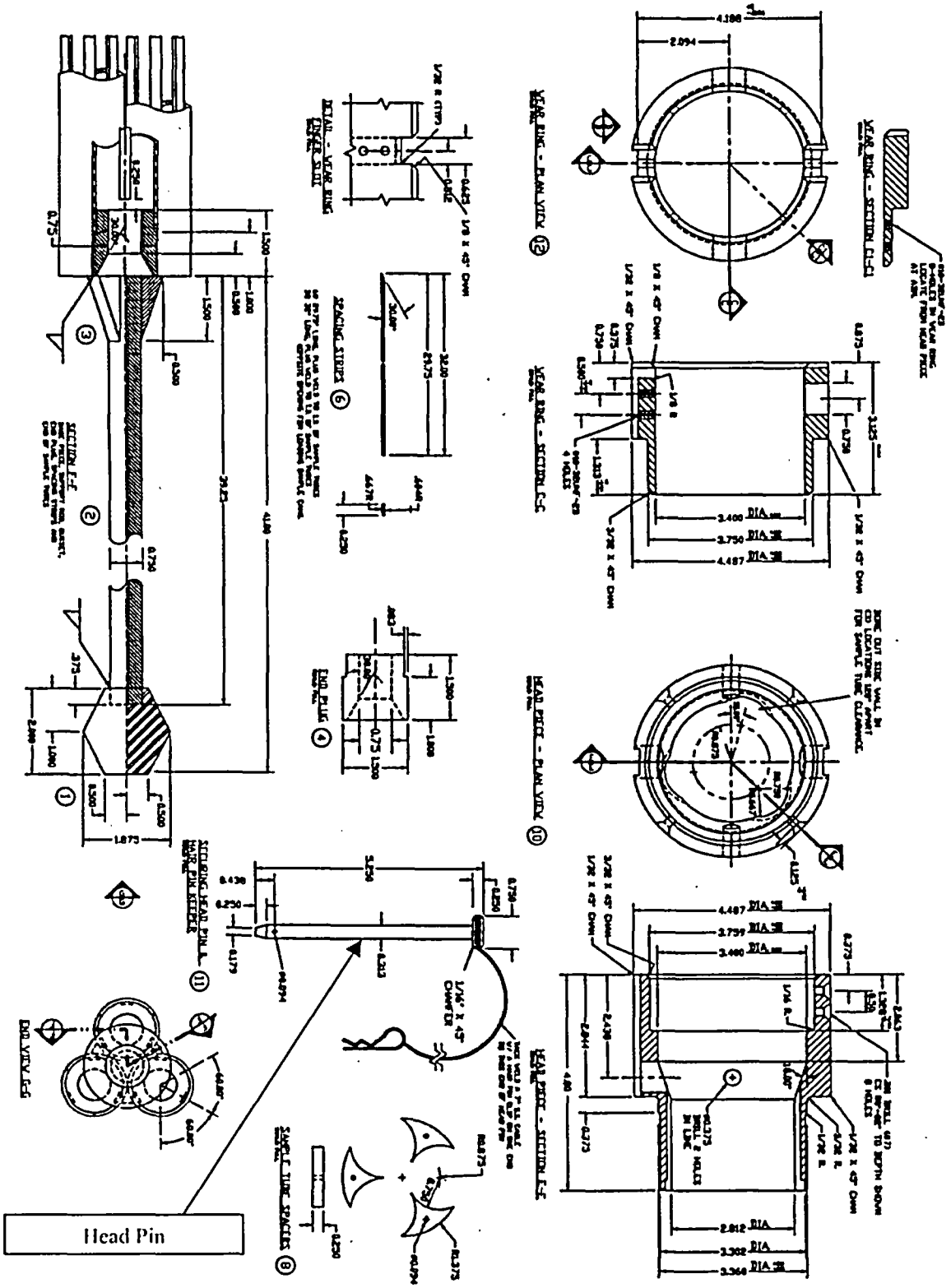
A Standing Order was issued which revised operating procedure EX-RO-105, "Reactor Irradiation Experiments." EX-RO-105 provides operating instructions for loading and installing the flux trap sample holder into the center test hole. The revision requires a Senior Reactor Operator to verify that the head pin is properly installed and secured before inserting the sample holder into the reactor. Personal interviews were held with the two operators who had conducted the sample holder loading, emphasizing the importance of second checking and being particularly sensitive to any mechanism that can alter the reactivity of the core while critical. This incident will also be reviewed with the remainder of the operating staff to reiterate its significance and ways to prevent reoccurrence.

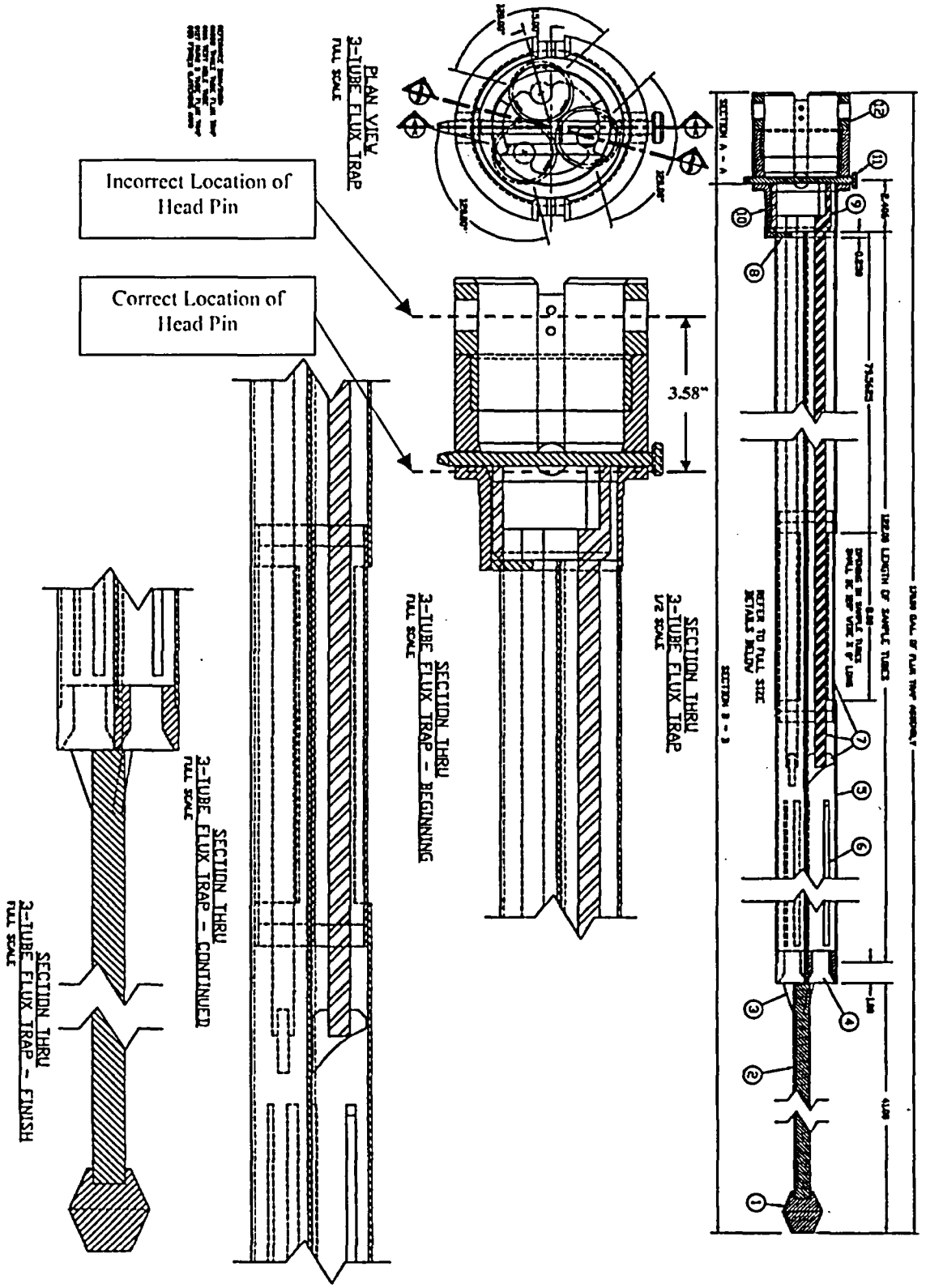
This event has been entered into the MURR Corrective Action Program as CAP entry No. 05-0058 and any additional improvements or corrective actions will be considered.

If additional information is desired please call me at 573-882-5276.

Les Foyto
Reactor Manager
Missouri University Research Reactor


Hold-Down Rod Assembly


Head Pin


PLAN VIEW
3-TUBE FLUX TRAP
FULL SCALE
Incorrect Location of Head Pin
Correct Location of Head Pin
3.58"
SECTION THRU
3-TUBE FLUX TRAP
1/2 SCALE
SECTION THRU
3-TUBE FLUX TRAP - BEGINNING
FULL SCALE
SECTION THRU
3-TUBE FLUX TRAP - CONTINUED
FULL SCALE
SECTION THRU
3-TUBE FLUX TRAP - FINISH
FULL SCALE