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March 2, 1998

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

Reference: Oregon State University TRIGA Reactor (OSTR)
Docket No. 50-243, License No. R-106

Subject: Scram Failure on February 17, 1998 - Event No. 33732

Gentlemen:

This purpose of this letter is to report a recent event in which the OSTR failed to shut down when the console manual scram button was pushed. This scram failure is a violation of Technical Specification (TS) 3.5.3 which states that "The reactor shall not be operated unless the safety channels described in Table I and interlocks described in Table II are operable." Table I lists six safety channels which are required for steady state operation, including the console scram button. This event requires a telephone or fax report within 24 hours in accordance with TS 6.7.a.4 and TS 6.7.a.5. and this written report which is required within 14 days in accordance with TS 6.7.b.2.

A preliminary notification of the event was made to our Senior Project Manager, Mr. Al Adams, at approximately 10:40 a.m. on February 17, 1998. Mr. Doug Weaver at the NRC Operations Center was formally notified of the event at approximately 4:35 p.m. that same day when more information was available. By that time it was understood that the other safety channels listed in Table I of the TSs had also been inoperable. The Oregon Department of Energy Duty Officer, Mr. Ken Niles, was briefed at approximately 4:40 p.m. The OSTR Reactor Operations Committee (ROC) has been kept fully informed regarding the event, and has approved the corrective actions, the text of this letter, and reactor restart on February 24, 1998. The Radiation Center actively kept Mr. Adams and the research reactor community up-to-date as information became available.

Background Information

A comprehensive list of startup checks is performed prior to reactor operation, usually at the beginning of each day. The startup check sheets are reviewed by the Reactor Supervisor who then approves reactor startup if everything is satisfactory. Each day the core excess reactivity is measured at 15 watts and the shutdown margin calculated.

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The reactor has a key switch which is used to supply control rod magnet current and to reset scram relays. The key for the switch is basically a cylinder with cutouts and a protrusion, much like those used in the U-style bike locks. The key is inserted, pushed down and turned once to the right to the OPERATE position. It can also be turned once more to the right against a spring to reset the reactor scrams. When released, the spring returns the key to the OPERATE position.

Description of the Incident

On the morning of Tuesday, February 17, 1998, a reactor operator trainee under the direction of a licensed reactor operator started up the reactor and performed the daily core excess measurement at 15 watts as usual. The operator instructed the trainee to manually scram the reactor once this had been done. When the trainee attempted to comply by pushing the manual scram button, the reactor failed to scram. The reactor operator immediately attempted to scram the reactor himself. When the manual scram button failed again, the operator checked the key switch and felt it click from a position a little to the right of the OPERATE position (between the OPERATE and RESET position) back to the OPERATE position. He then pushed the manual scram button again which resulted in a proper scram. The operator turned the key to the OFF position, removed it and notified the Reactor Supervisor of the event. From the first attempted scram to the actual scram, the time period was approximately 2 to 3 seconds.

The Reactor Supervisor subsequently notified the Reactor Administrator, who then notified the Radiation Center Director. The Reactor Supervisor and Reactor Administrator declared that the reactor was to remain shut down until further notice.

Causes of the Occurrence

The occurrence has two causes. The first is the fact that the spring return key switch failed to return completely to the OPERATE position after being turned to reset the scrams. Logical analysis concludes that it must have been making electrical contact in the RESET position, i.e. touching contacts A4 and B4. (See attached figures.) The root cause for its failure to completely return to the OPERATE position appears to have been a long term build-up of dirt. Since being removed, cleaned, and relubricated the switch shows no tendency at all of being sticky or of not fully returning to the OPERATE position.

The second cause is a wiring change that makes the OSTR circuit different from that in the original General Atomics (GA) Instrument Maintenance Manual. Figure 1 shows the relevant portion of circuitry as designed and shown in the GA manual. It can be seen that if the key switch is turned to the OPERATE position, magnet current is supplied from terminal block one, terminal number four (TB1-4) through TB1-9, then TB2-3, A3, A1 and the console power switch. However, when the key is turned to RESET, this circuit is opened and there is no magnet current, thereby causing the rods to drop in if they were up, or disabling their withdrawal if they were down.

A careful examination of the *actual* OSTR console circuitry showed that it was different from that illustrated in the GA manual. The difference can be seen in Figure 2, where it is shown that the jumper between TB1-9 and TB2-3 is in fact between TB1-9 and TB10-10. The impact of this change is that control rod magnets have power whenever the key switch is in either the OPERATE or the RESET position. During the event under discussion, when the key switch did not fully return to the OPERATE position, the reset relays and the control rod magnets were both energized. Therefore, when the manual scram button was pushed, the relay did not close and the reactor did not scram.

It should be noted that the purpose of the contacts on the B deck is to switch the REACTOR ON lights so that they come on whenever the key switch is turned to the OPERATE or RESET position. These lights are installed in the walls at various locations around the facility as well as near the experimental facilities associated with the radiography beam ports.

Investigations of OSTR documentation have resulted in the conclusion that the jumper was wired in this manner sometime during the initial installation of the reactor console. The records which were reviewed in an attempt to determine when this occurred included the 10 CFR 50.59 safety evaluation file, the reactor installation log, the Reactor Supervisor's log, the Reactor Operations Committee minutes, the reactor console log, the console circuit diagrams and the circuit change log, as well as the active and inactive experiments log. In addition, personnel who were involved with the facility in the early days were interviewed to see if they had any recollection of changes associated with the key switch.

Since the earliest days of the history of the OSTR, there have been dozens of 10 CFR 50.59 evaluations made documenting, evaluating and approving even very minor, insignificant changes to the facility. It would be completely inconsistent with this recorded track record for the reactor operations staff to have made such a change in the console circuitry without performing a documented 10 CFR 50.59 safety evaluation. In addition, the person who was the OSTR Reactor Supervisor from construction through August 1994 kept a very comprehensive journal. Initially this discussed the facility construction, and later it covered the reactor start-up tests. Once operational, the journal became known as the Reactor Supervisor's log. This person was a diarist and seemingly wrote about everything that went on, from the significant to the trivial. There are entries in his construction and startup notes which discuss the connection of the REACTOR ON lights and the advice of the GA representative regarding them being hooked up to the console key switch. These occur in January and March of 1967 prior to initial reactor criticality. *These are the only references found regarding connections to the console key switch.* It is this, along with the documented track record with respect to all other facility changes, which leads to the conclusion that the jumper was wired in this position from the very beginning, even prior to the initial criticality. It should be noted that it is not our intention to assign blame for the error. This would be pure speculation since OSU, GA and contractor's personnel were all working on the installation at this time.

Corrective Actions

1. The console key switch has been cleaned and relubricated, and now shows no tendency to stickiness. If it ever shows any tendencies in the future, it will be removed and cleaned. There is no proposal to put this switch on a routine cleaning schedule because. a) it took over 30 years to exhibit the problem the first time; b) routinely disassembling the console panel to remove and clean the switch may well cause more problems than it solves; and c) even if it does stick again, it will not be possible to withdraw the control rods due to the wiring changes described below.

2. The wiring has been restored to its as-designed condition (Figure 1). Specifically, the connection between TB1-9 and TB10-10 has been removed and a jumper has been installed between TB1-9 and TB2-3. This action ensures that the event cannot be repeated, since whenever the key switch is turned to the RESET position, the magnet current is interrupted. TRIGA facilities which are wired in this manner have performed physical tests demonstrating that this arrangement performs as intended.

3. The OSTR Scientific Instrument Technician, with the assistance of the reactor operations staff, has performed a physical, electronic check of the wiring in the scram circuitry and demonstrated that it is as originally designed and approved. These tests were performed under the observation of an NRC inspector, Mr. Craig Bassett. Other non-scram related circuits have also been checked and shown to be as-designed. These checks provide good assurance that there are no other similar unknown conditions or deviations from the approved design.

4. An additional item has been added to the reactor startup check procedure (OSTROP 2) which requires withdrawing one of the control rods a little, then turning the console key switch to the RESET position and observing the rod drop due to the magnet current circuit being opened.

5. Prior to restarting the reactor again following this event, and in addition to the routine startup checks which test each individual scram, the semi-annual console check procedure (OSTROP 15.11) was performed. This procedure checks such items as the console power supplies. Performing the procedure provided additional assurance that no further disturbance had been made to the console, and that it was performing completely normally.

Measures to Prevent Recurrence of Such an Event

1. The corrective actions listed above will prevent recurrence of this specific event.

2. There are procedures currently in place (OSTROP 6) which require documented review and approval of all changes to the facility, tests, experiments and procedures. These procedures have been very effective over the lifetime of the facility in preventing events such as this from occurring. These procedures have been reviewed and it is believed that no changes to them are necessary.

3. As discussed earlier, it is believed that the wiring discrepancy probably occurred during the initial installation, prior to first criticality. Current controls are more than adequate to prevent such an error from being made now. For these reasons, it is believed that no further measures are required to prevent recurrence of similar events.

Safety Implications of the Event

It should be pointed out that while this was certainly a very significant event, and has been treated with extreme seriousness, it actually has *very low actual safety implications*.

Although the automatic and manual scrams were inoperable, it should be remembered that the operator still had three methods of scramming the reactor available to him. The first was to turn off the console key switch. This was what he was starting to do when he found the switch click back to the OPERATE position. This would have interrupted control rod magnet power, thereby dropping the rods. He could also have cut magnet power and dropped the rods by pushing the "CONT/ON" buttons individually (or the "AIR" button for the transient rod) or by pressing the scram bar which pushes them all together. Finally, he could have briefly turned off the console power, which again would have dropped the control rods.

During this event, the reactor was only at the very low power of 15 watts, and then only for 14 minutes. Even if the reactor had been at its full operational power of 1 MW and for some reason the reactor power had increased beyond the normal scram setting of 1.06 MW, this would have been observed by the operator fairly quickly and he would have acted in exactly the same way that he did act; resulting in the reactor being shut down within the same 2 to 3 seconds. In this situation, it is hard to see how the power would have exceeded much above the 1.06 MW (the OSTR is licensed up to 1.1 MW). The maximum fuel temperature would probably still have been below about 400°C. The limiting safety system setting for the fuel is a temperature of 510°C, and the Technical Specification safety limit is a fuel temperature of 1150°C. Even this temperature is still significantly below the that at which fuel clad damage and subsequent fission product release would be expected.

If all else failed, there is the inherent basic safety feature of all TRIGA reactors, namely the large negative temperature coefficient of reactivity, which becomes increasingly negative as the temperature increases. Any uncontrolled power rise is automatically limited by this temperature feedback effect. This is the property which enables the OSTR to be safely pulsed up to 3,000,000,000 watts with three of its six normal scrams switched out.

Finally, it should be noted that while this discussion has assumed some power excursion of unknown cause, to even get such an event would require several system failures and total operator inactivity.

Conclusions

In conclusion, we would like to point out that while we regret its occurrence, the event reported here was dealt with very quickly and effectively by the reactor operator. The event was also promptly reported, thoroughly investigated, the root causes were identified and effectively corrected in a timely manner once identified. The facility staff cooperated closely with the NRC staff and went to great lengths to communicate with the research reactor community to encourage other facilities to look for similar failure modes. In addition, we believe that sufficient measures are in place to prevent the re-occurrence of such an event in the future.

Should there be questions regarding the information in this report or should you require more information, please let me know.

Yours sincerely,

Brian Dodd, PhD
Director

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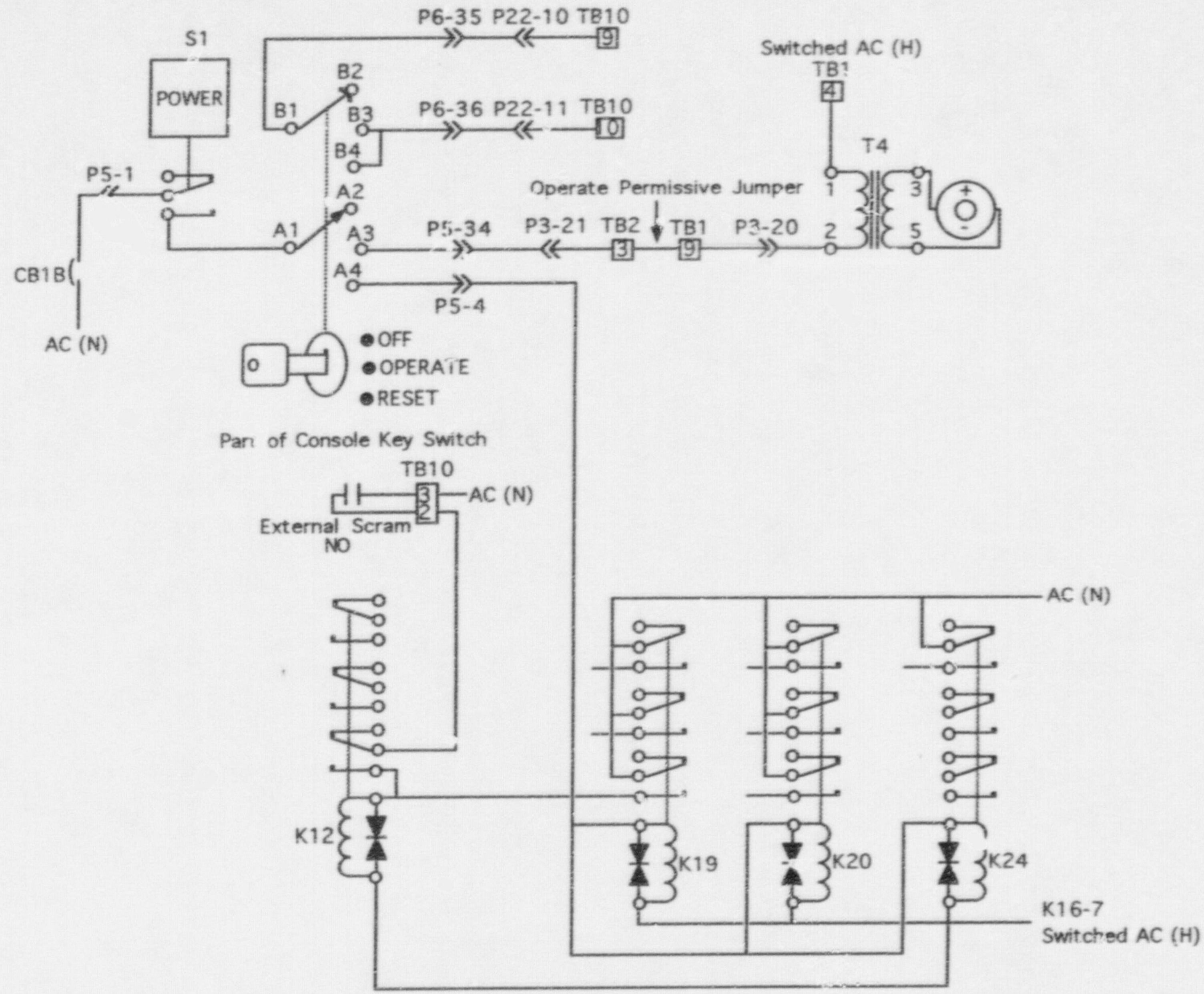

Figure 1. Reactor Operate Circuit, As-designed

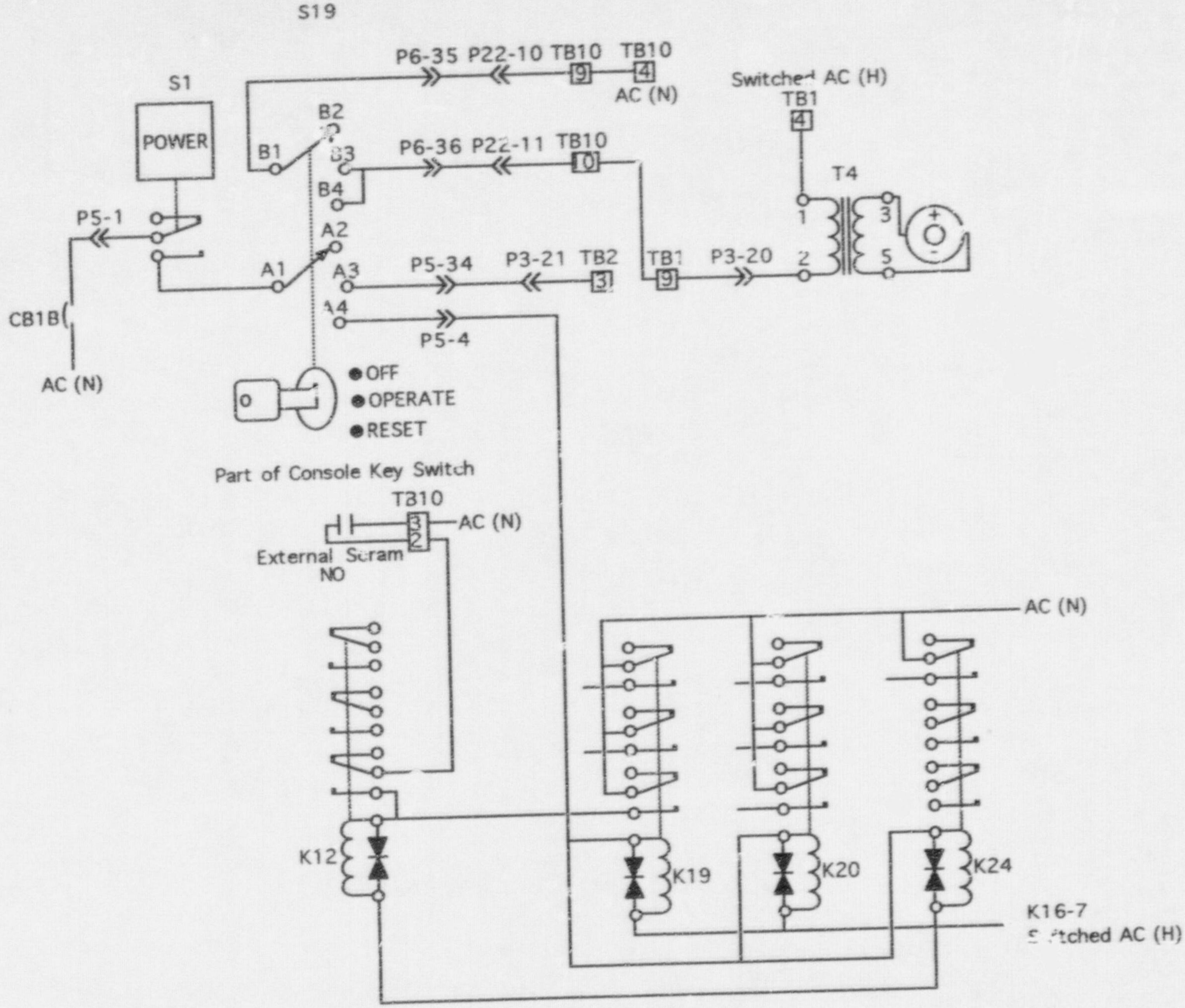

Figure 2. Reactor Operate Circuit - As Found