NUCLEAR REACTOR LABORATORY

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May 23, 1980

Mr. Boyce H. Grier, Director
U.S. Nuclear Regulatory Commission
Region #1
631 Park Avenue
King of Prussia, Pennsylvania 19406

Attention: Mr. E. Greenman, Reactor Inspector

Re: Reportable Occurrence 50-20/80-2, License R-37: Binding of a Shim Blade During Reactor Startup

Gentlemen:

Massachusetts Institute of Technology hereby submits this 10-day report of an occurrence at the MIT Research Reactor in accordance with Paragraphs 1.13.2d and 1.15.3 of the Technical Specifications. An initial report was made by telephone to Region #1 (Mr. E. Greenman) on May 20, 1980.

The format and content of this report is based on Regulatory Guide 1.16.

1. Report No. 50-20/1980-2

2. a) Report Date: May 23, 1980

   b) Date of Occurrence: May 19, 1980

3. Facility: M.I.T. Research Reactor
   138 Albany Street
   Cambridge, Massachusetts 02139

4. Identification of Occurrence: Intermittent binding of shim blade #1 during startup of the reactor such that this blade could not have been operated in accordance with Technical Specification 3.9.3 which requires that the time from the initiation of a scram signal to 80% of full insertion be less than 1.0 second. It should be noted that Technical Specifications 3.9.2 and 3.11.2c allow operation of the reactor with one control blade inoperable if that blade can be maintained at or above the average shim bank position. However, the nature of the binding was such that shim blade #1 could not have met that condition.

5. Conditions Prior to Occurrence: The reactor had been shutdown over the weekend. Full power mechanical and instrument startup checklists had been completed in preparation for the usual Monday-Friday operating week. A normal reactor startup was in progress.

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6. Description of Occurrence: A reactor startup was being conducted in accordance with approved operating procedures. The startup was halted, in accordance with these procedures, when the shim bank position exceeded the estimated critical position by 0.50 inches. Each of the six shim blades was then sequentially inserted while monitoring the reactor power level. The level decreased as expected for blades #2 through #6. However, no decrease was observed on insertion of shim blade #1. Subsequent measurements were then conducted and it was determined that blade #1 was evidently only operating from the full-in position to a point about 8.00 inches above the core bottom. The reactor was then shut down using the standard procedure. All blades inserted fully. Reactor power did not exceed 1.25 Kw during the above evolution.

   A visual inspection was immediately made of blade #1. It was found that, as suspected from the observations made during the startup, blade #1 was being picked up by the electro-magnet that couples it to the drive mechanism. However, at a height of about 8.00 inches, the blade was separating from the magnet. Once separated the blade did not, as would be expected, fall back into its slot next to the core housing. It did, however, move in normally whenever the drive mechanism was driven in so as to engage the blade.

7. Description of Apparent Cause of Occurrence: This occurrence was apparently due to the presence of a small particle, possibly more than one, of foreign material that impeded the motion of the blade.

   Each shim blade rides in one of six 0.375" slots that border the outer perimeter of the core. The blades are nominally 0.300" thick. They are routinely measured every six weeks (more frequently when initially installed); thicknesses are in the range 0.320-0.340". Measurements are made under water with a gage that fits over the full 7" width of the blade, which accounts for the values exceeding nominal. There is no trend toward thickening.

   Each blade is attached by a webbed offset plate to a weighted guide piece that moves vertically in a tube machined to a 1/16 inch clearance (see Figure 1). The use of this weighted guide piece insures both that the blade will drop rapidly and that, should there be any misalignment with the drive, the resulting wear will not occur on the blade. An armature, with a flat upper surface, sits atop the guide piece. The blade may be raised or lowered by mating the armature to the lower surface of an electromagnet that is connected to the drive mechanism. Hence, the only support provided to the blade is in the vertical direction via an electromagnet. There is neither any lateral support nor any type of mechanical latch. This means that, in the event of any friction between the blade and its slot or between the weighted guide piece and its tube, the blade will readily separate from the drive mechanism. The reason for this design is to insure that, in the event of a scram signal, the blade will readily decouple and insert.

Blade position is indicated by a magnetic proximity switch at the "full-in" position. Continuous indication of blade position is provided by signals taken from the drive mechanism. Hence, once the blade has been raised above the "full-in" position, there is no direct indication of its position. Were the blade to detach from the drive mechanism and not fall back into its slot, the proximity switch would not activate and the blade height indication would continue to reflect the status of the drive mechanism. The operator can readily detect such a problem by observing an anomaly between blade motion and reactor response.

Subsequent to the determination that blade #1 was binding, both the blade and its associated guide piece were removed and examined in accordance with standard procedures. There was intermittent binding, either of the blade or the guide rod, throughout most of its upward travel during removal. Although the binding had been sufficient to cause decoupling, it was not enough to prevent lifting the assembly by hand. Just before the blade came completely out of its slot, the binding ceased and, thereafter, the assembly could be moved throughout its travel in both directions with no evidence of binding whatsoever. The blade was furthermore observed not to be contacting any core or experimental component.

No foreign material was found in the blade slot or guide tube that could have impaired the motion of either the blade or its guide piece. However, four pieces of foreign material were found on the horizontal surface surrounding the core. Three of these were near blade #1 and may have been the cause of the binding. The four pieces are:

a) A #5-40, 5/32 inch long, Phillips screw made of stainless steel. (This was found a considerable distance from the blade.)

b) A piece of glass about 1/4" x 1/4" x 30 mils.

c) A piece of aluminum wire about 50 mils diam. x 1/8" long.

d) A piece of stainless steel wire about 30 mils diam. by 1/8" long.

Some of these might have been sufficient to cause the blade to bind had they been entrapped in either the blade slot or the guide tube. In addition, several flecks of chrome plating were found. The origin of the wire pieces and the chrome flecks is known. The former are used to secure bolts used for in-core experimental facilities while the latter is used to prevent corrosion on the shim blade electro-magnets. The darkening and induced activity of the glass indicated exposure in the reactor for some time. It may have been carried over on an experiment from a hot cell or glove box where flourescent lights had been broken in the past. There are no plausible theories as to the origin of the screw. Screws of that size, but not that type, are used on certain reactor components. They are always staked in position before permanent use.

The pieces of foreign material were removed, and a small suction pump was used to "vacuum" any areas of the core tank that showed discoloration. No further foreign material was found.

Blade #1 and its guide piece were reinstalled. It was tested for friction, drop time, and swelling. All measurements were well within specification and in close agreement with previously measured data. There was no evidence of any swelling and/or mechanical distortion. The blade was visually observed to function properly. It was tested ten times over its full range of travel and the drop time measured in each case. No problems were observed.

8. Analysis of Occurrence: No damage to the reactor resulted from the binding of this blade. All blades were known to have been operating properly during the previous week's operating period as all responded neutronically as expected during reshims, etc. Operation of the reactor with a blade stuck below the average shim blade bank height may, as is discussed in Technical Specification 3.11.2c's basis, only cause damage if the blade is both more than 2.0 inches below the bank height and if reactor power is above 100 Kw. Reactor power never exceeded 1.25 Kw during the startup in which the binding was detected. No damage could have occurred.

The shutdown margin is based on the assumption that the most reactive blade is in the full-out position. At the time when blade one's binding was detected, the shutdown margin, as defined by Technical Specification 3.9.1, was such that it still would have been met with both the most reactive blade and blade #1 full-out. The reflector "dump", worth $7\%\Delta K/K$, provides a further margin of safety.

In regards to the presence of foreign material in the reactor core, none of the items found was large enough to have significantly blocked cooling flow to a fuel element channel. All but the screw and possibly the glass would have passed through the channels. Any blockage would occur at the channel entrance (unfueled) and would not exceed about 10% of the channel, resulting in a negligible effect on flow.

9. Corrective Action: The corrective actions consisted of:

a) Performance of blade thickness and drop time measurements on the other five shim blades. All data was within specification. No evidence of swelling was detected on any blade.

b) Replacement of the electromagnet that was found to be the source of the flecks of chrome plating.

c) Reemphasized to all personnel the importance of preventing the entry of any foreign material into the core tank.

d) Reemphasized the value of cleanliness on the reactor top and in all areas where experiments and samples are handled, such as benches, hot cells, glove boxes, etc.

10. <u>Failure Data:</u> No previous failure of this type has occurred at the facility. However, as discussed in ROR-76-1, a shim blade did previously become stuck in its slot as a result of swelling. However, the blades that currently in use are of an entirely different design in that they are made of boron-impregnated stainless steel whereas the one that stuck in 1976 was a cadmium-aluminum sandwich.

Sincerely,

John A Bernard Jr

John Bernard
Superintendent

Lincoln Clark, Jr.

Lincoln Clark, Jr.
Director of Reactor Operations

JB/gw

cc: MITRSC
USNRC-OMIPC
USNRC-DMB

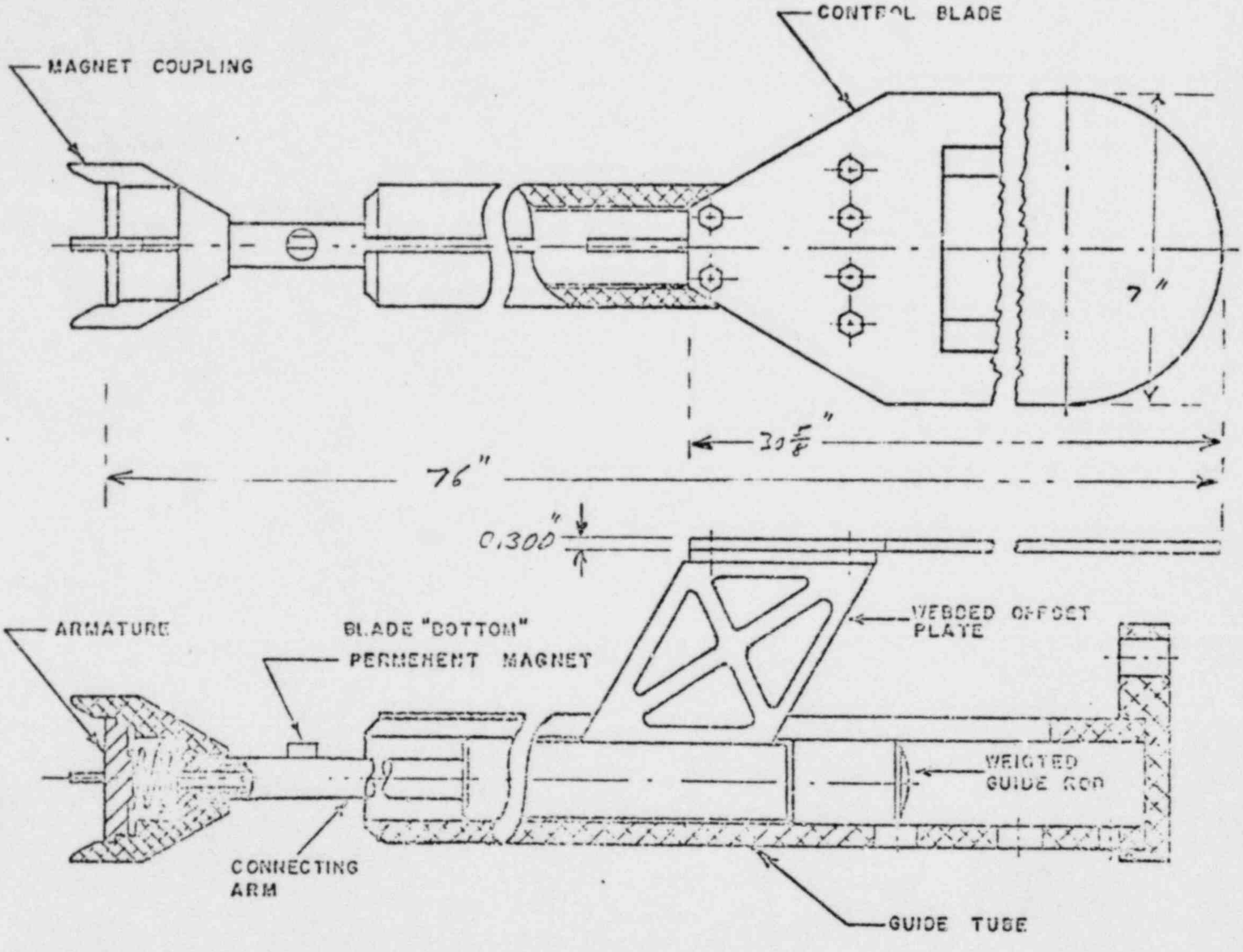

FIGURE 1

CONTROL BLADE ASSEMBLY