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U.S. Nuclear Regulatory Commission
Attn: Mr. Alexander Adams, Jr.
Senior Project Manager,
Non-Power Reactors and
Decommissioning Project Directorate
Office of Nuclear Reactor Regulations
Washington, DC 20555

Subject: Nuclear instrumentation information which may be useful to Non-Power Reactor facilities

Dear Mr. Adams,

Executive Summary

The PULSTAR reactor at North Carolina State University has two Gamma Metrics Wide Range Linear neutron flux channels. One channel, designated the "Linear Channel" was operated in the auto-ranging mode and used for power monitoring and control with a maximum range of 1 MW. The other channel was designated as the "Safety Channel" and was operated in the manual range-change mode on the 1 MW range.

In November 1995, the Linear Channel experienced a failure to automatically up-range and the range control card was returned to Gamma Metrics for repair. It was noted that both the linear and safety channels had been operating with the neutron flux scram smart bi-stable set so that it was enabled on the 1 MW range. The bi-stable mode was changed at that time so that both units would produce a scram at 120% of range on all ranges. In December 1995, the unit was successfully bench-tested with the repaired card, but again failed to up-range and exhibited spurious automatic range-changing when it was returned to service. The unit was returned to Gamma Metrics at that time.

In January 1997, the Safety Channel spuriously down-ranged from the 1 MW range to the 300 kW range when the reactor power was increasing through 150 kW. While operator manually scrammed the reactor, the scram function remained operable at 360 kW due to the having the scram function enabled on all ranges. This unit was also returned to Gamma Metrics for repair.

Facilities using the same type of equipment should be aware of these range change problems in both the automatic and manual range change mode and the fact that a spurious range

change can defeat the scram function if the smart bi-stable is set so that the scram is active on one range only.

Part 21 Assessment

The licensee has reviewed 10CFR Part 21 and concluded the Gamma Metrics Wide Range Linear monitor ranging malfunctions experienced do not result in disabling the protective function of the monitor by themselves and do not create a substantial safety hazard. Nevertheless, the information has been shared with the TRTR community, Gamma Metrics, and the NRC since our experiences and the findings may be useful to other licensees.

Discussion

NC State University Linear Channel

The first problem experienced with the Gamma Metrics Wide-Range Linear Monitor occurred in November 1995 with the PULSTAR Reactor "Linear Channel" that is ranged with reactor power, used for power control, and provides redundant scrams for the PULSTAR Reactor "Safety Channel". This event was previously reported to the NRC and was summarized in the February 1996 TRTR Newsletter. The range control card was suspected and returned to Gamma Metrics where several components were replaced. The monitor was reassembled and successfully tested on the bench top and the channel was returned to service. On December 20, 1995 the reactor was restarted under testing authorization and multiple range changes were deliberately introduced during a gradual power escalation. The channel again failed to automatically up-range and the reactor was shutdown.

The entire monitor was returned to Gamma Metrics where modifications were made in the internal grounding. During the subsequent receiving inspection it was noted that several cable connectors were not seated properly and that a pin on one of these connectors was burned. Gamma Metrics provided a replacement connector and associated harness that was installed by the reactor staff. During pre-start-up testing, it was found that actuation of the rod reverse demand would cause the range to jump to a different range when the range control was in the manual mode. A Gamma Metrics field engineer spent one week at the site but was unable to diagnose the problem. The monitor was then sent back to Gamma Metrics. A PULSTAR facility design change was approved for re-installing the linear channel picoammeter that had been used prior to the Gamma Metrics Wide-Range Linear Channel.

In October 1996, the linear channel was returned to NC State University. Changes that had been made included replacement of the printed circuit board backplane. During the initial bench-top check-out of the returned unit, new spurious range changes were observed including oscillatory behavior. This included increasing the range to greater than 1 MW even though this is inhibited by design in the NC State University version of the monitor. The unit was again returned to Gamma Metrics where it currently remains.

NC State University Safety Channel

The same type of unit is operated on the 1 MW range in the manual range-change mode. In January 1997 this unit spuriously down-ranged from the 1 MW range to the 300 kW range as the reactor power was increasing through 150 KW. At 150 KW, an internal trip circuit is enabled to protect against loss of flow or the lower plenum flapper valve not closed. While the operator manually scrammed the reactor, the scram function remained operable at 360 kW due to having the scram function enabled on all ranges. This was verified during a post-shutdown check-out. This unit has also been returned to Gamma Metrics for repairs.

Results

Our bench-top testing with the Linear Channel and consideration of the circuit design indicated in 1995 that:

- In either the automatic or manual range change mode, spurious ranging did not affect the protective features of the monitors unless :
  - There is a spurious down range **and** the smart bi-stable is set so that the scram is active on one range only
  - The unit is on the 1 MW range, a spurious uprange occurs, and there is a concurrent or common mode failure of the maximum range limit function

By setting the smart bi-stable so that it is operable on all ranges, the protective function will be maintained for single-failure spurious range changes. A spurious range change to a range greater than 1 MW requires both a spurious range demand and failure of the maximum range limit function.

It should be noted that the individual Gamma Metrics channels are not single failure proof by design. Many other single failures could cause a channel failure. Redundancy is provided through the use of two separate channels for high neutron flux scram and low flow scram enable.

The first problem experienced with the Gamma Metrics Wide-Range Linear Monitor was in November 1995. We performed a series of bench-top tests at that time in an attempt to determine the root cause of the auto-ranging problem.

The bench-top tests and review of Gamma Metrics documentation for the unit demonstrated the following:

- Auto or Manual Mode ranging malfunctions are not likely to affect the protective function(s) of the unit,

- A spurious down-range can defeat the scram function IF the smart bi-stable is set so that the scram is active on one range only,

- The smart bi-stable comparator should be set on the tenth rotary position (dumb position) which causes the bi-stable to be operative on ALL decades.

It should be noted that Gamma Metrics explicitly explains the smart bi-stable options in their technical manual.

Conclusion

The Wide-Range Linear Monitor configured to provide protection only on the full power range with a coincident spurious down-range would disable the bi-stable and not cause a trip (over-range for the lower scale). Such a scenario may lead to a Technical Specification violation for not having a required protective action. This specific possibility is eliminated by placing the rotary switch on the smart bi-stable card in position "10" (dumb setting) on the NCSU units.

We have advised the TRTR community via the Internet recommending that facilities with identical equipment should review the smart bi-stable description and configuration.

Please feel free to contact us at (919) 515-2321 with any questions or comments.

Sincerely yours,

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cc: Mr. Craig Bassett, USNRC Region II
Senior Project Manager

Gamma-Metrics, Inc.