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NUCLEAR ENERGY DIVISION

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ATOMIC POWER EQUIPMENT DEPARTMENT

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SUBJECT: SAFETY SYSTEM RELAY FAILURES

At a recent meeting with some of your technical staff a request was made to provide information on reported relay failures. Following is a description of the failures, evaluation of the cause and corrective action taken. I trust this will fulfill the request.

I. Description of Failure

In April of this year our Nuclear Instrumentation Department (NID) was informed that three separate safety system logic AC relays had failed to open when de-energized. It was further reported that one relay operated normally after the armature was opened manually. The relay was removed from the panel and examined. Spring tension appeared normal and all parts appeared clean upon disassembly. Residual magnetism caused by a DC fault was suspected as a possible failure mechanism, but no such fault could be found.

II. Evaluation of Cause

One of the relays was returned to the vendor for further examination. The vendor discovered that portions of the molded plastic contact carrier were chipped and the conclusion was reached that the failure mechanism was due to misalignment resulting from the carrier (armature) not being properly guided. All sites were instructed to inspect and replace any chipped carrier guides. At the same time, the vendor initiated a design improvement program to find a stronger guide material and to reduce the shipping damage by improved packaging.

Continued testing at NID and the vendor revealed that the cause of sticking was not the carrier guides, but rather the paint on the pole piece which adhered to the steel armature plate of the energized relay. To prove this mechanism, 29 AC relays and 32 DC relays had the paint removed from the pole piece and replaced with a thin teflon coating. Twenty-nine (29) additional AC relays and 32 DC relays were used as received from the vendor. All 122 relays were mounted in panels similar to those in which the reported failures occurred and were energized at rated voltage for a period of 48 hours, de-energized and observed for proper operation. Meanwhile, the vendor was performing a similar test using clamps to provide added pressure between the armatures and the pole pieces. Five relays were untreated and 10 had teflon applied to the armature.

The results of the tests are shown in Table I (vendor results in parenthesis) and support the conclusion that the mechanism of failure is adherence of the paint on the pole piece to the armature plate while the relay is energized. The fact that the DC relays did not stick was thought to be due to their having a lower operating temperature (no eddy current losses).

TABLE I

Relay Type	Quantity	Number Stuck
DC	32	0
DC-Treated	32	0
AC	29 (5)	7 (4)
AC-Treated	29 (10)	0 (0)

The seven inoperative relays were manually opened and re-energized 12 hours to determine if heat curing the paint might be a possible curb against recurrance of the failure. All seven operated correctly, at the end of 12 hours (as did the other 112). On the basis of these results and the recommendation of the vendor all reactor sites with NID-supplied relays of the same type and vendor were instructed to energize the relays for 48 hours unless it could be positively established that a particular relay had been energized for that period or longer. In the latter case, the relay was exempt from the 48 hour run if it could further be proven to have operated properly upon being de-energized. In addition, all NID-equipped sites were instructed to de-energize the normally energized relays once every 24 hours for a week following the 48 hour run. A similar instruction was issued to NID Manufacturing for relays in the shop.

In June, word was received from one of the overseas sites that relays were still sticking after five cycles of operation.

III. Corrective Action

Discussions between NID and the vendor resulted in the conclusion that the paint was most likely thermoplastic and the only solutions to the problem were to either remove the paint from the pole piece or to coat the armature with a material to which the paint would not adhere. The vendor recommended a teflon paint which had been tested and proved satisfactory. When requested to provide proof that the teflon paint would last for the life of the relay, the vendor demurred. The material was too new to have real time life data and the relay life was too long to allow Arrhenius curves to be generated since the necessary extrapolation would not be defensible.

Further investigation by the vendor revealed that relays made by others used the same pole piece material, uncoated, met MIL-C-2212, and had not experienced any corrosion difficulties. Also, another relay type made by the vendor of the problem relay was using the same pole piece material uncoated.

On the basis of this information, NID and the vendor decided to remove the paint from the face of the pole pieces for relays in the field, in NID's shop and in the vendor's shop. The vendor will leave the pole face unpainted for future production. A Field Memo was issued by NID to all NID-supplied sites instructing in the paint removal process, precautions to be observed and tests to be run following reassembly.

The vendor reported on July 1, 1970 on the results of a corrosion test on a relay in which a pole piece with an uncoated face was submerged in salt water for a period long enough to build up a corrosion layer. The pole piece was reassembled into its relay and tests were run which gave no indication of degradation of performance. The vendor was requested to devise and run a test which would prove that unremoved paint from surfaces other than the face of the pole piece would not migrate to the face and cause sticking. It is felt that since only a small percentage of relays with paint on the pole face stuck in the field and in the tests described above then it most likely required an optimum thickness to provide sufficient adherence. The small amount which might migrate to the face is highly unlikely to be such an amount and, further, if the paint has sufficient strength to bond it most likely is too viscous to run. Results of these tests will be made available to you as soon as they are available.

IV. Conclusions

The relay in question has been manufactured and used for 30 years without problems and with a record of high reliability. For this reason, it was chosen for this critical application. Discussions with the vendor indicate that prior to NID's purchase of the relays which failed, the vendor moved his manufacturing plant and was in the process of training new personnel. This change in personnel and lack of control of paint thickness resulted in the failures.

I feel the steps taken as described above in paragraph III, plus increased testing and surveillance by NID Quality Control adequately preclude recurrance of this failure. If I can be of further assistance in this matter, please let me know.

Sincerely,

Ivan F. Stuart

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