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IN 87-24

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

June 4, 1987

NRC INFORMATION NOTICE NO. 87-24: OPERATIONAL EXPERIENCE INVOLVING LOSSES OF ELECTRICAL INVERTERS

Addressees:

All nuclear power reactor facilities holding an operating license or a construction permit.

Purpose:

This notice is provided to alert recipients of potential problems involving electrical inverter losses that have led to unplanned plant transients and/or inoperability or improper functioning of safety-related and other important plant equipment. It is expected that recipients will review this information for applicability to their facilities and consider actions, as appropriate, to preclude similar problems from occurring at their facilities. However, suggestions contained in this notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Past Related Correspondence:

IE Information Notice 84-80, "Plant Transients Induced By Failure of Non-Nuclear Instrumentation Power," November 8, 1984

IE Bulletin 79-27, "Loss of Non-Class 1E Instrumentation and Control Power System BUS During Operation," November 30, 1979

IE Information Notice 79-29, "Loss of Nonsafety-Related Reactor Coolant System Instrumentation During Operation," November 16, 1979

IE Circular 79-02, "Failure of 120 Volt Vital AC Power Supplies," January 11, 1979

Background:

Inverters in nuclear power plants provide "uninterruptible" vital ac electrical power to safety- and non-safety-related instrumentation and control systems. Generally, loss of this function results in some type of undesirable system condition and/or plant transient, including unnecessary actuation of safety systems such as reactor protection and engineered safeguards systems; loss of indicators that provide plant status information; system disturbances,

including reactor coolant system transients; improper response of the feedwater and steam generator water level control systems; loss of safety-related electrical equipment functions; damage to mechanical equipment; and challenges to operators and the remaining functional equipment. Such conditions and/or transients clearly have significant safety implications since they result in challenges to safety equipment and plant operations and/or a degradation of plant equipment.

The NRC case study report, AEOD/C605 dated December 1986, "Operational Experience Involving Losses of Electrical Inverters," includes the review of 94 licensee event reports (LERs), totaling 107 events involving inverter losses that occurred during 1982 through 1984. The study includes 35 additional events from the Nuclear Plant Reliability Data System (NPRDS) that occurred in the same timeframe. These 142 events occurred at 51 distinct plants: 26 designed by Westinghouse, 11 by General Electric, 9 by Combustion Engineering, 4 by Babcock & Wilcox, and 1 by General Atomic. The total number of events included in the study for each of the 3 years along with the number of reactor units which were operating during each of those years is summarized below.

Parameter	1982	1983	1984
Operating Reactor Units	72	74	82
Inverter Loss Events	34	51	57
Losses/Operating Reactor	.47	.69	.70

As indicated above, the NRC has issued information on inverter losses since 1979; and industry groups have issued approximately 14 reports related to this issue.

Description of Circumstances:

The NRC case study report identified three potential failure mechanisms for inverters. One of these involves relatively high ambient temperature and/or humidity within inverter enclosures. This condition appears to result in accelerated aging of components that form a part of the inverter circuitry causing a significant reduction in component life expectancy and inverter loss.

Another mechanism for inverter failure involves the electrical interconnecting and physical arrangements for the inverter circuitry components. In some installations, these arrangements are such that when certain components fail, other components also may fail or degrade.

The third failure mechanism involves voltage spikes and perturbations. Many of the electrical loads in a plant have inductive characteristics. During plant operations that involve energizing and deenergizing these loads, voltage spikes and perturbations are generated. The solid-state devices in the inverter circuitry are sensitive to these voltage spikes, and this has resulted in component failure, blown fuses, and inverter losses. Additionally, secondary voltage perturbations caused by lightning strikes or switching surges can have an adverse effect on inverter operation.

Discussion:

The NRC case study report indicates that the failure mechanisms involving service condition parameters (e.g., ambient temperature and/or humidity and voltage spikes and perturbations) have common-cause implications. However, none of the events reviewed and evaluated in the report involved the simultaneous loss of redundant inverter-powered buses.

The dominant cause of inverter losses was attributed to component failures. Such components include diodes, fuses, silicon controlled rectifiers, capacitors, transistors, resistors, printed circuit boards, transformers and inductors. It also appears that major contributing factors for the occurrence of component failure events are high ambient temperature and/or humidity within inverter enclosures and electrical disturbances at the inverter input/output terminals. In addition, incorrectly operating circuit breakers, improperly setting up test equipment, removing the wrong inverter unit from service, and improperly transferring power sources for a bus are some personnel actions that make them the second largest contributor to inverter losses.

It is suggested that licensees consider monitoring of temperature and/or humidity internal to inverter enclosures and evaluating input and output voltages of the inverter unit during steady-state and transient conditions to assure that manufacturer's recommendations are being considered. Additionally, to minimize the number of inverter loss events resulting from personnel actions, licensees might consider reviewing related maintenance and testing procedures and practices for inverters. Further, specialized training and practice sessions with involved plant personnel and verification of appropriate sequence of steps to achieve desired related maintenance and testing activities also may be considered.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the Regional Administrator of the appropriate regional office or this office.

Charles E. Rossi

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contact: Vincent D. Thomas, NRR
(301)492-4414

Attachment: List of Recently Issued NRC Information Notices

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Original Signed by
Charles E. Rossi

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Office of Nuclear Reactor Regulation

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VDThomas	FAshe	AWDromerick	Tech Ed	RLBaer
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Edward L. Jordan, Director
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VDThomas	FAshe	AWDromerick	DGable	~~RLBaer~~	~~JERosenthal~~
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