March 27, 1996

Mr. Richard B. Miller
Westinghouse Nuclear Services Division
Westinghouse Energy Center, Mail Stop: East-410
Post Office Box 355
Pittsburgh, PA 15230

SUBJECT: REQUEST FOR A TECHNICAL REVIEW OF A DRAFT INFORMATION NOTICE REGARDING FIRES IN EMERGENCY DIESEL GENERATOR EXCITERS DURING OPERATION FOLLOWING UNDETECTED FUSE BLOWING

Dear Mr. Miller:

The U.S. Nuclear Regulatory Commission (NRC) is planning to issue an information notice discussing a problem identified at the Wolf Creek Generating Station. The problem revealed appears to be of generic nature that could lead to a dormant failure of the emergency diesel generator.

We ask that you review the enclosed draft of that information notice to ensure the technical information is accurate. Your cooperation in this matter is appreciated. Please return any comments by April 5, 1996. A copy of this request and your response will be placed in the Public Document Room for review by the public. Your response should be mailed to:

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTN: John Tappert, NRR/DRPM/PECB
MAIL STOP: O-11E4

Please address any questions you may have on this matter to John Tappert of my staff. Mr. Tappert may be reached by phone at (301) 415-1167. If no comments are received by April 5, 1996, we will assume the technical information in the notice is correct.

Sincerely,

Original signed by Edward F. Goodwin

FOR

Alfred E. Chaffee, Chief
Events Assessment and
Generic Communications Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Enclosure: Draft Information Notice

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

April XX, 1996

NRC INFORMATION NOTICE 95-XX: FIRES IN EMERGENCY DIESEL GENERATOR EXCITERS DURING OPERATION FOLLOWING UNDETECTED FUSE BLOWING

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the potential for damage (possibly fire) to emergency diesel generator (EDG) exciters resulting from sustained high-power operation after undetected blowing of a secondary fuse. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On September 30, 1994, during refueling at the Wolf Creek Generating Station, EDG-A was undergoing postmaintenance testing and balancing. After about one hour of sustained operation above full power as part of a routine prolonged full and above full-power run, a fire occurred in the main power potential transformer of the static exciter-voltage regulator (exciter). The fire was extinguished quickly by deenergizing the exciter and using a portable carbon dioxide fire extinguisher. After the fire in the EDG-A exciter, the licensee performed electrical checks on the EDG-B exciter and found no problems. On October 11, 1994, again after about an hour of above full power operation of EDG-B, its exciter potential transformer also caught fire. This fire was also quickly extinguished by deenergizing the exciter and using a fire extinguisher. After each fire, the licensee found that one of the 100-ampere fuses in the secondary circuits of the respective exciter potential transformer had blown. It was later determined that the fuses had not blown as a result of the fires, but that the blown fuses were a contributing cause of the fires.

The phase B windings of the potential transformer removed from the exciter in EDG-A were severely charred, and the primary and secondary cables were blistered from the terminal lug back several inches. Some collateral damage had occurred to the portions of the A- and C-phase windings closest to the center, B-phase, windings. The condition of the damaged windings in both cases was consistent with progressive insulation breakdown caused by sustained current well in excess of the winding ampacity. Even with lower current in

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the primary, the primary and secondary windings being wound together caused thermal damage to the primary insulation with its ultimate electrical failure as well. The A-phase windings of the potential transformer for EDG-B were similarly damaged.

The blown fuse in the exciter for EDG-A was a power amplifier fuse in the phase C line of the secondary branch circuit supplying one of the power amplifiers. The blown fuse in the exciter for EDG-B was the corresponding fuse in its phase B line. The licensee determined that the fuses had blown in each case as the result of manual engine shutdown without exciter shutdown. This had occurred with the generators unloaded (output breakers open) at the end of the EDG test run preceding the prolonged high-power runs during which the exciter caught fire. The blown fuses were not detected at the time because these fuses had no blown-fuse indication. The fires occurred in both cases after about an hour of sustained operation above full power. Because there was no blown-fuse indication, the normal full and above full-power runs for routine testing were conducted subsequently without knowing that the fuses had blown and "single phased" the potential transformers.

Discussion

Single-phasing the secondary windings of the delta-connected potential transformers, as a result of the blown fuses, left them at about 58 percent of rated capacity with one phase winding carrying two-thirds of the total load. The other two windings were effectively put in series with each other; together they were now in parallel with the first winding, but with twice the total impedance and hence, only one-third total load. This effect is illustrated in Figure 2 of Attachment 1 to this notice. Subsequent operation with the undetected blown fuse for about 1 hour at or above full load severely overloaded the affected windings. It is expected that prolonged operation at any power level significantly above the reduced capacity of the single-phased potential transformers would eventually cause damage. However, even with the imbalanced load, total excitation current demand from the potential transformer, being within expected limits, was not sufficient to blow either or both of the other two fuses. Operation continued until the overloaded windings overheated and suffered progressive insulation breakdown, internal short circuiting of the windings, and the resultant fire.

Although an undetected blown fuse for any reason could cause potential transformer single-phasing and subsequent sustained high-power operation could lead to fires, the reason for the blown fuses at Wolf Creek revealed another apparent design deficiency. In both cases, the exciters were not shut down automatically when the engines shut down due to mechanical causes not accompanied by any of the normal electrical signals that would have otherwise automatically shut down the exciters. On a normal manual shutdown from the control panel, the exciter is turned off automatically as part of the normal shutdown sequence of relay actuations. Similarly, in the event of one of the standard alarm conditions that require immediate EDG shutdown, such as low lube oil pressure, the system automatically shuts down the exciter.

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However, in both cases at Wolf Creek in which fuses were blown, the engines had been shut down mechanically in a manner in which there were no attendant electrical signals to the system to automatically shut down the exciters. In the first instance, after it appeared that control of EDG-A may have been lost upon a failed attempt at a normal shutdown (the unit tried to resume speed due to an unrelated malfunction), the unit was shut down manually at the engine by the operator shifting the engine manual control lever to the stop position which shuts the fuel racks. In the second event, EDG-B shut itself down due to a mechanical failure associated with the governor and the mechanical overspeed trip device, but without an actual overspeed a n condition occurring. In systems equipped with underfrequency and/or voltz-per-hertz protective features, this contingency is provided for, but the system at Wolf Creek had no such features. Therefore, when the engines stopped in both cases under the circumstances described, there was no electrical signal generated to effect automatic exciter shutdown.

Engine shutdown without exciter shutdown caused a potential transformer secondary fuse to blow in each case as follows: The exciters at Wolf Creek (and Callaway) are type WNR manufactured by the Applied Products Division of Westinghouse Electric Corporation (Westinghouse). Figure 1 of Attachment 1 to this notice is a simplified functional block diagram of the affected static exciter-voltage regulator design. The potential transformers that caught fire (designated "PT" in Attachment 1) are Model 26616, delta-connected, 3-phase, step down 4160-Vac to 480-Vac, 45-kVA, 60-hz transformers, manufactured by the NWL Transformer Company in Bordentown, New Jersey. The primary windings of the PT are connected to the 4160-Vac, 3-phase generator output busses. The PT secondary windings supply a portion of the generator DC field excitation through power amplifiers. A major portion of the generator field excitation with the generator under load is supplied by current transformers (designated "CT" in Attachment 1) from the generator output through rectifiers. However, with a generator unloaded and its output breaker open, only a minimal amount of excitation is provided by the current transformers; most of it being provided by the potential transformers.

Expanded safety parameter display system trace printouts of EDG voltage, speed, and load for both events showed that as the generator slowed and produced less output voltage (in both cases the generator was already unloaded with its output circuit breaker open), the exciter, not having been turned off, sensed this and demanded more generator field excitation current to attempt to compensate. In both cases, the exciters attempted to maintain voltage for about 20 seconds during engine coastdown, after which voltage decayed rapidly. Attempting to maintain voltage with the generator slowing caused excessive current in the potential transformer secondary (now the sole source of excitation power with the generator breaker open) which blew one of the fuses. With the resultant reduction in generator field excitation, coupled with the collapsing stator (armature) induced voltage as the machine slowed, the available current was insufficient to blow either of the remaining fuses. Although these Westinghouse exciters are used at the Standard Nuclear Unit Power Plant System (SNUPPS) plants, Wolf Creek and Callaway, their general features are not uncommon and other designs including Basler Electric Type SB (series boost) exciters (without underfrequency or volts-per-hertz protection), are potentially susceptible to problems similar to those described herein.

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The licensee is evaluating installation of blown fuse indication on the EDG exciter cabinets. As a temporary measure, the licensee established procedures and trained operators to verify the condition of the potential transformer secondary fuses following all EDG shutdowns, particularly those in which there are indications (such as no exciter shutdown light) that the exciter was not turned off automatically. Procedures and training will also cover the conditions under which the exciter shutdown pushbutton is to be actuated and under which the alternate power amplifier is to be selected to maintain operability, e.g., in case an EDG demand signal is received during the fuse verification, or in case a fuse should blow during operation with or without an attendant fault or overload condition.

The licensee, in consultation with Westinghouse (and Cutler-Hammer, which now owns the exciter design), the architect/engineer (Bechtel), and the EDG system supplier (Coltec), is evaluating the design of this EDG system in terms of ensuring automatic exciter shutdown in case of a manual or other mechanical engine shutdown without electrical signals. The licensee is also evaluating procedures and operator training to prevent blowing the exciter potential transformer power amplifier fuses under the condition in question. In other designs, such as newer Basler equipment, underfrequency protection is often available that will independently shut down the exciter upon loss of the prime mover. Volts-per-hertz protection can also serve to avoid the conditions in question. However, EDG exciter systems of other designs that remain on, either through design flaw or malfunction, after engine mechanical shutdown may behave in a similar manner.

No specific action or written response is required by this information notice. If you have any questions regarding this matter, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Dennis M. Crutchfield, Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Stephen D. Alexander, NRR
(301) 415-2995

John Whittemore, RIV
(817) 860-8294

Attachments:
1. Exciter Block Diagram and
   Blown Fuse Effect Diagram
2. List of Recently Issued NRC Information Notices

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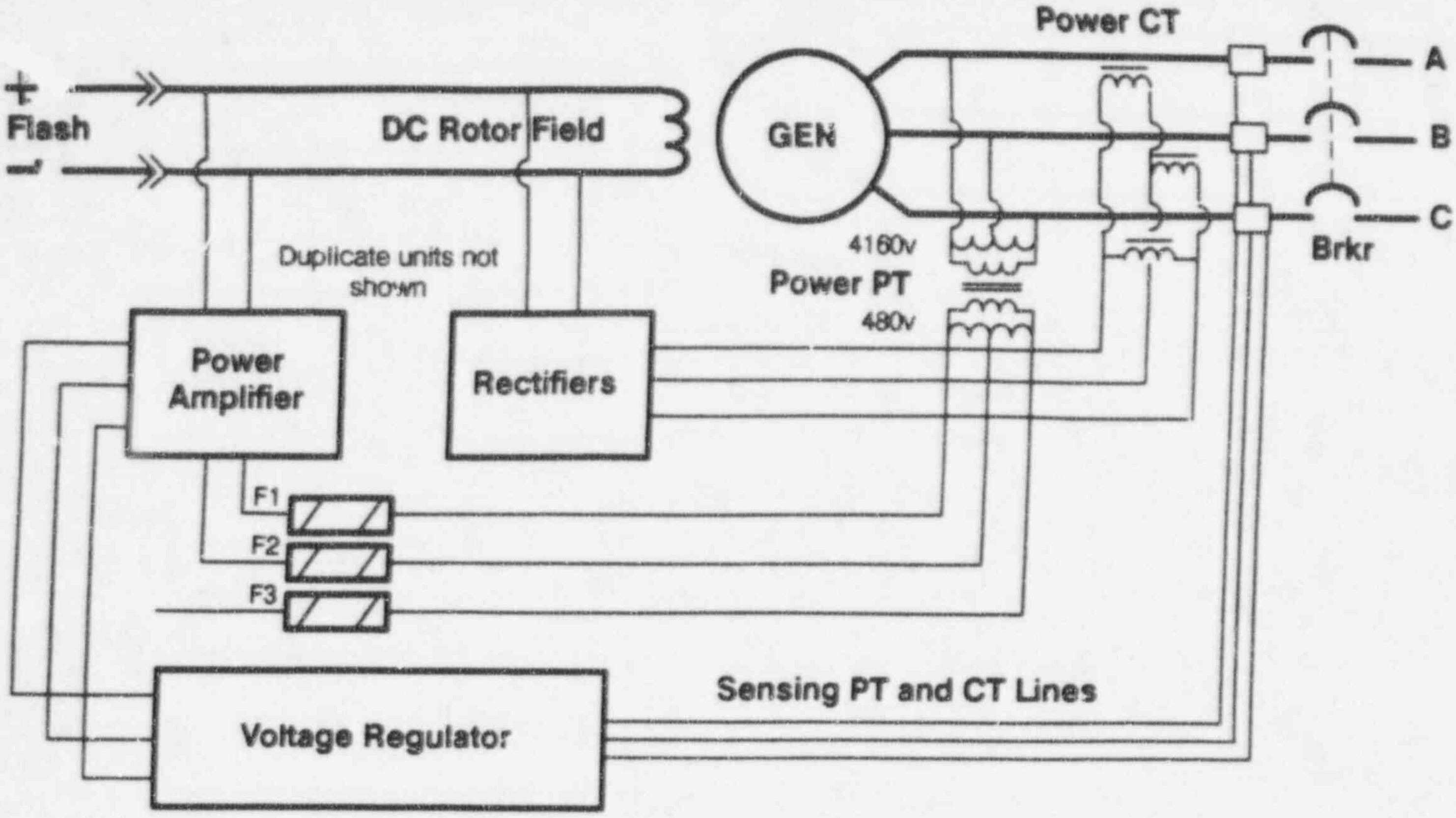

Figure 1: Emergency Diesel Generator Static Exciter–Voltage Regulator
Simplified Functional Block Diagram

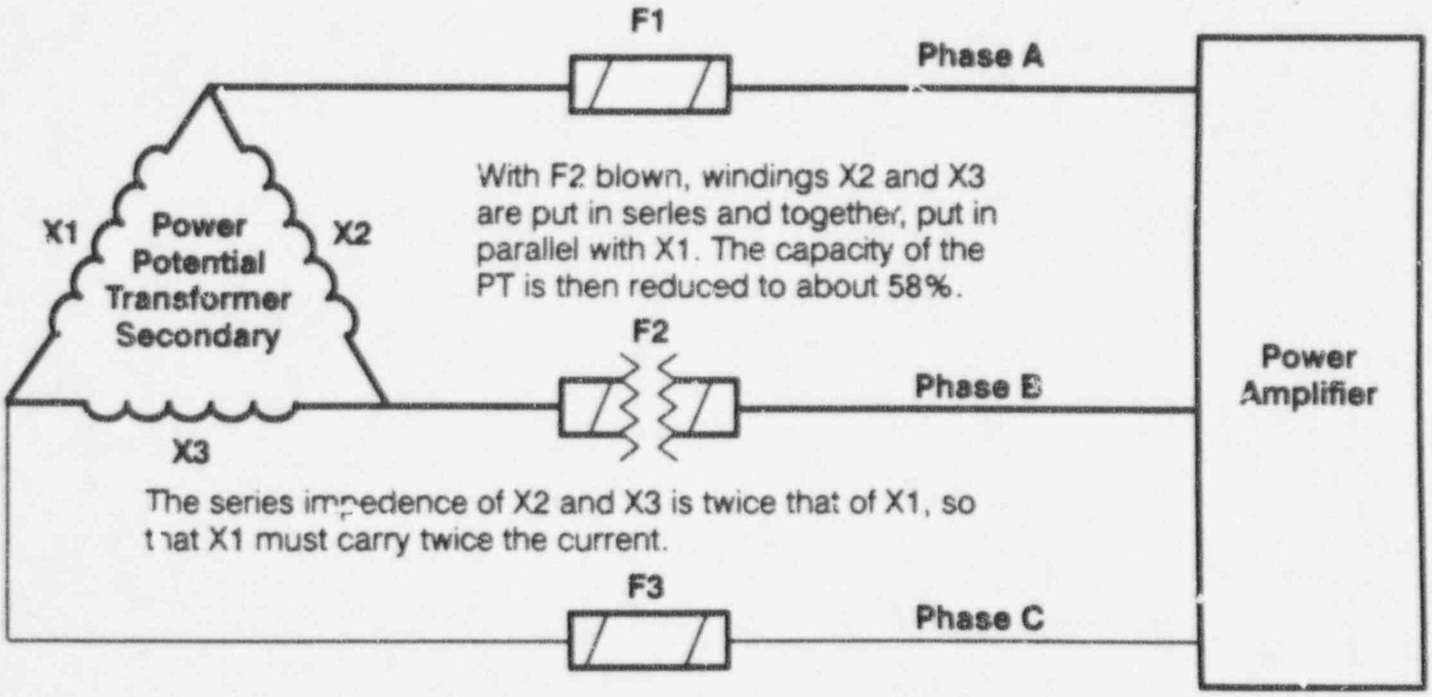

Figure 2: Effect on Potential Transformer Secondary Windings of Single–Phasing
Due to Blown Fuse