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August 19, 1992

Document Control Desk
Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Special Report: Test Failure of Division I Diesel Generator at Clinton Power Station (CPS)

Dear Sir:

CPS Technical Specification 4.8.1.1.3 requires all diesel generator failures, valid or non-valid, to be reported to the NRC within 30 days pursuant to Specification 6.9.2, SPECIAL REPORTS. Due to valid failures of the Division I Diesel Generator (DG1A) during surveillance testing on July 17, 1992 and August 7, 1992, the attached SPECIAL REPORT is being submitted in accordance with the CPS Technical Specifications to provide the information required by Regulatory Guide 1.108, Revision 1, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," Regulatory Position C.3.b. As these events constitute the seventh and eighth valid failures in the last 100 valid tests performed on DG1A, additional information recommended in Regulatory Guide 1.108, Regulatory Position C.3.b is also provided in the SPECIAL REPORT as required by Technical Specification 4.8.1.1.3.

As discussed with Mr. R. D. Lanksbury of USNRC Region III, IP requested the due date for this report be extended until August 19, 1992 so that the results of the investigation into the August 7, 1992 failure could also be included in this report. Mr. Lanksbury agreed to IP's request.

Sincerely yours,

RJ Phares /for

F. A. Spangenberg, III
Manager, Licensing and Safety

DAS/mfm

cc: NRC Clinton Licensing Project Manager
NRC Resident Office
Regional Administrator, Region III, USNRC
Illinois Department of Nuclear Safety

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Description of Event

At 0943 hours on July 17, 1992, the Division 1 diesel generator (DG1A) was started for routine surveillance per Clinton Power Station (CPS) Procedure 9080.01, "Diesel Generator 1A (1B) Operability - Manual." Although DG1A reached the required voltage and frequency within the time specified by Technical Specification 4.8.1.1.2, when the operator attempted to synchronize the generator to offsite power, the output breaker failed to close. The breaker also failed to close on a second attempt. The breaker was locally racked out and then racked back in. The breaker successfully closed on the next attempt. DG1A was then fully loaded and the surveillance test was completed without further problems.

Maintenance Work Request (MWR) D25003 was initiated to troubleshoot and identify the cause of the breaker failure. While functionally testing the breaker control switch and synchronization switch, Electrical Maintenance personnel recorded resistance readings across the switch contacts. Inspections at the remote shutdown panel, as well as inspection of the undervoltage relay and control circuity contacts, revealed no abnormalities. Further troubleshooting was suspended while a more in-depth action plan was developed. The intent of the action plan was to functionally test all active components in the breaker closing circuit and record pertinent quantitative information in order to determine the root cause of the failure to close.

Performance of the next routine surveillance test on July 24, 1992 was successful with no recurrence of the output breaker closure problem. Another successful surveillance test was completed on July 31, 1992. [As a result of the July 17, 1992 failure, DG1A was being tested on a weekly test frequency per Technical Specification Table 4.8.1.1.2-1.]

The comprehensive action plan identified above was finalized on August 6, 1992. Scheduling arrangements were made to enter an outage on DG1A the following week (on August 13, 1992) to perform the investigation outlined above. However, at 0305 hours on August 7, 1992, prior to implementation of the action plan, the output breaker again failed to close during routine testing. The synchronization switch was cycled, and breaker closure was attempted several times. These attempts were also unsuccessful. The breaker was then racked out and then back in. Similar to the occurrence on July 17, 1992, the output breaker closed on the next attempt. DG1A was then fully loaded and the surveillance was completed without further problems. However, because a similar failure had previously occurred on July 17, 1992 and the root cause of that event had not yet been determined, DG1A was declared inoperable.

Investigation continued under the action plan (MWR D25003). Performance of point-to-point and contact resistance readings in the breaker cubicle revealed problems with the 1-2 contact pair of truck-operated contacts (TOC) switch H1. The purpose of this switch is to signal the output breaker closing circuitry that the breaker is racked in. (Closure of the breaker is prevented if it is not fully racked in.) The TOC switch contains a number of contacts which provide input to the breaker logic. Some, but not all, of these contacts also provide input into breaker status indication circuits. Inspection of the TOC switch revealed its contacts to be pitted and tarnished. In addition, Electrical Maintenance personnel noted that other contacts in this switch would close before the 1-2 contact pair would close and that the 1-2 pair would open before the other contacts would open. Because the 1-2 contact pair does not provide input to breaker status indication, the 1-2 contact pair could be open without any indication of the problem. Experimentation with different breaker racking positions while jarring the cubicle demonstrated that jarring (such as occurs during breaker closure) could cause contact pair 1-2 to open while the remaining contacts in this switch remained closed.

The H1 TOC switch was replaced. As a precaution, TOC switch H2 (which is of a similar design but provides a different function) was also replaced. Following replacement, continuity readings were taken across the 1-2 contact pair of the H1 TOC switch. The output breaker was then racked to the "test" position and successfully cycled three times. Continuity readings across the 1-2 contact pair of the new H1 TOC switch were taken, and no changes were noted. The breaker was then racked back in. At 1238 hours, DG1A was started. The diesel generator was successfully synchronized with offsite power, loaded, and then unloaded three separate times. No problems were experienced during this evolution. DG1A was then loaded to rated conditions following the third breaker closure. Following DG1A shutdown, continuity checks across the 1-2 contact pair of the new H1 TOC switch were again performed, and again no changes were noted. Based on the above corrective actions and post-maintenance testing, DG1A was restored to operable status at 1410 hours on August 8, 1992.

The root cause of the DG1A output breaker failure to close on July 17, 1992 and August 7, 1992 has been determined to be failure of the H1 TOC switch. IP believes that the 1-2 contact pair of the H1 TOC switch lost electrical continuity due to (1) slight breaker movement, and/or (2) buildup of oxidation/pitting on the contact surfaces.

<u>Corrective Actions</u>

As stated above, the H1 TOC switch was replaced, as well as the H2 TOC switch. IP will inspect/replace similar TOC switches in the Division II output breaker cubicle and switches which perform a similar function in the Division III output breaker cubicle by October 1, 1992. In addition, IP will inspect/replace TOC switches in similar breaker cubicles in safety-related applications by the end of the fourth refueling outage (which is currently scheduled to begin in September 1993). Further, IP will review the vendor manual for the 4.16 kV switchgear to identify any additional recommendations regarding maintenance of the TOC switches. Any necessary procedure or preventive maintenance program changes will be made prior to inspecting/replacing those TOC switches in the non-diesel generator safety-related applications.

Additional Information Required per Regulatory Guide 1.108, Regulatory Position C.3.b

These events constitute the first and second valid failures in the last 20 valid tests performed for DG1A and the seventh and eighth valid failures in the last 100 valid tests performed for DG1A. Therefore, the surveillance frequency for DG1A has been increased to at least once per seven days in accordance with Technical Specification Table 4.8.1.1.2-1. This surveillance frequency will be maintained until seven consecutive failure-free demands have been performed and the number of failures in the last 20 valid demands has been reduced to one or less. In addition, as these events caused the number of valid failures in the last 100 valid tests to be greater than or equal to seven (on a per-diesel generator basis), the additional information recommended in Regulatory Guide 1.108, Regulatory Position C.3.b is provided below.

Corrective Measures to Increase Diesel Generator Reliability

The eight valid failures of DG1A which have occurred in the last 100 valid tests occurred on: (1) October 19, 1989 (reference IP SPECIAL REPORT U-601561 dated November 17, 1989); (2) November 20, 1989 (reference IP SPECIAL REPORT U-601577 dated December 20, 1989); (3) December 11, 1989 and (4) December 27, 1989 (reference IP SPECIAL REPORT U-601589 dated January 11, 1990); (5) December 30, 1989 (reference IP SPECIAL REPORT U-601599 dated January 29, 1990 and supplements U-601632 dated March 29, 1990 and U-601678 dated May 30, 1990); (6) April 4, 1991 (reference IP SPECIAL REPORT U-601834 dated May 6, 1991); and (7) July 17, 1992 and (8) August 7, 1992 (reference this SPECIAL REPORT).

The DG1A failure on October 19, 1989 was the result of a slow start caused by an inadequate fuel supply to the engine. Air had entered the fuel supply system when the DG1A day tank was inadvertently drained too low during the performance of a surveillance test. The day tank level was intentionally being lowered to demonstrate the capability of the diesel fuel oil transfer system to automatically transfer fuel from the storage tank to the day tank as required by the Technical Specifications. In order to demonstrate this auto-start function of the fuel oil transfer pump, fuel is drained from the day tank to the storage tank to lower the level of fuel in the day tank. During this test on October 19, 1989, the entire day tank volume was inadvertently drained back to the fuel oil storage tank. This allowed the fuel in the engine-driven fuel pump suction piping to drain back into the drained day tank and allowed air to enter the fuel pump suction piping. The day tank was restored to its normal level prior to starting the engine; however, the fuel system piping (from the day tank to the fuel injectors) was not sufficiently primed to remove all the air. The resulting air entrainment prevented proper starting of the engine.

To ensure that the day tank level remains above that of the fuel pump suction piping during surveillance testing, a design change was implemented. This design change (Field Alteration DOF002) raised the low day tank level setpoint for auto-start of the transfer pump to 85% full (versus the previous 70% full for DG1A). This design change ensures that the fuel transfer pumps automatically start prior to the day tank level reaching the level of the fuel pump suction piping. In addition to this design change, changes to the DG operating procedure (CPS Procedure 3506.01) and the routine operability surveillance procedures (CPS Procedures 9080.01 and 9080.02) have been implemented to ensure that the engines are properly primed prior to starting. No difficulties associated with air entrainment in the fuel supply lines have been experienced subsequent to the DG1A failure on October 19, 1989.

The DG1A failures on November 20, December 11, and December 27, 1989 were also the result of slow starts. As identified in IP SPECIAL REPORT dated January 11, 1990, the root cause of these slow starts was the subject of an Action Plan. The objectives of this Action Plan were to identify the root cause and resolve those factors which may impact the ability of DG1A to routinely meet its starting requirements.

Corrective actions for the November 20, 1989 failure included readjustment of the settings on the speed controller for the electronic governors of DG1A. Following the subsequent slow start on December 11, 1989, troubleshooting under the Action Plan was begun. This troubleshooting identified a defective speed sensing relay. One function of this relay is to trigger de-energization of the air start systems for DG1A after the engine is running. Monitoring of the relay contacts associated with this function revealed intermittent opening and reclosing during the initial portion of the starting sequence. The potential impact of this condition was to reduce the effectiveness of the air start motors and the governor boost. The defective speed sensing relay was replaced, and DG1A was restored to operable status on December 13, 1989. However, DG1A experienced an additional slow start on December 27, 1989. Further troubleshooting under the Action Plan identified no specific problem which would have caused the subsequent slow start.

After further review of the starting history of DG1A, Nuclear Station Engineering Department (NSED) personnel, with the concurrence of the diesel generator manufacturer, decided to replace the governor on the 12-cylinder engine. (DG1A is a tandem diesel generator set utilizing a 12-cylinder engine and a 16-cylinder engine.) This decision centered on the fact that the slow starts appeared to be time dependent and were characterized by a marked decrease in engine acceleration midway to synchronous speed. This distinct feature began occurring following replacement of the governor on the 12-cylinder engine during February 1989. Following subsequent replacement of the 12-cylinder engine governor on December 27, 1989, three maintenance troubleshooting starts were conducted. Each of these troubleshooting starts resulted in start times that were less than 9.1 seconds, significantly faster than the starting times of 12.8, 12.3, and 12.7 seconds experienced during the failures on November 20, December 11, and December 27, 1989, respectively, and the Technical Specification limit of 12.0 seconds.

Following these troubleshooting starts, a start of DG1A was attempted on December 30, 1989 in order to demonstrate its operability. The diesel cranked but did not start. Investigation into this failure determined that a contact pair on the K19 control set-up relay had failed. Following replacement of the affected K19 relay, DG1A was restored to operable status on December 30, 1989 with a resulting starting time of 8.9 seconds.

Root cause evaluation of the K19 relay failure concluded that the small load that the relay contact pair carries (22 mA) is insufficient to ensure electrical "cleaning" of the contact surfaces following extended use. The resulting lack of electrical continuity resulted in the failure of the diesel generator to start. In response to the Division I diesel generator failure, the corresponding relay on the Division II diesel generator was replaced and an appropriate replacement frequency for this relay was established. (The Division III diesel generator does not utilize this relay in any application.)

As stated previously, the slow-start problem of DG1A was the subject of an Action Plan whose objective was to identify the root cause and resolve those factors which may impact the ability of DG1A to routinely meet its starting requirements. Investigation of the potential slow-start contributors included installing instrumentation to monitor start control circuitry and governor response. This instrumentation did not reveal any specific cause for the slow starts outside of the governor itself. As identified in the January 11, 1989 SPECIAL REPORT, prior to replacement of the 12-cylinder engine governor on December 27, 1989, the governors of DG1A were different models. Both models were approved for use on the installed engines, and the governor manufacturer had stated that the two models were interchangeable. Replacement of the governor on the 12-cylinder engine (EGB13P model 9903-266) on December 27, 1989 resulted in restoring consistency in the models for the two engines (EGB13P model 9903-265).

Based on testing of the removed governor at Woodward, IP concluded that the most probable root cause of the DG1A slow-start problem was misapplication of the Woodward EGB13P model 9903-266 governor when used in tandem with the Woodw rd EGB13P model 9903-265 governor. [The initial response (zero RPM to 200-300 RPM) of the model 9903-266 governor was observably slower than that known to occur during starts using a 9903-265 model governor.] As corrective action, IP required future use of matched model number governors.

Objective data strongly suggests that replacement of the 12-cylinder engine governor with a model 9903-265 on December 27, 1989 under the Action Plan resolved the DG1A slow-start problem. Although the root cause was not conclusively identified, implementation of the Action Plan effected a thorough investigation and confirmed the effectiveness of corrective actions taken. In addition, subsequent testing has demonstrated that the slow-start problem of DG1A has been resolved. (As of August 10, 1992, 89 valid tests have been performed on DG1A without a slow-start failure.)

The DG1A failure of April 4, 1991 was caused by the failure of the output breaker to close when the operator attempted to synchronize the diesel generator with offsite power during a surveillance test. Maintenance Work Request (MWR) D17315 was initiated to investigate the failure. The undervoltage and auxiliary relays were removed, inspected, and recalibrated; the breaker cubicle, control power fuses, and breaker contacts were inspected. No discrepancies were found.

Since troubleshooting did not reveal a cause for the DG1A failure, the output breaker was racked in and DG1A was tested with satisfactory results. Additionally, the diesel generator was loaded and unloaded a number of times, thus causing the output breaker to be cycled several times. This provided reasonable assurance of the breaker's reliability.

No specific cause for the April 4, 1991 breaker failure was ascertained. The May 6, 1991 SPECIAL REPORT for this event concluded that the cause may have been a failure of the breaker to completely engage due to a problem with the breaker racking mechanism; but as previously stated, the breaker subsequently functioned properly. Notwithstanding, an MWR was initiated to inspect and lubricate the racking mechanism for the DG1A output breaker to ensure its proper functioning in the future. No discrepancies were found during this subsequent inspection.

The root cause and corrective action for the valid failures of DG1A on July 17, 1992 and August 7, 1992 were previously discussed.

<u>Assessment of the Existing Reliability of Electric Power to Engineered Safety Feature Equipment</u>

The IP electrical system design provides a diversity of power supplies. The 138-kV offsite power supply system provides power to CPS by means of a transmission line that connects CPS to the IP grid at the Clinton Route 54 Substation. Electrical power can be fed to the substation through a line from the South Bloomington Substation or through a line from the North Decatur Substation, or both. The line from the Clinton Route 54 Substation terminates directly (through a circuit switcher) at the Emergency Reserve Auxiliary Transformer (ERAT), which transforms the electrical power to 4160-volt auxiliary bus voltage.

The 345-kV offsite power supply system provides power to CPS via three separate transmission lines. These lines connect CPS to the IP grid at the Brokaw, Rising, and Latham Substations. All three lines terminate at the station switchyard ring bus which feeds (through a circuit switcher) the Reserve Auxiliary Transformer (RAT), which in turn transforms the electrical power to 6900-volt and 4160-volt auxiliary bus voltages. Only one 138-kV line and one 345-kV line are required by the CPS Technical Specifications.

In the unlikely event that the offsite AC power sources described above become unavailable, there are three diesel generator units on site. Diesel generator 1A (DG1A) supplies power to Division I electrical equipment, diesel generator 1B (DG1B) supplies power to Division II electrical equipment, and diesel generator 1C (DG1C) supplies power to Division III electrical equipment. These diesel generator units are capable of sequentially starting and supplying the power requirements for safe shutdown of the plant.

The transmission line feeders to CPS have proven to be extremely reliable. The only measured power interruption of the transmission line feeders occurred in 1989 for approximately four seconds on one of the three 345-kV feeders.

CPS has never experienced a complete loss of offsite power. However, an event on November 11, 1988 resulted in loss of AC power to non-safety related loads due to the need to disconnect the RAT from the switchyard. AC power remained available to the safety-related loads via the ERAT. This event is described in CPS Licensee Event Report (LER) 88-028 and is summarized below.

On November 11, 1988, a short-circuit in main power transformer 1C resulted in a main generator trip, main turbine trip, and a reactor scram. Following the loss of the main power transformer, the non-safety related loads transferred to the RAT per design. Cooldown of the reactor was initiated and the plant entered cold shutdown on November 13, 1988.

On November 14, 1988, arcing was noted on the RAT circuit switcher. Plant operators began transferring the safety-related loads from the RAT to the ERAT. Following a controlled load shedding of the non-safety related equipment from the RAT, the RAT was disconnected from the station switchyard ring bus by remotely opening 345-kV circuit switcher 4538. Inspection of the circuit switcher revealed that the blade disconnect hinge assembly on the B phase, line side, was damaged and required replacement. Following replacement of the circuit switcher, the RAT was reenergized, approximately 14-1/2 hours after it was removed from service. This event did not result in any unplanned actuation of any engineered safety features. Periodic infrared thermography testing was implemented on circuit switcher connections to identify future degradations before an outage occurs.

Basis For Continued Plant Operation

As described above, the IP electrical system design provides a diversity of power supplies to the safety-related equipment needed to achieve and maintain the plant in the safe shutdown condition. These power supplies consist of: (1) the 138-kV offsite transmission line from the Clinton Route 54 Substation which supplies the ERAT, and (2) the station switchyard ring bus which supplies the RAT. The Clinton Route 54 Substation can be fed by two separate lines from two separate substations. The ERAT is sized to carry all the safety-related loads of CPS. The station switchyard ring bus can be fed by three separate 345-kV lines which originate from three separate substations. The RAT is sized to carry all the station loads (safety-related and non-safety related).

In the event of a complete loss of offsite power, all three diesel generators sequentially start and supply the power requirements for the respective divisions of safety-related equipment. Based upon the operability of the diesel generators and the redundancy and demonstrated reliability of the offsite AC sources, continued plant operation is justified.

Summary of Testing of DG1A

Of the last 100 valid tests performed for DG1A eight have resulted in valid failures. These valid failures were previously discussed in detail. Additionally, 57 non-valid tests were conducted during this time period in order to perform troubleshooting and post-maintenance testing. Three of these non-valid tests resulted in failures:

(1) The first of these non-valid failures occurred on December 27, 1989 and, as reported in IP SPECIAL REPORT U-601589 dated January 11, 1990, was the result of improper placement of jumpers associated with the installation of test equipment. This test equipment was installed to aid in troubleshooting under the previously-discussed DG1A Action Plan to resolve the slow-start problem as discussed above.

(2) The second of these non-valid failures occurred on May 15, 1990 and, as reported in CPS LER 90-011 dated June 14, 1990 (reference U-601688), was the result of the failure to reopen the service water supply to the diesel engine jacket water heat exchangers following replacement of the service water bellows connections to the heat exchangers. Because the cooling water supply was isolated, the diesel tripped due to high jacket water temperature. This failure was originally classified as a valid failure; however, as documented in NRC letter to IP dated January 25, 1989, this failure was reclassified as non-valid.

(3) The third of these non-valid failures occurred on January 9, 1992 and, as reported in IP SPECIAL REPORT U-601931 dated February 5, 1992, was the result of a reverse power trip during diesel generator synchronization. This trip was caused by operator error during closure of the output breaker.

Testing of DG1A has been accomplished at the frequency required by the CPS Technical Specifications. The required frequency of surveillance testing of the diesel generators at CPS is specified by Technical Specification Table 4.8.1.1.2-1. The frequency of testing for a given diesel generator is determined by the demonstrated reliability of that diesel generator. Technical Specification Table 4.8.1.1.2-1 states that the diesel generator testing frequency shall be at least once per 31 days if the number of failures in the last 20 valid tests performed is one or less <u>and</u> in the last 100 valid tests performed is four or less. The surveillance frequency must be increased to at least once per seven days if the number of failures in the last 20 valid tests performed is two or more <u>or</u> if the number of failures in the last 100 valid tests performed is five or more. Footnote "**" (of Technical Specification Table 4.8.1.1.2-1) further states that the seven-day surveillance frequency must be maintained until seven consecutive failure-free demands have been performed <u>and</u> the number of failures in the last 20 valid tests performed has been reduced to one or less.

At the start of this report period (i.e., during the last 100 valid tests of DG1A), DG1A had experienced zero valid failures in the last 20 valid tests and three valid failures in the last 100 valid tests (only 51 valid tests had been performed for DG1A since receipt of the CPS operating license). Therefore, DG1A was being tested on a monthly basis in accordance with Technical Specification Table 4.8.1.1.2-1.

The valid failure on November 20, 1989 constituted the second valid failure in the last 20 valid tests and the fifth valid failure in the last 100 valid tests (only 59 valid tests had been performed for DG1A since receipt of the CPS operating license). Therefore, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A increased to weekly.

On September 27, 1990, IP received Amendment No. 49 to the CPS Technical Specifications. This amendment revised Technical Specification Table 4.8.1.1.2-1 to allow a diesel generator's testing frequency to be returned to monthly if seven consecutive failure-free demands have been performed and the number of failures in the last 20 valid tests has been reduced to one or less, regardless of the number of failures in the last 100 valid tests. At that time, DG1A had experienced zero valid failures in the last 20 valid tests and seven valid failures in the last 100 valid tests. As a result, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A returned to monthly.

The valid failure on April 4, 1991 constituted the first valid failure in the last 20 valid tests and the sixth valid failure in the last 100 valid tests. As a result, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A was again increased to weekly. By May 16, 1991, seven consecutive failure-free tests had been performed and the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A returned to monthly.

The valid failure on July 17, 1992 constituted the first valid failure in the last 20 valid tests and the seventh valid failure in the last 100 valid tests. As a result, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A again increased to weekly. The valid failure on August 7, 1992 was the second valid failure in the last 20 valid tests and the eighth valid failure in the last 100 valid tests. As a result, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A remained at weekly.

The current valid failure count for DG1A, as of August 10, 1992, is two valid failures in the last 20 valid tests and seven valid failures in the last 100 valid tests. Therefore, the testing frequency required by Technical Specification Table 4.8.1.1.2-1 for DG1A remains at weekly. This testing frequency will be maintained until seven consecutive failure-free demands have been performed and the number of failures in the last 20 valid tests has been reduced to one or less.

As can be seen from the above discussion, the surveillance testing for DG1A has been conducted in accordance with the frequencies required by Technical Specification Table 4.8.1.1.2-1.