

CONTROL BLOCK: 1 1 1 1 1 1 ①

(PLEASE PRINT OR TYPE ALL REQUIRED INFORMATION)

Dupe 7906180620

Additional Event Description and Probable Consequences:

Following successful completion of the Unit 4 Integrated Safeguards Test (ISGT) while Unit 3 was in hot shutdown and Unit 4 was in refueling shutdown, a 24-hour, simultaneous full-load test of the two Turkey Point Emergency Diesel Generators (EDGs) was commenced. This EDG test was being conducted pursuant to the commitment in our letter of May 7, 1979 (L-79-113).

The "A" EDG tripped due to differential-relay lockout on B and C phases. The "B" EDG was manually stopped, and thus the test was terminated after approximately ten hours.

(Reference attached "Emergency Diesel Generators, Sequence of Events").

Additional Cause Description and Corrective Actions:

Subsequent investigation and testing revealed a design error present on both the "A" and "B" EDGs which resulted in overheating of the Exciter Power Transformers (EPTs) at sustained high-load operation.

Through investigation and testing, we arrived at the following conclusions:

1. The EPTs, when connected to the EDG in a 4-wire wye arrangement, are subjected to a circulating third-harmonic current. This current is large enough to cause overheating in the EPTs. The current is caused by the harmonic content of the diesel generator voltage, not by the magnetizing current requirement (which is a small percentage of rated current) of the transformers.
2. Each phase of the EPT primaries was connected directly across a phase of the EDG. Because the delta-connected EPT secondaries are a low impedance path for third harmonic currents, the impedance reflected to the primaries is essentially zero for third-harmonics. Third-harmonic currents will, therefore, flow in each phase in an amount determined by Ohm's Law, $I=E/Z$, where E is the third-harmonic content of the EDG phase voltage, and Z is the sum of:
 - (1) the internal impedance of the EDG phase,
 - (2) the impedance of the EPT primary, and
 - (3) impedance reflected into the EPT primary from the secondary.
3. The manufacturer of the EDG states that the third-harmonic content of the generator output is 2%. Rated generator current is 434 amps per phase. Two percent of this value, or 8.68 amps, is a reasonable estimate of the third harmonic-current available from each phase. Extrapolation of the measured neutral current agrees closely, about 2.9% (12-1/2 amps) at 3125 KVA. Because 2% of the generator rated current is equal to 138% of the transformers rated current, the generator has ample capacity to overheat the transformers with circulating third-harmonics alone.

4. We conclude that it is improper to connect a low KVA rated transformer to a high KVA rated generator without limiting the flow of third harmonic currents.
5. Removal of the neutral connection could subject the transformer to "neutral instability" if its load were not balanced. Because testing disclosed that the neutral current contained only 180 Hz. current, we concluded that the load on the transformer is essentially balanced; therefore, the neutral could be disconnected without causing "neutral instability".
6. Removal of the primary neutral connection will not block the flow of desirable third harmonic magnetizing current in the transformer. Magnetizing current can still flow in the delta-connected secondary.
7. During the investigation, an improper fuse contact on the primary side of one phase of an EPT was found. This deficiency combined with the primary neutral connection allowed the transformer bank to operate in an open-delta configuration and thus did not indicate a primary fuse failure. The modification/repairs to correct the problems will preclude operation in an open-delta configuration which results in exceeding the transformer design parameters.
8. Because the circulating currents were contained in the EPT delta-connected secondary, the modification to remove the primary neutral did not affect the voltage regulator.
9. Differential relaying for the generator will be improved by this modification. Circulating phase currents are measured by generator CTs only, so their suppression will improve the margin to trip by reducing the phase currents to their design values. (No generator protection exists on the neutral connection).

A modification was implemented to remove the offending neutral connection.

The modification/repairs have been completed, and a 24 hour full load test has been successfully performed on each EDG.

Emergency Diesel Generators
Sequence of Events

5/25/79 11:11 PM Unit 3 off-line for Unit 4 Integrated Safeguards
Friday Test (ISGT) and 24 hour Emergency Diesel
 Generator (EDG) load test.

5/26/79 9:15 AM ISGT first run - "A" diesel generator lockout - 2
Saturday agastats out of timing (LER 251-79-8)

 4:15 PM Second ISGT completed - OK

 6:00 PM Commenced 24 hour load test on "A" and "B" EDGs.

Diesel Generator sets (2)

Supplier: A. G. Schoonmaker Co., Inc.

Manufacturer: Electro-Motive Division (EMD) of
 General Motors Corp.

Model: EMD Model 999-20
 generator - A-20
 engine - 20-645E4

Generator Rating: 4160V, 3 phase, 60 Hz, 3125 KVA

5/27/79 4:35 AM "A" EDG trip - B & C phase differential.
Sunday

 5:05 AM Shutdown "B" EDG - Normal manual shutdown.

Found A phase exciter power transformer (EPT) on
"A" EDG grounded. B & C phase EPTs dripping
liquid insulation on floor.

Nameplate data of Exciter Power Transformers (3)

GE - single phase
Model - 9T24Y1004
Serial - MD
Cy - 60
KVA - 15
Insulation - 4160Y
Hi - 2400 Lo - 240/120
Temp. rise - 115° C
Approx. imp. - 2.1%
Weight - 275#

NOTE: One replacement EPT in storeroom and two received from GE factory in Ft. Wayne, Indiana. Sunday evening - 10:00 PM at Lauderdale Airport.

5/28/79 Monday	8:00 AM	Three EPTs from "A" EDG at GE apparatus shop for rewinding
5/29/79 Tuesday	12:35 PM	Started "A" EDG after installation of 3 new EPTs
	12:55 PM	Commenced 24 hour EDG load test on "A" EDG
	2:45 PM	"A" EDG tripped - B & C phase differential
	11:00 PM	Commenced installation of 3 distribution type aerial transformers and instrumentation in order to trouble shoot "A" EDG problems.
5/30/79 Wednesday	8:53 PM	Started "A" EDG to verify circulating currents in EPTs (Probable cause for faulting EPT)
	9:32 PM	Stopped "A" EDG - Verified presence of circulating currents. Disconnected neutral lead.
	11:30 PM	Started "A" EDG to verify absence of circulating currents with neutral disconnected.
5/31/79 Thursday	4:10 AM	Stopped "A" EDG - test satisfactory - no circulating currents.
	4:25 AM	Removed "B" EDG from service to disconnect neutral lead.
	7:00 AM	Started "B" EDG.
	7:01 AM	Stopped "B" EDG - no control of voltage.
	10:00 AM	Inspected voltage regulator, test ran "B" EDG again and confirmed high voltage, but no voltage control and no obvious cause.
	11:30 AM	Commenced hot to cold shutdown on Unit 3 due to EDG problems.
	1:00 PM	Found missing fuse clip on "B" EDG which caused voltage regulation problems.
	3:25 PM	Started "B" EDG after fuse clip repairs.
	3:45 PM	Commenced 24 hour load test on "B" EDG.
	7:20 PM	Stopped hot to cold shutdown on Unit 3. RCS @ 450° F.

	7:20 PM	Commenced Unit 3 heat-up back to 547° F.
	11:00 PM	Unit 3 at hot shutdown.
	11:10 PM	Six new GE Transformers on site from Ft. Wayne, Indiana.
6/1/79	11:50 AM	Commenced warming Unit 3 steam lines.
	3:45 PM	Completed 24 hour load test on B EDG - Satisfactory.
	3:46 PM	Commenced going critical with Unit 3.
	3:55 PM	USNRC I & E - Region II requested hold on going critical with Unit 3 until NRR is supplied additional technical data.
	5:10 PM	USNRC NRR and I & E - Region II satisfied - power operation approved.
	5:25 PM	Unit 3 critical.
	6:45 PM	Commenced pulling Vacuum on Unit 3.
	8:25 PM	Rolled Unit 3 turbine
	9:39 PM	Unit 3 on-line.
	10:50 PM	"A" EDG out-of-service for changeout of 3 EPTs and removing instrumentation.
6/2/79 Saturday	4:06 AM	Unit 3 at 100% power.
	5:05 PM	Started "A" EDG after replacing 3 - 15 KVA EPTs
	5:07 PM	Commenced 24 hour load test run on "A" EDG - 2750 KW.
	7:07 PM	Reduced load on "A" EDG from 2750 KW to 2500 KW.
6/3/79	5:30 PM	Completed 24 hour test run on "A" EDG and returned "A" EDG to normal service - test satisfactory.



