Case study
Major Fault Caused by Stator Winding Circuit Ring Failure

Joël Pedneault-Desroches, P. Eng.
Presentation Outline

Introduction
Inspection report
Chronology of events
Repair
Conclusion
August 13, 2017: 202 MVA, 13.8 kV generator failed and forced the evacuation of a power house.
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Inspection report

Main damages to the generator:

- Stator circuit ring (section of 6 feet)
- 18 Bottom bars seriously damaged
- Cable ducts and instruments
Inspection report: Stator circuit ring

Circuit ring insulation is burned and damaged around the fault.

60 cm (3 feet) of S2 circuit ring is missing (copper pipe of 3 ½ inches and ¾ thickness)
Inspection report: Stator circuit ring (2)

Golf ball hole in circuit E1 (phase A)

Circuit E1 moved by a inch

Support bloc opened by the force of the fault
Inspection report: Bottom bars

Insulation of 18 bottom bars was seriously burned and covered by copper.
Many cable ducts and instruments were burned.
Neutral cable, neutral CTs cables, RTDs cables...
Inspection report: Generator circuit breaker

Burned spots in the mobiles contacts

Current fault: 
~ 100 kA rms
(~12 pu)
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Chronology of events: Protection

08:57:03: After being stopped for a part of the night, the group is started
08:58:03: The generator circuit breaker is closed
09:00:46: Abnormal voltage of third harmonic at the neutral of the generator detected
09:00:47: Smoke detected in the generator
09:01:06: Current in reverse sequence detected
09:01:21: Current in reverse sequence alarm
09:01:24: First overvoltage in the neutral of the generator
09:01:27: Tripping with complete stop by differential protection, fire protection activated
Chronology of events: Protection

08:57:03: After being stopped for a part of the night, the group is started
08:58:03: The generator circuit breaker is closed
09:00:46: Abnormal voltage of third harmonic at the neutral of the generator detected
09:00:47: Smoke detected in the generator
09:01:06: Current in reverse sequence detected
09:01:21: Current in reverse sequence alarm (400 ms)
09:01:24: First overvoltage in the neutral of the generator (15-25 ms)
09:01:27: Tripping with complete stop by differential protection, fire protection activated

Duration of the fault ≈ 41 seconds
Fault started with a resistive contact that made circuit S2 (phase B; neutral end) rise in temperature and start an arc that caused:

- Smoke detection inside the generator;
- Intermittent ground fault not constant enough to shut down the unit by the operation of protections (lower voltage side);
- Damage the insulation of the circuit E1 (phase A; high voltage end).

It ends by a phase-to-phase fault with E1 and S2 causing the unit to trip by differential protection.
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Repair: Stator bars

Wave winding
First bottom bar cost 20 top bars
Bars replaced: 18 bottom and 37 top (55 total)
Challenge: Work to be done with the rotor in place
Repair: Stator bars (2)

1 – Removing the bars after debrazing and removing the wedges
Repair: Stator bars (3)

2 – Replacing the bars after cleaning and painting the slots with semi-conductive paint

(Hipot tests on spare bars before installation: 34 kVac, after insertion of the bottom bars: 32 kVac, after insertion of the top bars: 30 kVac)

“U” packing with semi-conductive resin:

- Semi conductive paper (0.1 mm)
- Semi conductive resin
- Roebel Bar
Repair: Stator bars (4)

3 – Final tests after the radial wedging with original wedges (ripple springs), brazing and attaching the bars

- Final Hipot: 13.8 kVac
- Winding resistance
Repair: Circuit ring

Preparing and brazing the junction

Original junction:

New junction:
Repair: Final look
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• Bad junction in the circuit ring can be difficult to detect with conventional protection setting and can cause serious damages to the generator.

• Protection logic has to be revised to reduce the damages in case of failure (protection sensitivity, combining smoke detection with ground fault for tripping...).

• Other monitoring solutions such as permanent thermal imaging should be considered to enable early detection of such faults.

• The fault caused a down time of 3 months; repair was a success.
Questions?