To Rewind or Repair: Options for Dealing with Less-Expected Outages

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Today's Discussion

• Two Project Case Studies
  • Large  88MVA  13.8kV
  • Small    4 MVA   4.6 kV

• Both “Less Expected” (forced) 2018 outages

• Both projects had technical challenges that had to be overcome while also satisfying current commercial expectations
Contrasting Large & Small Hydro Generators

• Voltage
  • Typically Large 6.9 kV and above; Small 6.9 kV and below
  NOTE: Lower the voltage – lower voltage stress
  • Insulation & coil design choices
  • Partial Discharge (PD)

• Budgets
  • Maintenance
  • Repair / Upgrade

• When comparing large and small hydro generators technically, we actually find many more similarities than differences!
  • Thermal and Mechanical stresses, deterioration, & failures
  • Repair processes & acceptance criteria
  • Needed Reliability
  • Challenge of aligning with commercial requirements and expectations
Tekapo B - Case Study

(Large)

• Second in a chain of eight stations in the central South Island of New Zealand.

• Station rated to 160MW, with two GEC 80MW generators commissioned in 1977

• No pass through or spill way at the plant.

• With one unit out of service at Tekapo, only half normal water flows, affecting 6 down stream plants and recreation river users.
Failure Sequence

- Fire system modification outage
- Start up - Protection relay ground fault on A phase (5.8A)
- A phase to B phase fault two cycles (40mS) later. (≈ 9kA)
- With Rotor removed and two failures isolated, IR/PI, then AC hipot test. Third failure - similar location as two previous
Failure & Repair Reality

- Three separate stator winding faults – but remaining winding passed Hipot
- Duration of repair - months, not weeks
- Key Concerns:
  - 40 year-old previously repaired winding
  - Only 20 spare coils in stock
  - Need to removal of at least 60 coils at each fault location to perform repair
- Owner Engineering Thought Evolution
  - Past thinking was simple - Rewind it
  - Recent privatization and market forces - greater focus on innovation and measured risk to gain economic benefit
Owner Options Considered

- Do Nothing
- Minor Repair
- Major Repair
- Full Rewind
- Complete Replacement
Minor Repair Phase

• Vendor’s Concept (not NEC)
  • Minor site repairs to coils removed to access failed coils
  • Use 20 spare coils

• Work on first failure area raised warning signs
  • heavy PD activity in the grading section
  • Coils removed, slot section ground wall tape damage

• Previously (1995) repaired coils –
  • serious deterioration in the repaired areas
  • On site coil repairs not sufficient to gain serviceable coils

• Abandoned for Major Repair
Major Repair Phase

• Vendor’s Concept (not NEC)
  • Strip and reinsulate top leg of all 216 coils.

• Trial samples encouraging but production concerns arose
  • Poor Tan Delta Testing concerns
  • Ineffective bond between the original coil stack and the new Resin Rich Mica Tape

• Concluded method was technically viable
  • Required further material and process trials
  • Unknown likelihood of success & time constraints

• Abandoned for New Coil Rewind
Rewind Phase

• New coil technical & commercial negotiations had completed just as abandoned major repair

• NEC issued order to expedite manufacture of 216 coils plus 50 spares
  • NEC had all materials in stock, production started immediately
  • Owner concerns with “Ambitious” manufacturing and Installation schedule

• NEC later issued rewind contract
  • Partial shipments of coils

• NEC handed the completed stator over on 25 May 2018, one day ahead of schedule

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Project Phases

Discovery and Planning
- 11/6/17
- 12/30/17

Minor repair phase
- 12/30/17
- 1/11/18
- 1/31/18

Full repair phase
- 1/11/18
- 2/8/18
- 4/30/18

Rewind phase
- 2/14/18
- 6/2/18

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Case Study Conclusions

• Repair efforts attempted could have realized a major time and cost savings.

• Continued discussions and plans for a complete rewind during repairs were invaluable.

• Unit returned to service 12 days early
  • Saved additional spill time
  • Relieved need for higher cost generation options
Ozark Beach Unit #7 – Case Study

(Small)

- Allis Chalmers; 4 MVA; 4.6kV; 164 RPM
- Unit experienced a ground fault
- Plant Logistics – walk in access but tools & Materials by Barge
- While assembled NEC secured to inspect, test, and attempt to cut coils and jumper to get online.
- Plant noted corporate comment to mothball or abandon unit if repair short of rewind not possible
Initial Site Findings

- Unit inspection by NEC quickly determined that a minor assembled repair was not possible
- Unit disassembled
- Multiple areas of concern
- Significant burning & overheating
- Visible core damage
- Compression finger plate segment severely damaged
- Original Asphalitic insulation system
- Presence of Asbestos and Lead
Path Forward

• Two primary options:
  • **Option I.** Abate asbestos & lead, repair & requalify core, rewind stator
  • **Option II.** Abate asbestos & lead, restack core, rewind stator

• Following extended deliberation by Owner:
  • Issues PO to NEC for Option I with request to incorporate:
    • Hard coil insulation system
    • Uprate winding as applicable under circumstances
NOTE: Twist Transposition & Thickness of Ground Wall Insulation
Containment, Asbestos/Lead Abatement, Striping & Cleaning Core
Core Repairs with Virgin Mica
44 Turns of Cable For Full Flux Test
IEEE 62.2 & IEEE 56
Installing Surge & Phase Ring
Installing Coils
Coil Group Progress Testing
DC Hipot 22kV one minute & Surge Test 11kV for ~5 seconds
Installing Side Ripple Springs & Wedges
Forming, Brazing, Cleaning, Insulating & Tying Connections
Case Study Conclusions

- Early failure inspection by experienced and qualified personnel can save time and money.
- An ugly appearance should not be the deciding factor in repairing and replacing a core.
- The repair options chosen struck a balance between key factors of price, schedule, and reliability.
- An end of life plan including a spare set of coils would have saved time and money.
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Questions

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