Generator Maintenance Assessments and Repairs
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Introduction - Some statistics...

Hydro-generators can fail!

Sources: 
Start and stop costs for hydropower plants, Bakken, B.H.; Bjoerkvoll, T.; Belsnes, M.M.; Skaare, P.E., Report #TR A5351, 2001-02-02

New developments in diagnostic and monitoring techniques for hydro-generators, G. Galasso, M. Märke, 1995 Waterpower and Dams conference, Barcelona, Spain
Introduction – What is maintenance and why?

What?

Actions taken to preserve or restore an asset in operable condition to achieve its maximum useful life.

Why?

• Prevent downtime
• Maximize useful life
• Save money
Agenda

Introduction

1. 2 types of maintenance: preventive and corrective

2. Maintenance typical timeline

3. Generator preventive maintenance

4. Generator corrective maintenance

Conclusion
1. 2 types of maintenance: Preventive & Corrective

**Preventive**
Prevent equipment failure

**Corrective**
Repair and return to service
2. Generator Typical Maintenance timeline

CORRECTIVE MAINTENANCE

- Unplanned punctual maintenance event following a failure

Commissioning

GENERATOR USEFUL LIFE

End of life

Frequency:

daily, weekly, monthly

Planned routine checks

3-5 years

Minor preventive generator assessment

5-10 years

Major preventive generator assessment

PREVENTIVE MAINTENANCE
3. Generator Preventive Maintenance

**Routine checks**

<table>
<thead>
<tr>
<th>Recommended checks</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winding temperatures</td>
<td>Daily</td>
</tr>
<tr>
<td>Flow and cooling temp.</td>
<td>Daily</td>
</tr>
<tr>
<td>Bearing oil flow and temp.</td>
<td>Daily</td>
</tr>
<tr>
<td>Walk-around</td>
<td>Daily</td>
</tr>
<tr>
<td>Visual on brushes</td>
<td>Weekly</td>
</tr>
<tr>
<td>Brush pressure and wear</td>
<td>Monthly</td>
</tr>
<tr>
<td>Collector filters</td>
<td>Monthly</td>
</tr>
<tr>
<td>Oil sample analysis</td>
<td>Annually</td>
</tr>
</tbody>
</table>

... Please consult your O&M manual
3. Generator Preventive Maintenance

*Generator assessments*

**What is an assessment?**

Assessing = getting an accurate picture

**Typical assessment:**

- A visual inspection
- Electrical and mechanical tests
3. Generator Preventive Maintenance

**Generator assessments**

Level of dismantling determines the extent of the assessment.

**Light assessment**
- **Duration:** Several days
- **Access:** Partial (some covers removed, rotor in)
- **Frequency:** Every 3-5 years

**Extensive assessment**
- **Duration:** Several weeks
- **Access:** Full (all covers removed, rotor out)
- **Frequency:** Every 5-10 years*

*Or whenever the rotor is pulled out.
3. Generator Preventive Maintenance

Visual inspection, what is inspected?

Stator winding

- Winding cleanliness
- Partial discharge
- Bar/coils side packing
- Ties movement, vibrations
- Insulation damage
- Bar caps looseness
- Wedge cracks, migration
3. Generator Preventive Maintenance

**Visual inspection, what is inspected?**

**Stator core**

- Core cleanliness
- Lamination damage
- “Buckling”
- “Chevrons”
- Corrosion fretting
- Vent. Ducts, clamping system
3. Generator Preventive Maintenance

Visual inspection, what is inspected?

Rotor poles

- Pole cleanliness
- Ground and turn insul.
- Pole connections
- Damper bars
- Pole winding blocks
3. Generator Preventive Maintenance

*Visual inspection, what is inspected?*

**Misc. components**

- Collector
- Bearings
- (organized) Spare parts
3. Generator Preventive Maintenance

**Electrical & Mechanical tests**

**Light assessment**
- Insulation resistance and polarization index
- Direct-current ramp test
- Stator power factor and loss dissipation test
- Dc phase resistance test
- Stator wedge tap test (random sampling)

**Extensive assessment**
- Insulation resistance and polarization index
- Direct-current ramp test
- Stator power factor and loss dissipation test
- Dc phase resistance test
- Wedge tightness test (selected or complete slots)
- Winding RTD tests

*Optional:*
- Blackout test
- Corona probe test
- Stator winding ac high pot.
3. Generator Preventive Maintenance

**Electrical & Mechanical tests**

**Light assessment**
- Knife test
- Insulation resistance test.
- Winding resistance.
- Winding high potential test
- Pole drop test (when possible)

**Extensive assessment**
- EL-CID test
  - **Optional:**
    - Stator core loop test
    - Stator roundness
- Insulation resistance test.
- Winding resistance.
- Winding high potential test
- Pole drop test
  - **Optional:**
    - Rotor concentricity
- Insulation Resistance test
3. Generator Preventive Maintenance

*What after the assessment?*

**Assessment report**

- Inspection and test results analysis
- Compare with history data
- Conclusions & recommendations

**Next steps**

- Plan on a maintenance repair ?
- Plan on a refurbishment ?
- Schedule the next maintenance
3. Generator Preventive Maintenance

**Examples of preventive repairs**

- Generator cleaning
- Stator winding rewedge
- Stator winding corona repair
- Generator phase reversal
- Bearing re-babbitting
- Rotor balancing
4. Generator Corrective Maintenance

**Generator failures**

- **Common failures:**
  Excitation and Auxiliary systems.
  *Downtime: short (hours-days)*

- **Least common failures:**
  Insulation failure.
  *Downtime: long (weeks-months)*

How to react to minimize the repair outage time?

Source: New developments in diagnostic and monitoring techniques for hydro-generators, G. Galasso, M. Märke, 1995 Waterpower and Dams conference, Barcelona, Spain
4. Generator Corrective Maintenance

*Store and prepare to react efficiently*

**Maintain spares at site**

- Critical spare parts *(coils, wedging matl, bearing...)*
- Proper inventory
- Contacts, vendors ...

**Prepare for the worst**

- Typical procedures & docum. *(Coil bypass, insulation repair...)*
- Trained teams or contacts
- Testing & repair equipment at site
4. Generator Corrective Maintenance

Assess the situation & apply the right solution

Start fast and right

- Failure sequence of event
- Perform an assessment *(visual inspection + testing)*
- Root cause analysis

Apply the best solution

- Refer to experts *in-house or OEM*
- Costs/benefits analysis

*Ex: Coil bypass vs coil replacement*
4. Generator Corrective Maintenance

Example – Stator air gap bar replacement

Context

• Failure to ground, 40 y/o winding
• “High voltage” air gap bar
• High penalty for loss of production

Solution: Stator bar replacement

• Fast repair: 2 weeks!
• Key elements:
  - Spare matl and eqpt at site
  - Trained teams with procedures
  - Rotor not removed
Conclusion

"An ounce of prevention is worth a pound of cure"

• Maintenance program to slow ageing and prevent failures.

• Generator preventive assessment = tool to prevent unscheduled outages and reduce their duration.

• Corrective repairs: Carefully prepare and act fast and efficiently

• Maintenance to be performed by skilled and trained personnel
Thank you!

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