Governor Maintenance and Health Monitoring

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After-Lunch (Nap Time) Session

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Digital Governor Primer

**NERC CIP – USA Bulk Electric System (BES)**
1. Sabotage Reporting
2. Critical Cyber Asset Identification
3. Security Management Controls
4. Personnel and Training
5. Electronic Security Perimeters
6. Physical Security of Critical Cyber Assets
7. System Security Management
8. Incident Reporting and Response Planning

**Unified Compliance Framework (UCF)**
1. Cyber Security Management Program
2. NERC Asset Identification
3. Information Protection
4. Access Control
5. Change Control
6. Configuration Management
7. Security Awareness
8. Security Annual Training
9. Personnel Risk Assessment
10. Access Review and Revocation
11. Physical Security
12. Security Patch Management
13. Malicious Software Prevention
14. Account Management
15. Security Status Monitoring
16. Vulnerability Assessment
17. Documentation and Records Review
18. Cyber Security Incident Response
19. Cyber Recovery
20. Cyber Asset Disposal

**NIST SP 800-53 – USA**
1. Access Control
2. Awareness and Training
3. Audit and Accountability
4. Security Assessment and Authorization
5. Configuration Management
6. Contingency Planning
7. Identification and Authentication
8. Incident Response
9. Maintenance
10. Media Protection
11. Physical and Environmental Protection
12. Planning
13. Personnel Security
14. Risk Assessment
15. System and Services Acquisition
16. System and Communications Protection
17. System and Information Integrity
18. Program Management
Session Overview

• Grid Stability: Who Needs It? What Provides It?
• Governors: Mechanical vs. Digital
• O&M Approaches: Mechanical vs. Digital
• Training for Success Mechanical and Digital
Eastern Frequency Response

Frequency Response Declined 24%
While Load and Generation Increased 20%
Mechanical Governor Performance

Before Maintenance and Calibration

After Maintenance and Calibration
Digital conversion is **not** required...
“What Is This Droop You Speak of?”

• Droop is a characteristic response ‘programmed’ into a governor to respond to variations in grid frequency.

  **5% Droop Example** As grid frequency varies from 2.5% above to 2.5% below nominal, wicket gates will move from 0% to 100%

• Droop does **not** change the sensitivity of the governor. It affects the amount of corrective action a governor will take for a given frequency deviation.

  The lower the numerical droop, the more the unit will respond
Understanding the Speed Droop “Curve”

\[
\text{Droop} = \frac{\text{Change in Speed (Load Adjust)}}{\text{Change in Gate}}
\]

- Speed Droop Curve
  - (Connected to a grid)
  - Speed Adjust

\[\begin{array}{c}
\% \text{ Speed / Load Adjust} \\
103 \\
102 \\
101 \\
100 \\
99 \\
98 \\
97 \\
\end{array}\]

\[\begin{array}{c}
\text{Gate Opening} \\
0 \\
0.1 \\
0.2 \\
0.3 \\
0.4 \\
0.5 \\
0.6 \\
0.7 \\
0.8 \\
0.9 \\
1.0 \\
\end{array}\]
Converting from Mechanical to Digital
Gateshaft Governor (circa 1920)
Testing Governor Response

Mechanical Governor

Digital Governor
Calculating Permanent Droop (Mechanical Governor)

<table>
<thead>
<tr>
<th>speed dial (turns)</th>
<th>off-line Frequency (Hz)</th>
<th>on-line Gate (%)</th>
<th>Active Power (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>58.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>59.06</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>59.64</td>
<td>38</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>60.16</td>
<td>59</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>60.68</td>
<td>85</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
<td>61.21</td>
<td>100</td>
<td>46</td>
</tr>
<tr>
<td>Speed no load</td>
<td></td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>droop</td>
<td>3.65%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
O&M Needs: Mechanical vs. Digital

• Periodic governor *maintenance* is required for mechanical and analog governors
• Periodic governor *calibration* is recommended for digital governors
• Plant O&M staff training is *highly* recommended for all governor types
Poor Preventative Maintenance
Measuring O&M Success
Reduced Frequency & Duration of Forced Outages

Increase Mean Time Between Failure (MTBF)
Preventative Maintenance during Planned Outages
Redundancy in Field Devices, Hydraulics, Controllers

Decrease Mean Time to Repair (MTTR)
Quick Troubleshooting
Critical Spare Parts On-Site
Quick Access to Other Spares
Fast Repairs, Local or Factory
Access to Emergency Support
Identification of Long Lead Items
Training of Personnel
Technical Support
Field Service
Mechanical Governor Maintenance

The two enemies of “classic” governors:

• Friction
• Lost Motion

How to find and eliminate them:

✓ Lubrication
✓ Monthly inspection
✓ Annual governor testing
✓ Overhaul when needed
Not a good day: Ocoee #2 Runaway 4/14/49
Time-Based Maintenance (TBM)

**Weekly**
Add oil to all pivot points.

**Monthly**
Check oil filters
Check dashpot oil level – add dashpot oil if needed

**Annually**
Add dashpot oil to strap suspended ballhead
Check ballhead bearings

**Every Two or Three Years**
Disassemble, clean, inspect, replace worn parts:
- Governor pilot valve
- Dashpot
- Ballhead
- Linkages
Lubricate and check movement of governor restoring cable
Check distributing and relay plunger for freedom of movement.
**TBM vs. RTF**

**Downsides of Time-Based Maintenance approach**
- Ignores actual governor performance!
- Governor wear is not uniform
- Good, useable parts may be discarded
- Annual outage for complete overhaul may be unnecessary

**Downsides of Run-To-Failure ‘Maintenance’**
- Governor maintenance may be neglected
- Poor governor performance exposed only during grid disruption!
- NERC / WECC penalties for non-performance

**Governor Health Monitoring is the optimal solution**
- Simple, quick governor performance verification
- Identification of poor-performing governors
- Lead time to schedule outage, purchase needed parts
Governor Health Monitoring

• An annual test using simple on-line method.
• Allows comparison against past performance.
• Provides tools to tune for peak performance.
• Enables scheduling of maintenance or overhaul, as needed. Avoids unnecessary outages.
Digital Governor Maintenance

• Oil Cleanliness  Annual Oil Analysis
• Calibration of Feedback Sensors  LVDT and MLDT
• Hydraulic Solenoids  Exercise to minimize silt build-up
• Control Relays  Exercise to verify contacts and wiring
• Servomotors  Check over full range of travel for binding
• Sensor Mounting  Check the torque on all accessible fasteners
• Battery Replacement  PLC button battery lasts only 5 years!
• Auxiliary Systems:  Oil Pumps and PMG/SSG’s
Oils

• Contaminated Oil is the #1 Cause of Governor Problems
• Oil Should be Free of Dirt, Air & Water
• When to Change or Clean Oil
  • Appearance
  • Smell
  • Water or other contaminants
  • Viscosity changes
  • Excessive wear
• Kidney Loop Filtration Systems
• Incompatible Oils / Choosing the Proper Oil
• Filter maintenance schedule
• Oil sample analysis
Governor Oil Pumps
Preventative Maintenance
Results of Run-to-Failure
Gear Damage
Wear Plate Damage
Gear Pocket Damage
Permanent Magnet Generator (PMG)

- Verify PMG voltage periodically
- Remagnetize when needed
- Overhaul auxiliary speed switches
Training

Staff training is critical to reducing downtime and keep governors running at peak performance.

• On-site Training
• Factory Training
On-Site Training

• Comprehensive on-site training classes include governor basics, operations, maintenance, and troubleshooting. Available for all types of governors.

• On-site classes focus on your specific governor installation. Hands-on sessions take place at an existing unit.

• Duration is typically 3 to 5 days, depending on the number of students and the amount of hands-on time desired.

• AGC staff have taught more than 200 training classes worldwide.
Governor School
Thank you for your attention!

Any questions?

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