P1827 - Draft Guide for Electrical and Control Design of Hydroelectric Water Conveyance Facilities

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RECLAMATION
Managing Water in the West

Paper Number: 15PESGM####
Why are gates and valves important at hydroelectric facilities?

Regulating

Flood Control

Emergency Closure

Maintenance/

Dewatering
Why is IEEE P1827 essential?

Why is this guide essential?

• ‘This guide describes the electrical and control design of water conveyance facilities associated with hydroelectric projects including associated penstocks, valves, and gates.’
• ‘This guide is applicable to design of new facilities and rehabilitation or replacement of existing facilities.’
• ‘...provides a control hierarchy capable of standalone operation or interfacing with other systems.’
• ‘...provides guidance in electrical and instrumentation work unique to water conveyance systems.’
P1827 Major Clauses

• General Considerations (environment and safety)
• Site Electrical Layout and Access
• Overview of Gates and Valves (types, operating mechanisms)
• Electric Supply and Distribution (backup power)
• Control, Monitoring, and Protection

Scheduled for publishing Fall 2016. Content within this presentation is DRAFT.
Fixed Wheel Gate Example

Inexperienced contractor and oversight resulted in the below recommendations:

- Add undervoltage (27)
- Add accumulators to allow emergency closure without power (remove mechanical hanger latches)
- Monitor bell alarm contacts on AC supply circuit breakers
- Feed AC source from permanent emergency standby generator
- Add leak detection pressure switch
- Monitor pump motor overload
- Monitor encoder status (single feedback source)
- Add backup position feedback (limit switches)
- Main pump cutout required.
Backup Power for Gate Operation

Do you want to be physically on the dam during an emergency?

P1827 Backup Power

• Provide for flood control gates, emergency shutoff gates, and other critical equipment
• Stored energy systems for hydraulic and pneumatic operated gates
• Operable without power.
Emergency Control of a Flood Gate

Typical local emergency controls include:

• Emergency stop to halt gate device movement (e.g., to stop gate device in event of a locked motor or motor contactor issues).
• Emergency bypass of a protection device (e.g., bypass a failed gate high limit switch if water is at an extreme high level).
• Independent emergency control system (e.g., normal controls have failed).
• Mechanically latched emergency close pushbutton for electrical actuation of emergency close solenoid(s). Other control operations should be blocked while emergency close is asserted.
• Mechanically latched hand operated mechanism capable of closing the gate in an emergency without any control power source. The mechanism should be adequately guarded against inadvertent operation.
Emergency Control of a Flood Gate

Emergency controls may override normal functions when:

• Abnormal water level
• Flow
• Sever conditions

Emergency controls may be manual or automated.
Emergency Control Circuit Supervision

• Loss of emergency close solenoid circuit continuity (e.g., by trickle current monitoring).
• Emergency close circuit blocking due to Normal/Maintenance switch being in maintenance position.
• Loss of continuity in cabling between intakes and remote trip devices in the powerhouse.
• Loss of power to any of the DC circuits.
## Gate and Operating Mechanism Protection

<table>
<thead>
<tr>
<th></th>
<th>Operating Mechanism</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hydraulic Gate</td>
</tr>
<tr>
<td><strong>Gate position at low-</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>low limit</strong></td>
<td></td>
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<tr>
<td><strong>Gate position at high-</strong></td>
<td>Optional. See notes 1 and 2.</td>
</tr>
<tr>
<td><strong>high limit</strong></td>
<td></td>
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<tr>
<td><strong>Mechanical overload</strong></td>
<td>Optional. See note 1</td>
</tr>
<tr>
<td><strong>Slack rope</strong></td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Motor thermal overload</strong></td>
<td>Recommended</td>
</tr>
<tr>
<td><strong>HPU Oil temperature high</strong></td>
<td>Recommended</td>
</tr>
<tr>
<td><strong>HPU Sump oil level low</strong></td>
<td>Recommended</td>
</tr>
<tr>
<td><strong>HPU Suction valve limit</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Emergency stop actuated</strong></td>
<td>Recommended</td>
</tr>
</tbody>
</table>
Automatic Emergency Systems
Considerations

• Conduit rupture
• Powerhouse flood
• Conduit low pressure
• Gate drifting closed
• Trashrack plugged
• Unit bearing critical over-temperature
• Turbine-generator overspeed
Automatic Emergency Systems
Considerations

• Seismic event
• Loss of gate operating mechanism control capability (power, signal, motive energy)
• Wicket gate shear pin failure
• Unit creep
• Fail to stop within preset time
• Reservoir level
• Incomplete sequence
Automatic Emergency Systems Considerations

- Seismic event
- Loss of gate operating mechanism control capability (power, signal, motive energy)
- Wicket gate shear pin failure
- Unit creep
- Fail to stop within preset time
- Reservoir level
- Incomplete sequence
Water actuated rotary valve example
Water actuated rotary valve example
Water actuated rotary valve example
Intake fixed wheel gate open/close

- Penstock gate control switch (remote at unit control board)
- Main and aux overspeed
- Governor low pressure and level
- Creep detection
- Unit emergency shutdown
- Penstock low pressure
- Turbine pit high level
- Incomplete shutdown
- Unique siphon breaker logic
## Gate Types and Function Excerpt

<table>
<thead>
<tr>
<th>Type of Gate</th>
<th>Regulating</th>
<th>Flood Control</th>
<th>Emergency Closure</th>
<th>Maintenance/ Dewatering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflatable gate</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Radial (Tainter) gate</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Ring gate</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Roller gate (crest spillway)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Sluiceway, or log shoot</td>
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<tr>
<td>Sleeve valve</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Slide gates</td>
<td></td>
<td></td>
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<tr>
<td>Vertical lift</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Bonneted (Paradox &amp; Ring seal)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Thank you!

Questions?