Testing and commissioning of geothermal power plants

ARGeo C7 Kigali Rwanda
Oct 31st – Nov 2nd 2018
Snæbjörn Jónsson

Photo: H. Hjartarson
Our value proposition

TEAM WORK - EXPERIENCE - RISK MANAGEMENT

Our team has successfully designed and brought into successful operation a few major geothermal power projects on time and budget over the past 20 years.
Please also refer to the newly established web: www.geothermal.is
Geothermal power plants in Iceland

Timeline of commissioning from 1979 to 2018, same core staff for decades

- **Krafla** - 60 MWₑ
- **Svartsengi** - 75 MWₑ and 190 MWₜ
- **Nesjavellir** - 120 MWₑ and 400 MWₜ
- **Reykjanes** - 100 MWₑ
- **Hellisheiði** - 303 MWₑ and 133 MWₜ
- **Þeistareykir** - 90 MWₑ
Thermal power plants – conventional / geothermal

Special for geothermal:

- Steam field (wells, pipes, separators, re-injection)
- Gas extraction and NCG disposal
- Remote areas (often) -> weak grids
What is required for successful testing and commissioning of power plants?

- **Skilled and experienced staff**
- **Equipment**
What is required for successful testing and commissioning of power plants?

- **Skilled and experienced staff**
- **Equipment** → **Hardware**
What is required for successful testing and commissioning of power plants?

- **Skilled and experienced staff**
- **Equipment**
- **Software**
What is required for successful testing and commissioning of power plants?

- Skilled and experienced staff
- Equipment
- Organisation
What is required for successful testing and commissioning of power plants?

- Skilled and experienced staff
- Equipment
- Organisation
- Owner’s support
Organisation of testing team

Test team

Similar to organization of entire projects

External entities
- Technical authorities (licencing, permissions..)
- Grid company
- Power purchasers
- ..etc....

Owner’s site engineer

Contractor’s site engineer

Test manager

Progress planning and registration

Mechanical team
Electrical- and relay protection team
Instrumentation team
Control system team
Organisation of testing activities

A: Acceptance testing
B: Control system test
C: Cold commissioning
D: Hot commissioning
Morning briefings

- Day schedule
- Co-operation between teams
- Potential hazards
- HSE matters
- Remarks from team members
If a test item is not successful, a remark is entered into a database and an automatic request for problem solving is issued to the responsible person within the test team.

When the problem has been solved, the responsible person enters a new remark with a short description of the matter.

The new remark is evaluated by the test manager and the next step is issued – e.g. repeating of the test item.

Example from a recent project:

Database for remarks, based on plant codes [e.g. KKS / RDS-PP]
Signal Description

Function Area: S5 - Steam supply 5
KKS Code: 00LB62 AA213 XQ01
KKS Description: Rakaskila 62 - Þettivist,loki - Stóðusk.

ID: S.1581

Comment Information

Test: B2  Date Written: 11.4.2011 17:57:11  Written By: Einar Pálmi Einarsson
Date Submitted: 11.4.2011 17:57:11  Submitted By: Einar Pálmi Einarsson

Category (read only)
- Operation Manual
- Machinery
- Electric equip. and wiring
- IO Marshalling
- PLC Program
- SCADA/HMI

Comment

Priority: B  Responsibility: Orkuveita Reykjavíkur  System: SIEMENS

Description (read only)

Hæ er ekki stóðuskyrun á lokanum og betta merki því ekki tengt né prófað

Status

- Fixed
- On hold
- To be tested during stop period
- Tested

Status History

<table>
<thead>
<tr>
<th>Date</th>
<th>Updated by</th>
<th>Description</th>
<th>Status</th>
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<tr>
<td>11.04.2011 17:57</td>
<td>einarp</td>
<td>Comment Submitted</td>
<td>NEW</td>
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<tr>
<td>12.04.2011 13:08</td>
<td>freyrh</td>
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<td>Stefnt að nota stóðuskyrunum sem losna þegar skipt verður um stjörnlöka í M</td>
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<td>Responsibility moved to Orkuveita Reykjavíkur</td>
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New Status:

Add  Save  Close
THR testing and commissioning

Main tasks

- Factory / Workshop
- Site / Power plant
- Steam admission
- Taking over
- Trial run
- Commissioning
- Field Tests
- Site Acceptance Test
- Shop Assembly and Testing

A1, A2

A3, A4, B1, B2, B3

C1, C2

D1, D2
THR testing and commissioning

Testing in phases, to avoid problems during start-up
THR testing and commissioning

Testing in phases, to avoid problems during start-up

[Diagram showing various components and connections with labels like HMI, Operator station, Marshalling cubicle, Engineering station, TS, MCC/VPD, and wire testing.]
THR testing and commissioning

Testing in phases, to avoid problems during start-up
THR testing and commissioning

Testing in phases, to avoid problems during start-up

Control system tests, servers, redundancy

Redundancy tests

Operator station

HMI

Ethernet

FLC

Marshalling cubicle

Engineering station

MCC/ VFD

TS

Fieldbus
THR testing and commissioning

Testing in phases, to avoid problems during start-up
THR testing and commissioning

Trial run tests including performance test

Hot commissioning – Owner with contractors
FAT tests
Wiring tests
Performance tests
Two examples from trial runs at THR

The transmission system in Iceland:

- Three 220 kV systems
- 132 kV ring connection
- Characterized by relatively large industry units
- Geothermal 28%
  Hydro 72%
- Geothermal power plants generally run as baseload

Courtesy of plant owner: Landsvirkjun and transmission grid owner: Landsnet
A. Islanding event

- Deliberate opening of substation breaker at Krafla
- Test to evaluate response speed
- Pre-event status: Units at 67% load and in load regulation
- Frequency rise triggers units to switch to frequency regulation
A. Response to islanding event

- Units able to reduce their load output within 1 s
- Demonstrates ability of the units to contain and stabilize frequency and voltage
- Significantly faster than similar sized hydro power plants
B. Load rejection

- Mishap in commissioning at the industrial area
- Protection circuits open substation breakers
B. Response to load rejection

Both units at full load
B. Response to load rejection

Substation breakers open
B. Response to load rejection

Unit 1 to no load
Unit 2 to house load
B. Response to load rejection

Steam exhaust contains pressure
B. Response to load rejection

Resynchronization unit 2

- Power [MW]
- Time [min]
- Pressure [bar]

Legend:
- Unit 1 [MW]
- Unit 2 [MW]
- Pressure [bar]
B. Response to load rejection

Resynchronization unit 1 with grid
B. Response to load rejection

Unit 1 switches to pressure control while steam exhaust is closing
Thank you....

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