



Refurbishment using High Head Francis turbines

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Introduction

- Type of refurbishment
- Typical site conditions
- Why Francis turbines rather than Peltons?
- Case Studies
 - Installation
 - Pipelines
 - Cooling water supply
 - Runner wear ring design

Typical Site Conditions

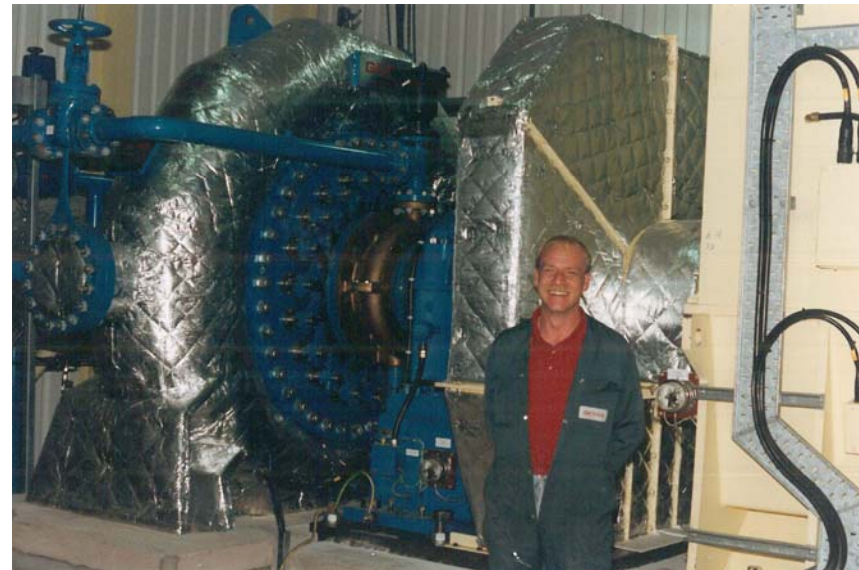


Francis Turbines or Peltons?



Dolgarrog 5 MW set

- Commissioned 1993
- 220m low head
- 360m high head
- New turbine in restricted space
- Provides power at full load for short periods during the day.

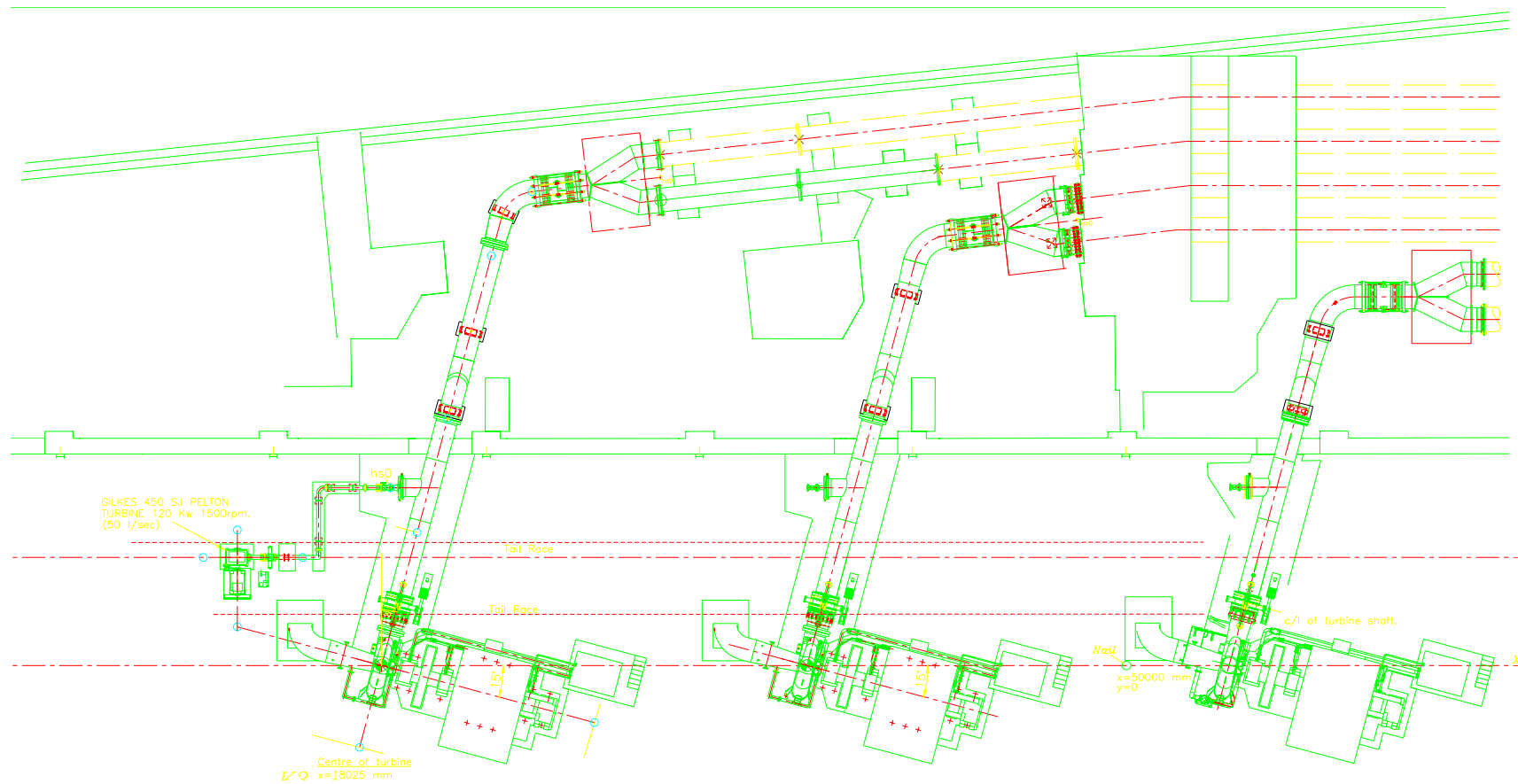


Kinlochleven 10 MW sets

- 3 turbines - first one commissioned 1995
- 273m head
- Refurbished while keeping station operational
- Provides power continuously



Kinlochleven Layout



Installation

- Set 1 still running while sets 2 & 3 installed.
- Usually a very restricted window for installation
- Modular approach is required.



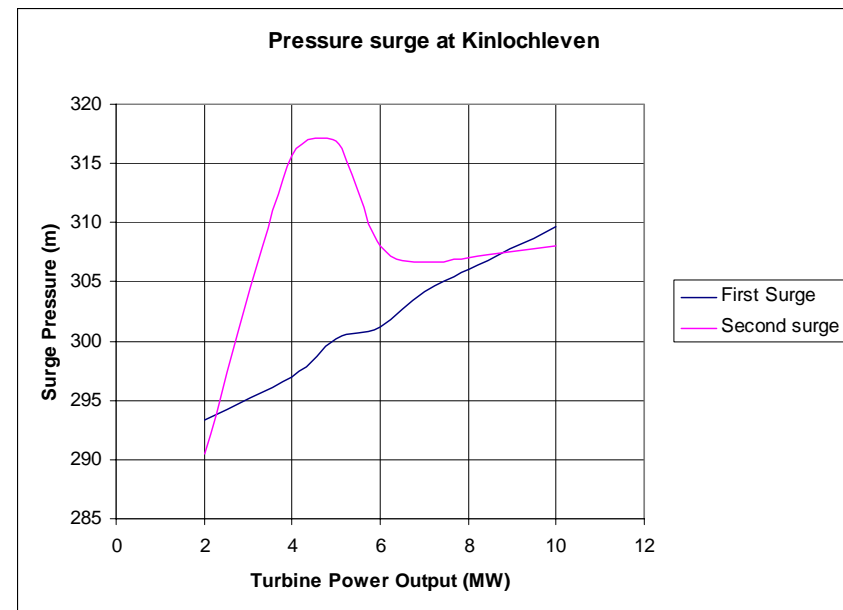
Pipelines

- Old pipelines can be fragile
- Anchor blocks may be needed to separate loads
- Lateral compensators to allow for expansion and contraction of pipelines



Pressure Surge

- Turbine and pipeline modelled for pressure surge
- Accurately predicted main surge due to choked flow
- Did not model secondary surge probably due to column separation



Draft tube for Kinlochleven

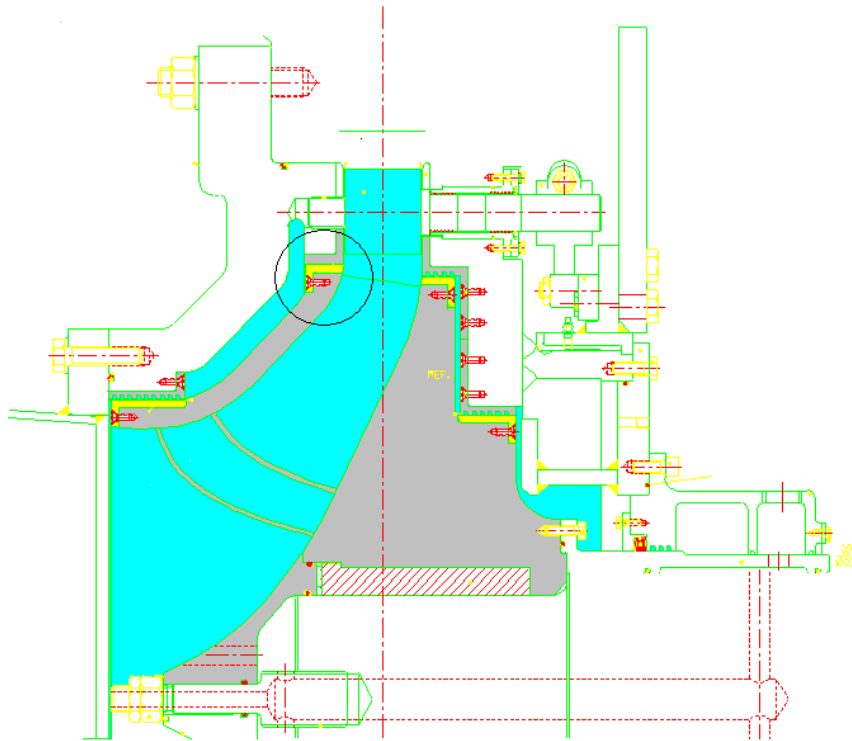




Cooling Water Supply

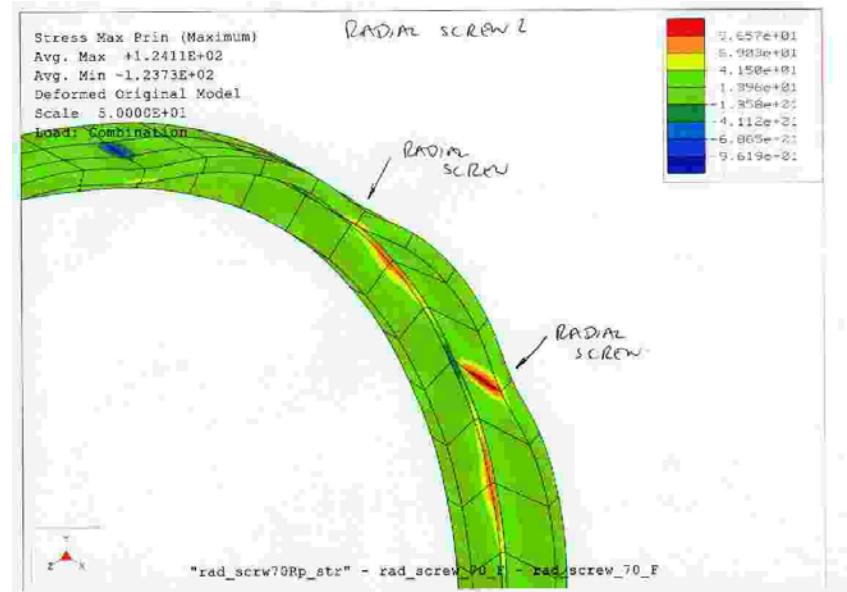
- Tailrace supply
- Problems with peat contamination
- Converted to airblast cooler
- Now using keel coolers

Wear ring support



Wear ring design

- Finite element analysis of pressure and loads
- Substantial forces imposed on load rejection.
- Extra fastening used to secure wear ring.





The Future

- Small horizontal shaft Francis turbines can be applied for refurbishment of old power stations provided:
 - The water is clean
 - The plant is used near best efficiency point
 - The whole system is considered in the surge analysis.