

Evaluating an L-0 Turbine Blade Removal

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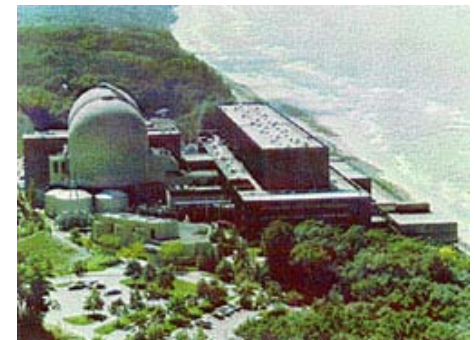
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The Situation

On September 20, 2008, at Indiana Michigan Power's (I&M) D.C. Cook Unit 1, four of the L-0 blades on "B" and one on the "C" low pressure (LP) turbine were liberated while in operation. This caused a Unit 1 shut-down for a total of 15 months.





AEP

- One of the largest investor-owned utilities in the US
- Made up of 7 regional companies
- Operates in 11 states with 5M customers
- 39,000 MW
- Generation types
 - coal – 66%
 - gas – 22%
 - nuclear – 6%
 - other – 6%





Sciencetech & Curtiss-Wright

Sciencetech is a worldwide provider of electric generation solutions.

- **Founded in 1983 as a consulting engineering and technical services**
- **Annual revenues of \$63 million in 2008**
- **Purchased by Curtiss-Wright in May 2007 (\$2B+ in sales in 2009)**
- **Known in the nuclear industry**

PEPSE
P
MAX
R*TIME
PdP





DC Cook Unit 1

- PWR, 4-Loop Westinghouse
- MSR – 1 stage reheat
- 3304 MWt, 1030 MWe (MDC net)
- Located on the shores of Lake Michigan
- Original GE turbines
- LP's replaced with Siemens in 2006
- On-line in 1975





The Problem

9/20/08 – 4 L-0 blades on LP “B” and 1 L-0 blade on LP “C” on Unit 1 were liberated, causing extensive damage to this turbine and shutting down the unit for 15 months.





Solutions Considered

- Install brand new rotors
- Remove the L-0's from all 3 LP's
- Remove the L-0's and L-1's from all 3 LP's + baffle plates
- Remove the L-0's from all 3 LP's + 1 baffle plate





Solution Chosen

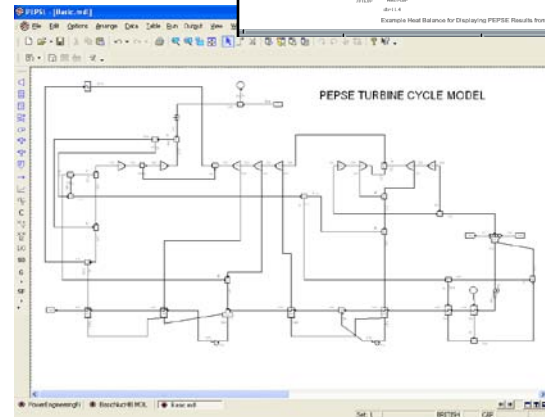
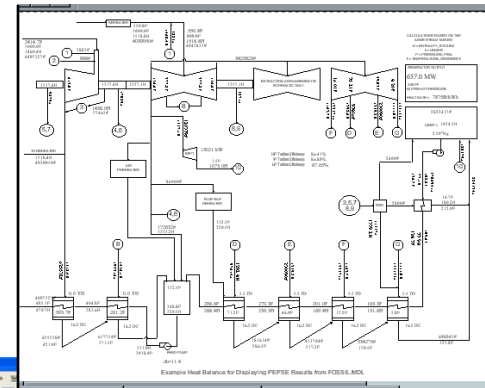
- Remove the L-0's from all 3 LP's + 1 baffle plate
- Baffle plate
4" wide "donut"
concentric rings of holes
stationary





Solution Evaluations

- Siemens – heat balances
- PEPSE model

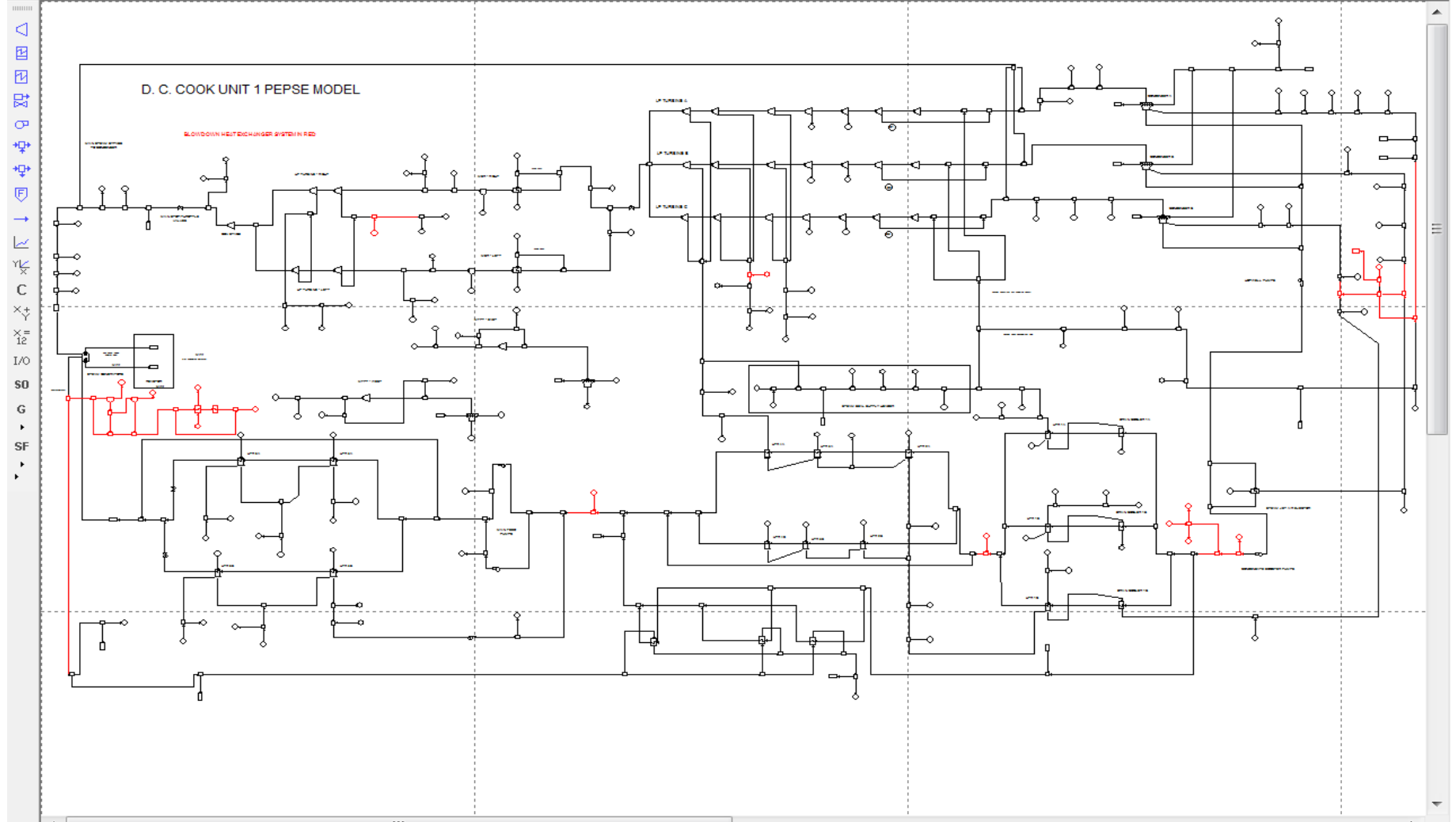


PEPSE - [DCCookUnit1withBDHX.MDL]

File Edit Options Arrange Data Table Run Output View Window Help

File Edit Options Arrange Data Table Run Output View Window Help

File Edit Options Arrange Data Table Run Output View Window Help



DCCookUnit1wi

Set: 1

BRITISH



Implementing the Solution

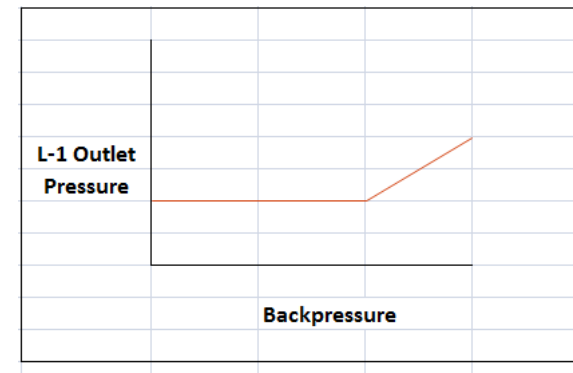
- **15 month outage to repair/replace turbine shaft line & install baffle plates**





Post Start-Up Results

- **Plant output 35 MWe > prediction**
 - High pressure turbine modifications
 - Steam seal replacement
 - “Plowing new ground”
 - OEM prediction of original output
- **Minimal backpressure effects**
- **Plant is very stable**





Lessons Learned

- **Get an independent model evaluation up front to develop better business case for interim solutions**



bp bildarchiv preussischer kulturbesitz



Where Do We Go From Here?

- **New LP rotors during next outage (Cook)**
- **Investigate new PEPSE capability (Sciencetech)**
- **Look at effects of internal blading (Japanese)**
- **Others**



Questions?



PEPSE Model Options

- L-0 Power Itself
- Raise BP, Leave L-0 in Model
- Remove L-0, L-1 Now Last Stage
 - With Exhaust Loss
 - W/O Exhaust Loss
- Remove L-0, L-1 Now Last Stage, L-1 Exhaust $P > BP$, ΔP In Stream to Condenser



What AEP Did

- Left L-0 in Model
- Removed Exhaust Loss Curve, Exhaust Loss = $(L-0 H_{in}) - (L-0 H_{out})$, i.e., $\Delta H = 0$ Across L-0
- Matched Siemen's HB's
 - LP Efficiency Multipliers
 - MR = 0 on L-1
 - MR = Siemen's value on L-2