Alden Turbine Development: Overview of Preliminary Engineering

November 16th, 2010
Voith Hydro

Presentation Overview

- Engineering Overview
- Design Modifications
- Model Testing
- Mechanical Layout
- Conclusions

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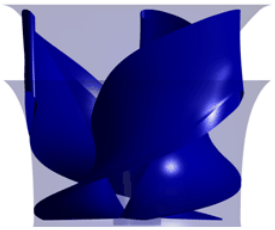
Engineering Overview



Alden runner concept

- Alden Research Laboratory developed a conceptual three bladed runner that was demonstrated to have exceptional fish survival rates.
- With funding available from DOE, EPRI and industry partners, Voith Hydro continued Alden turbine development (initiated December 2009).
  - refine hydraulic shapes using Computational Fluid Dynamics (CFD).
  - perform preliminary mechanical design and layout for supporting equipment.
  - design and manufacture model for hydraulic testing in York facility.
  - selection of electrical, BOP (balance of plant) and auxiliary equipment for generator and excitations systems.
- Overall Goal: Develop preliminary integrated turbine system to an 80% level for determination of equipment costs and supply schedule for application at pilot site.

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Design Modifications

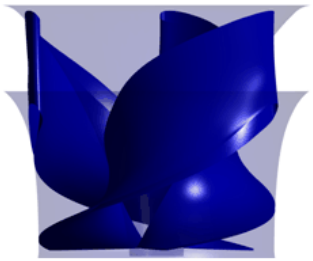
- **Computational Fluid Dynamics (CFD) utilized to:**

  (i) Maintain fish friendly criteria outlined by Alden Research Laboratory (minimum pressure, shear rates, and pressure change rates)

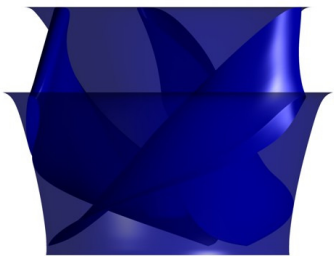
  (ii) Improve turbine performance

  (iii) Where possible, reduce machine size to decrease civil costs

- **Modifications defined for the spiral case, stay vanes, wicket gates, runner and draft tube.**



Original runner



Modified runner

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Design Modifications

- Comparative loss calculations performed for each design.

Runner Design	Total Losses [%]
Original	11.21
Modified	4.57

Table 1: CFD Predicted Losses

- Modified Alden turbine expected to be ≈ 6.6% better than original at selected design condition for School Street (Q = 1500 cfs, H = 92 ft net head).

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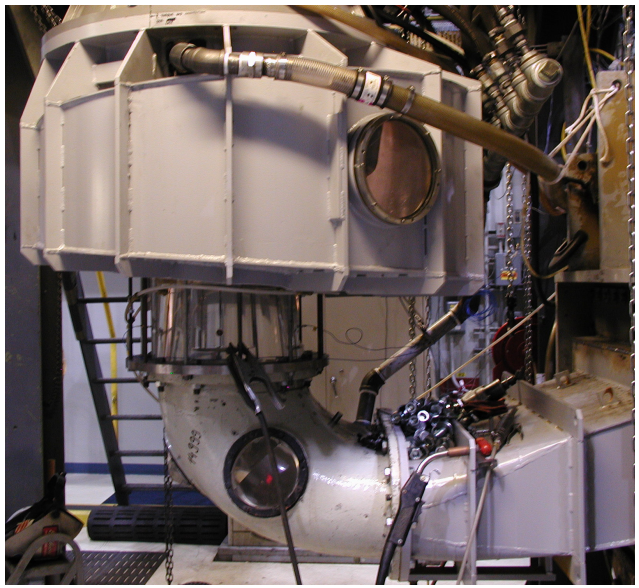
Model Testing

- **Modified Alden turbine geometry manufactured for model testing in York, PA**

  - model built at a scale of 1:8.71



Modified Alden Model Runner

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Model Testing

- Testing conducted from August to November 2010
- Achieved competitive Model performance
- Thrust, runaway speed, cavitation, pressure pulsations within accepted range for School Street application.

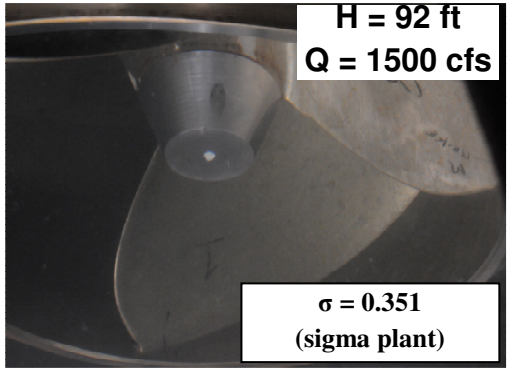

Photo at design condition under stroboscopic lighting.

- Testing showed that Alden turbine met or exceeded design goals.

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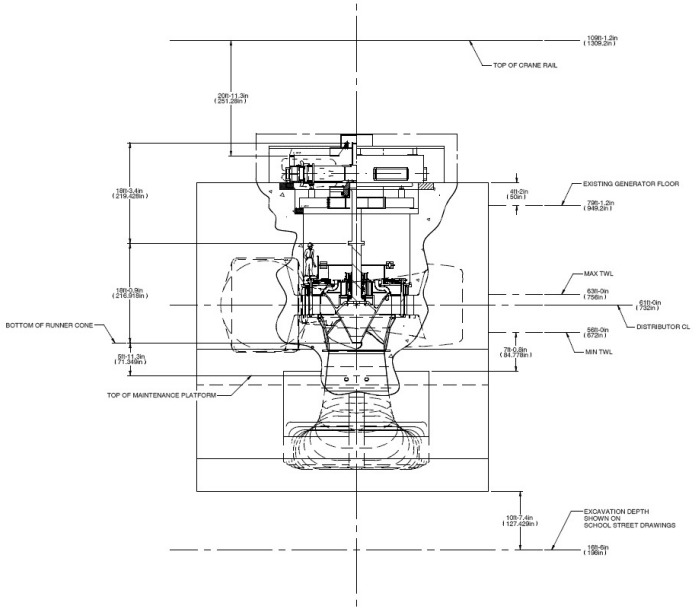
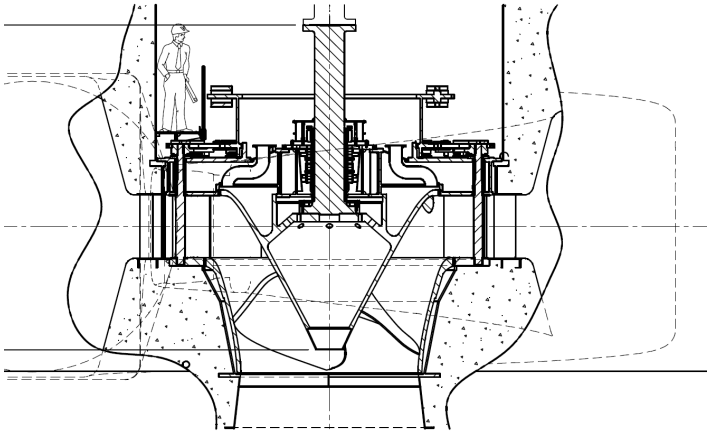
Mechanical Layout

- **In conjunction with testing, layout for mechanical and balance of plant equipment performed for School Street.**





- **Structural considerations evaluated with Finite Element Analysis (FEA)**

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Conclusions

- Currently Voith Hydro is wrapping up the model testing of the Alden turbine.
- Testing demonstrated:
  - Competitive prototype efficiency
  - Exceptional cavitation behavior
  - Thrust, pressure pulsations and runaway speed not significantly different from typical Francis turbine.
  - Based on testing, Alden turbine operation can extend beyond head range at School Street.
- Preliminary mechanical layout completed.
- Selection of balance of plant and scope of supply underway.
- Cost estimate and schedule for power unit equipment to be available at the end of the year.

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Conclusions

- Current project estimate will be based on powerhouse extension at School Street.
- EPRI is in the process of identifying alternate demonstration sites with comparable site conditions.
  - Costs can be scaled accordingly (cost difference should not be significant as long as concept is similar).
- Engineering study results will be incorporated into final report available March 1st, 2011.
- Study results will be presented at turbine workshop in Spring 2011.

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Engineering Overview

- **Development work performed based on application at Brookfield Renewable Power's School Street Station.**

- **Design Point:**

  Net Head = 92 ft

  Discharge = 1500 cfs

  N = 120 rpm

- **Runner inlet diameter (D_{1a}) = 12.8 ft**

- **Anticipated head range ≈ 89 to 96.5 ft**

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