

# **Synergistics Solutions**

## **Ontario Hydro Problem Solving Division**

"We CANDU what others CANNOT!"

### **Description of Project Management Chart**

The outline for inspecting all of the pressure tubes at the Pickering station (units 1 through 8) for the life-time of the reactor was organized into a Gantt chart. Our design team decided to look at the variables that needed to be found in order to have an effective plan that is on time and cost efficient.

First we assumed that the average life of a CANDU reactor is approx. 30 years. Next, we determined that there were 390 pressure tubes in Pickering A and 380 pressure tubes in Pickering B.

Using a statistical analysis, a confidence level of 95% was established with a confidence interval of 25%, for which our population size of pressure tubes was 390 or 380 produced a required sample size of 15. (Ref: Service Plan

By taking an unbiased, random, statistically descriptive sample size, we obtained that each inspection will cover a batch of approximately 14-15 pressure tubes. The start time for the inspections to begin is on August 16, 1984.

The first inspection to take place will be for Unit 2, because we do not want another rupture to take place such as the one in channel G16. At approx 10 weeks later, Unit 1 will be shutdown so that inspection can take place, where approximately 15 pressure tubes will be inspected.

Beginning in January 85, Unit 2 will be on an outage for 168 weeks so that all the pressure tubes can be retubed with Zr.-2.5%Nb. It was decided that one unit should be retubed at a time between Unit 1 and 2.

This is to allow workers some time to properly analyze and evaluate the pipes and tubes of the system and their relevant periphery. In addition, coming to Unit 2 later on allows a degree of experience to be gained by the workers.

To increase productivity and retain a high level of power capacity to the community only one unit at a time will be taken offline in this process of retubing(unit 1 then 2) and concurrent inspection(units 3 to 8).

Also the workers involved in the retubing are obviously exposed to radiation, so they will need to work on rotation. We at Ontario Hydro are very careful about what we expose our workers too and as such we may need to expand the workforce temporarily.

Some manpower will be diverted to the retubing, from inspections, initially, and it is expected that there will be an extension in the time to inspect the 15 tubes of unit 3, from 10 wks to 20wks.

It is hoped that with a new - temporary - employee base we will again restore the previous time-to-completion average of 10wks. Owing to the urgency of this matter and the fact that we currently do not have such a force at our immediate disposal we estimate it will take the HR Dept. at least 10 weeks to properly validate new candidates for the jobs of retubing and inspection.

Since the time taken for retubing is fairly long, inspections will continue at a somewhat diminished rate as manpower is spread over both projects until sufficient new workers are added to the rotations to offset the workload of both projects. This will be done in least cost-demanding fashion using CBR analysis.

Lastly, the inspections for the units 3-8 are planned in such a way so that outages do not overlap, therefore saving money for the future by preventing unnecessary downtime in the overall plant.

## **SERVICE PLAN**

### **Inspection Quantity**

Confidence Level: 95%

Confidence Interval: 25%

Number of Total Tubes: 380/390 (assumed)

**Statistical n value: 15 tubes**

### **Inspection Pattern**

Assuming - an inspection of ~ 15 tubes, taking 10 wks.

### **Inspection Technique**

Synergistics Solutions recommend the use of Kinectrics™ technique for inspecting CANDU's pressure tubes. Involving a Non-destructive (NDT) method of ultra-sonic evaluation we will be able to evaluate the performance of garter springs and the deviation of the pressure tubes within the calandria.

Using their technique, resonant standing waves are excited in the gas-filled gap between the pressure tubes and calandria tube and a measurement of reflected response is taken. "The technique uses a low-frequency wide-bandwidth probe-transmitter in a pitch-catch pair of transducers excited by a sine burst with a large number of cycles. The excitation of gap resonance reveals a frequency, which is uniquely related to the absolute value of gap width."

The technique will also evaluate the surface porosity and degradation over time as we create a map of the surface characteristics of the tubes, for comparison at later dates to new inspection data, thereby allowing a history-based assessment of any future corrosion or degradation.