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Technical Note

Function and Design of the PHTS Hydrostatic Pressure Tester as supplied to NB Power, Bruce A Restart & OPG Darlington Unit 2

Purpose: To test a Primary Heat Transport System (PHTS) that has been upgraded or modified such that a hydrostatic pressure test is required by the Canada Nuclear Safety Commission (CNSC) before the PHTS can resume operation.

The PHTS Pressure Test Requirement: CNSC provides the Operator (OPG/Bruce/NB Power) with a PHTS test pressure value that must be maintained for 10 minutes. Typically the test pressure is 10% higher than the operating PHTS design pressure. The actual PHTS pressure reading is observed on several, 4 or more, pressure gauges located in the Main Control Room.

Technel Engineering Inc. Design: TEI has designed and built three different, portable, temporary cart systems, sometimes called Test Skids, each with different operator provided design requirement:

1. NB Power (2012 test date) 47.7 litres per minute (lpm) at 20.7 MPa which required a 15 HP motor

2. Bruce A Restart (2012 test date) 40.5 lpm at 17.9 MPa which required a 25 HP motor

3. OPG Darlington Unit 2 (2019 test date) 132 lpm at 14.6 MPa which required a 50 HP motor. The OPG high flow requirement was objected to, but ignored, as being overly cautious as the New Brunswick test only required about 20 lpm for the final test.

Basic Cart Design: The cart is designed to provide the required CNSC test pressure for 10 minutes at an unknown PHTS leak rate. The leaks emanate from new or re-conditioned valves and possibly flanges. Although the leak from each valve maybe in drops of D2O per minute, the quantity of valves and flanges results in a leak rate of lpm.

The TEI design, see the attached OPG schematic, uses a positive displacement pump **, a motor frequency (speed) controller, a back pressure regulator, a high accuracy (+/- 0.1% of reading) digital pressure display, a flow display in lpm along with various valves, safety pressure regulators and an analog pressure and temperature gauge. The cart also has a surge tank (~100 litre capacity) that feeds the pump. The surge tank level is maintained at a 50% - 75% level by a control tech operating a manual make-up valve on the cart. The make-up water (D2O) is from an external Operator source.

The actual operation is an iterative process by which the cart control tech adjusts the pump flow rate (speed controller) and the maximum pressure (back pressure regulator) till the cart output matches the unknown PHTS leak rate and the required CNSC test pressure.

The operator control actions are based on the actual pressure gauge readings in the control room. Based on those readings, the control tech will increase/decrease motor speed (flow) and/or increase/decrease the back pressure regulator.

Critical to a successful test is that after every cart adjustment, motor speed and/or back pressure, significant time is necessary to wait for the PHTS to react then settle to the latest adjustment. This can take 20+ minutes for the last cart settings (flow rate and/or pressure) to show up on the control room gauges. This is a must as the PHTS has a long time lag due to the PHTS volume (300,000 litres +).

Based on the control room gauge readings, the cart control tech will adjust up or down the flow and/or back pressure until the leak rate is determined and the required test pressure is met.

** In Korea, a centrifugal pump is used. Because of its design, this type of pump is more difficult to precisely adjust the output pressure. The positive displacement pump speed can be adjusted in 0.1 Hz increments, resulting in small increments of flow and the resulting increments in PHTS pressure.

A positive displacement pump provides flow regardless of the system pressure that it is pumping into. As an example, it will pump 10 lpm regardless of whether it is into a 20 kPa or a 20 MPa pressure vessel.

William Ormerod – May 2019