BC Hydro Undertakes Landmark Transmission Project

by Tonia Jurbin • Contributing Editor

***Top:** The exit pit shows the completed tunnel with all carrier pipes. A grout tube is also shown. **Bottom:** Massive concrete manhole/vault being lowered into the ground.*

After months of planning, route selection, engineering-design work, public consultation and negotiations with the cities of Vancouver and Burnaby, the installation of a high-profile, 5.6 mile high voltage (230,000 volt) transmission cable started in February 2003. Expected completion is in April 2004.

This is a milestone project for British Columbia Hydro & Power Authority, Canada's third largest electric utility, as it is the first new 230 kV underground transmission circuit built since 1982.

"We needed to have an additional, reliable source of power to the downtown core to reinforce the grid, and to allow for future growth," explains Bill Orpen, assistant project manager for this undertaking. "All that we knew when we started was that the new transmission line had to be underground, seismically sound, and it had to start at the Horne Payne Substation in Burnaby, and end at Cathedral Square Substation in Vancouver."

Cathedral Square is believed to be the only underground substation in North America. The route selection for this project was the biggest challenge the designers, planners and property representatives faced. They had to balance technical, social and legal considerations, as well as meet the requirements of the British Columbia Utilities Commission.

In addition to five civil construction contracts, there is:

- A supply contract for the PVC ducts, manufactured by Ipex out of Langley, BC, worth about $520,000 ($C700,000);
- The lion's share of the $32.7 million ($C44 million) project was the $7.4 million ($C10 million) supply and install contract awarded to Fujicura out of Japan for about 17.4 miles of high voltage transmission cable; and
- Construction of 11 giant manholes with inside dimensions of 32.8-feet long by 11.5-feet deep by 10-feet wide. Built by AE Concrete of Surrey, BC, at a cost of $30,000 ($C40,000) each, these two-piece, 180,000 pound manholes are the largest ever built in BC.

The transmission duct itself is a concrete encased structure with a cross sectional area of about 2.3 square feet with four 6-inch ducts for the transmission cables, and three 2-inch ducts for grounding fiber optic cables and allowing for future growth. British Columbia's west coast, being the most seismically active area in Canada, required a seismically sound design for the duct which is being conservatively installed at or near the hard bouldery glacial till at depths ranging from 8 to 21 feet.

First contract

The first civil contract, a short section of just under a mile, was awarded to Pedre Contractors Ltd. of Langley, BC, and included a tunnel and some of the deepest excavations in the most congested utility corridors on the project. The first shovel in the ground on this landmark job was to build the 20-foot long by 20-foot deep by 12-foot wide jacking pit for the 74-inch tunnel going under the TransCanada Highway. The tunnel construction was sub-contracted to Pacific Underground Installations of Surrey, BC.

"Pipe jacking is a generic term that is used for advancing pipe in a trenchless underground installation without disturbing the surface," explains Orpen. "In this case, the contractor went under the highway by conventionally removing the soil; they used jackhammers from within a steel casing that is pushed up against the face of the wall."

The steel lead ring is advanced hydraulically as the till is chipped out by the crew with jackhammers. Once they have advanced the length of a 8-foot, 4-inch concrete pipe section, the ram is backed off so that another concrete section can be dropped into the space. The approximately 150-foot long tunnel under the highway required 20 of these 5-foot inside diameter, 7½-inch thick concrete pipe sections. Each 13,000 pound section was dropped onto a cradle and jacked into place. The work was labor intensive as all the material was hand excavated.

The tunnel contract originally estimated at about $163,000 ($C220,000), took about six weeks to build. It is an unusual tunnel in that the designers called for unreinforced concrete. High voltage transmission ducts cannot have a continuous steel connection around the electrical cables because of induction and hotspots. In fact, even the concrete ducts themselves were unreinforced except in the soft peat areas where the contractors had to make sure the rebar wasn't touching adjacent pieces, and the plastic coated rebar wire had to be double wrapped with electrical tape.

It is also unusual these days with so much equipment available to have a crew at the tunnel face with air-hammers. Linda Schellenberg, project manager for Pacific Underground explained. "Because the glacial till here is extremely hard with lots of rocks and boulders, we had to use the jackhammers. The boulders ranged from hard hat size to about two feet in diameter, often making it necessary to split them before they could be removed to prevent over-excavation. Crews spent more than 30 hours manually removing rock embedded in the face."

Every over-excavation location had to be tracked and later filled in with grout through 2-inch ports drilled through the thick pipe walls. About 5.2 yards of cellular concrete was used for the external grouting.

Schellenberg continues, "because the pipe was unreinforced, we also had to make sure that the jacking pressures wouldn't crush the sections. We crush tested the pipe both vertically and horizontally prior to starting so we would know what we were up against. From the tests, we learned that we could use about 300 tons of jacking pressure. There was a pushing block strapped to the pipe which evenly distributed the pressure of the jacking ram around the circumference of the pipe, and the jacking pressure was continually monitored. At times we applied large amounts of friction reducer as a preventative measure to reduce the friction between the rock (till) and the exterior of the pipe."

Lubricating fluid

The contractor hadn't planned on using lubrication – it was only applied when the pressures exceeded 200 tons after about half of the sections were installed. The Baroid product, Enviro-Torq, was pumped through a one-inch line running along the 1 o'clock and 11 o'clock positions which allowed it to run down the outside of the pipe. The crews typically used about 250 gallons for each 8-foot section.

Pacific Underground was able to average about six feet per day. However, as in most underground construction projects, there are always surprises and at about 60 feet from the end of the tunnel, one of the concrete sections near the tunneling face fractured and imploded the side of the casing. The project shut down for about three days while experts from Ocean, the pipe suppliers, came out to evaluate the failure. The fracture that went around three quarters of the circumference of the section had to be repaired; otherwise the section would have to be removed.

Later, it was determined the spalling was due to external rock loading. A jagged 8-inch rock caught itself on the outer joint and rode the front until the stress from the jacking pressure fractured the joint. As the pressure was applied, the rock rolled and imploded the side of the casing. Ocean cut the pipe and retrieved the rock. They formed and poured a repair right inside the pipe. Steel ribbing was installed around the inside of the broken section, but this was also tricky because the ribs had to be expanded precisely before every jacking sequence. Too much expansion pressure would make it impossible to ram the casing any further forward, but not enough expansion and the fractured concrete might shatter when they applied the ramming pressure. The ribs had to be continually adjusted as the rest of the tunnel sections were installed, and then removed when the jacking was complete.

One of Schellenberg's biggest challenges in planning this tunnel installation was safety. The job had to be treated as a confined space and safe retrieval of the crew had to be planned. There were also concerns over falling rock, entanglement, heat exhaustion and the possibility of encountering silica. Continuous ventilation was provided and air quality constantly monitored. "The biggest challenge once we got going was to keep the pipe on strict line and grade tolerances. Every time we hit a rock that had to be removed from the side of the pipe, the pipe wanted to take the path of least resistance. At the same time, it was essential to keep the jacking pressures applied uniformly to the circumference of the pipe. When you have concrete pipe with 7½-inch thickness, even a 4-inch alignment variance is a slow and constant battle to correct. The corrections have to be gradual because you can create problems for the duct installation."

Once completed, the ducts were pulled through the tunnel; eight 8-inch ducts for the transmission cable, four 4-inch ducts for cooling fluid, and four 3-inch ducts for future fiber optic cables. About 100 yards of grout was pumped into the inside annulus once all the ducts were in place.

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