COOLING SYSTEM RETROFIT INCREASES CAPACITY AND EXTENDS LIFE OF MANITOBA HYDRO TRANSFORMERS

By Ed Verwaayen and Rene Bray

Manitoba Hydro's HVDC Division is based in Winnipeg, Manitoba and manages Manitoba Hydro's HVDC transformers. The division generates 5000 MW of power, and the Dorsey and Henday stations have a transmission capacity of 3854 MW of power.

In early 2002, the HVDC Engineering Division realized it had a problem — it needed seven transformers to be uprated through improved cooling and they needed it done within three months.

Manitoba Hydro asked Unifin International to do the job. Both companies had a long working history and most of the original equipment used at the HVDC stations for cooling Sync Condensers and thyristor valves came from Unifin.

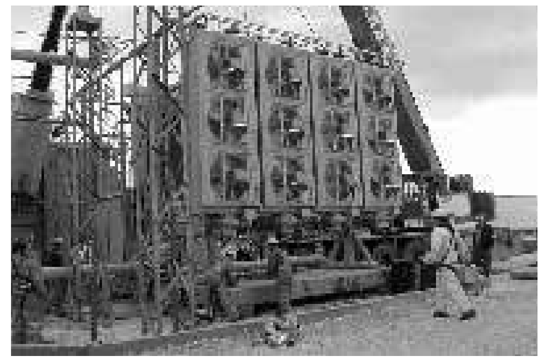
Two of their transformers had failed due to localized hot spots and malfunctioning gauges. Manitoba Hydro could not afford to lose more transformers due to overloading, so Unifin and Manitoba Hydro engineers designed an on-site solution that would meet increased demand on the transformers. Each transformer's current design criteria were analyzed and a redesign solution was proposed which included hinged cabinets and special motors and fans designed to handle the Manitoba Hydro environment. (See exhibit 1)

The new design also included standard uniform coolers — the same size for each transformer. This made the coolers interchangeable, thus minimizing the number of spares required. These coolers lowered the TOR (Top oil rise) to as low as 22°C.

Before the replacement, a series of radiator panels mounted on an A-frame with pumps was used to cool the transformers. The units were unable to withstand increased capacity due to poor airflow and transformer 'hot spot' temperature limits.

Transformer oil temperature increases at a higher rate than ambient temperature because air density decreases as air temperature rises. However, fans on coolers or radiator panels move a fixed volume of air irrespective of air temperature.(fans move the same amount of air — only the density changes with temperature). The result is less air mass flowing through the radiators and less capability to dissipate heat on hotter days. This increases the top oil temperature beyond the ambient increase alone, since the top oil temperature is equal to the sum of the increase in ambient temperature and the increase in temperature rise.

The problem transformers at Manitoba Hydro were forced-oil, forced-air types (FOA in the USA and OFAF in most other countries). FOA transformer



oil coolers pump the transformer oil through the inside of fintubes while air is blown over the fins by propeller fans. The heat transfer surface consists of

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Before installation: Note old radiator coolers in block with poor airflow.

After installation: Notice improved airflow and access for maintenance.

Transformer Analysis

Station	Dorsey	Dorsey	Henday	Henday	Henday
Transformer	T31S	T32/42 D	T32/42 D	T41 D	T31S
Coolers	6+1	12+2	12+2	5 (original) +2 Additional	5 (original) +2 Additional
ORIGINAL TOR / BOR	44°C/38°C	39°C/32°C	47°C/40°C	33°C/23°C	41°C/36°C
NEW DESIGN TOR / BOR	23°C/20°C	21°C/19°C	22°C/20°C	28°C/20°C*	34°C/30°C*

* Gradients were also reduced by 5°C due to increased oil velocity with the addition of pumps.

multiple rows of finned aluminum tubes.

This one piece, or integral, construction, provides maximum heat transfer efficiency coupled with long service life. This design also incorporates spirally wound extruded turbulators that further enhance heat transfer efficiency.

These new coolers also came with Cardinal pumps with Tecsonics bearing-wear measurement systems. This allows the user to test for bearing wear and plan future outages based on pump bearing wear, instead of pump failure, which could cause a system failure or unplanned shutdown.

Radiator banks were the original cooling equipment was. Radiators are two plates of steel welded together. This design is effective but, at larger transformer sizes, becomes cumbersome and more expensive to use than coolers. Maintenance of this equipment is also increased due to poor air flows within the large construct of radiators [which decreases thermal efficiency] and a requirement for more fans. Radiators also have a lot of seam welds which leak over time.

Coolers only have leak points at the headers, thus providing fewer points for transformer oil to leak. Larger motors are used for coolers and thus fewer motors are required to achieve the same thermal transfer, resulting in reduced maintenance. Radiator panels are very good for OA (oil and air natural flow) and FA (forced air or fans) ratings but on FOA (forced oil and forced air), coolers provide better performance.

INSTALLATION

The coolers were installed by Manitoba Hydro at the site onto cooler frames supplied by an OEM. Electrical components and other changes were made at the same time. Installation was completed in 3 days for each transformer, including commissioning. Installation was done in the same physical location in spite of an upgrade in performance. All coolers from Unifin arrived within two months of ordering and met or exceeded requirements.

PERFORMANCE

Performance calculations were made on site using Unifin's Unitherm design program. This gave immediate feedback for alternate designs. It was felt advantageous to have all coolers and pumps the same size and performance rating.

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