BONNEVILLE POWER ADMINISTRATION

Electronically Commutated Motor (ECM) HVAC Pump Case Study

April 3, 2015

A BPA Energy Efficiency Emerging Technologies Initiative Report

Prepared for
TJ Sharkey (CONTR)
Bonneville Power Administration

Prepared by
Courtney Carrier
Jackola Engineering

An Emerging Energy Efficiency Technology Report

The following report was funded by the Bonneville Power Administration (BPA) as an assessment of the state of technology development and the potential for emerging technologies to increase the efficiency of electricity use. BPA is undertaking a multi-year effort to identify, assess and develop emerging technologies with significant potential for contributing to efficient use of electric power resources in the Northwest.

BPA does not endorse specific products or manufacturers. Any mention of a particular product or manufacturer should not be construed as an implied endorsement. The information, statements, representations, graphs and data presented in these reports are provided by BPA as a public service. For more reports and background on BPA's efforts to "fill the pipeline" with emerging, energy-efficient technologies, visit the E3T website at http://www.bpa.gov/energy/n/emerging_technology/.

Acknowledgements

BPA:

Erik Boyer
503-625-1392
ebboyer@bpa.gov
Mechanical Engineer

TJ Sharkey
503-625-1365
tjsharkey@bpa.gov
Mechanical Engineer

Facility Representative:

Courtney Carrier
406-755-3208
ccarrier@jackola.com
Mechanical Engineer

Utility Representative

Don Newton
406-751-4485
d.newton@flathead.coop
Key Accounts Representative

Table of Contents

Project Objective

The objective of this project is to document the design considerations, and recommended controls sequence for an office ground-source heat-pump system energy efficiency project. The energy efficiency project includes the replacement of a heat pump condenser loop pump and system upgrades. The first upgrade installs a new pump with an Electronically Commutated Motor (ECM). The second upgrade will consist of removing several small, secondary circulation pumps and installing 2-way flow control valves at each heat pump, which will allow optimized operation of the new ECM pump.

Project Location

The office building is located in Kalispell, MT.

Existing Mechanical System

The existing mechanical system is a water source heat pump, utilizing a supply well and injection well (source) coupled to an internal building loop (load) with a flat plate heat exchanger. The load side of the system (internal building loop) uses a primary/secondary piping system with constant speed pumps on both the primary and secondary sides. There are two ¾ HP primary pumps piped in parallel, each sized to provide approximately 60% of the required flow at design conditions. When loads are minimal, such as during shoulder seasons, only one of the two pumps run. As loads increase, the second pump is manually engaged to increase building loop flow. These pumps operate in this fashion 100% of the time. Upon a need for either heating or cooling, the fifteen heat pump(s) and secondary circulator(s) are engaged. Each secondary circulator is rated at 90 Watts, for a total of 1.8 HP.

Upgrades

The upgrades will occur in the following two phases:

Phase 1: Replace one of the existing ¾ HP pumps with an ECM type that will decrease the energy consumption. It will be sized based on the full block load conditions of the building and the flow will be adjusted through its integral variable flow controls to provide a constant flowrate in order to meet the potential full flow required by the system. The existing piping and pumping system will be maintained during this phase.

Phase 2: The primary/secondary pumping/piping system will be converted to a "header" supply/return system with motorized control valves for each heat pump. This will permit a variable flow system and take full advantage of the energy saving ECM technology. The minimum required flowrate through each heat pump will be adjusted, allowing the new ECM pump to operate at its minimum rate.

Design Considerations

Typically, an ECM pump would be used in a variable flow application to maximize the operational efficiency. Because the ECM pumps, readily available in the North American marketplace, are relatively small (<2HP), their flow and head capacities are limited. Design should generally incorporate variable flow, low head piping elements, and closed piping systems to permit the lowest pumping energy associated with ECM pumps.

Application Examples

ECM pumps should be considered for most variable flow and many constant flow applications. Manufacturers have case studies indicating that even in constant speed applications ECM pumps can provide higher efficiency and lower operational costs when compared to traditional pumps. When used in variable flow systems such as hydronic heating and cooling systems, the operational savings can be higher. Hydronic radiant floors, variable chilled water systems, geothermal, and domestic hot water recirculation systems are a few examples where ECM technology can be applied. Control methods for these type of applications may include proportional-pressure, constant-pressure, constant-temperature, differential temperature, constant-curve duty, and maximum or minimum curve duty. Many of these control methods are built into the integrated controller of the pumps, including pressure and temperature sensors.

Recommended Control Sequence

For Phase I of this heat pump condenser loop upgrade, the pump will be programmed to run 100% of the time, similar to the existing pump system. This is required because the existing system utilizes a primary/secondary loop design where flow through the primary loop must remain, regardless of the mode of the individual heat pumps. The specified ECM pump has an integral control system that monitors pressure across the pump. The maximum flowrate will be a function of the buildings instantaneous load, typically highest during morning warmup, and shall be programmed within the pump integral control system.

A main feature of the ECM pump technology is how their speed can be controlled without significant energy losses. Most include integral controls that can respond to internal pressure changes or can be controlled with an external controller based on temperature differential.

Phase II of this project will include the conversion of the system to take advantage of the integral differential pressure controller.

The piping will be changed from a primary/secondary system with each heat pump requiring an individual pump to a simple supply/return header system with a single pump and 2-way flow control valves on each heat pump. With the new system, when individual heat pumps operate, the 2-way control valve will open and the compressor will be engaged. This will reduce the pressure differential across the supply and return header. The new ECM pump will sense this reduced pressure and increase in speed and flow. As each heat pump operates additional flow will be provided. As zones are satisfied, the heat pump will disengage, and the flow *control valve will close, increasing the differential pressure in the system, which in turn will cause the ECM pump to decrease speed. This constant differential pressure control mode is typical with most ECM pumps and requires no external controls.*

Required Commissioning

Phase 1: Upon installation, the commissioning process for the specified pump is relatively easy. With the required flow and resulting pressure differential known, the pump can be programmed to provide the flow with its integral controls. It will do so at the minimal required energy consumption. A digital manometer will be used to verify flow.