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ENGINEERING

SYSTEM SOLUTIONS

In this issue, we begin with a discussion of McQuay research on the effect of variable flow on centrifugal chiller performance – the results of which prove that, within limits, the rate of chilled water through centrifugal chillers can be reduced proportional to load without penalizing unit efficiency or operating stability.

In addition, we have a brief introduction to McQuay's Vision™ customized air handler – the most flexible commercial air handler available today, and the ideal compliment to chiller applications.

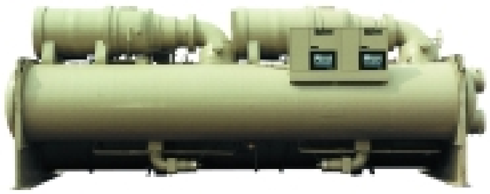
You can find this and other issues of Engineering Systems Solutions on our website at www.mcquay.com. Also, check out our "What's New" page for information and literature on McQuay's new Distinction Series™ Dual Compressor Centrifugal Chillers, Vision customized air handlers, and other McQuay products.

McQuay provides semi-custom system solutions for commercial HVAC applications. This newsletter is written specifically for the HVAC engineering community. We welcome your comments, feedback, and article suggestions.

Dave Laurenz
Director of Sales
McQuay International

Will Variable Evaporator Flow Negatively Affect Your Centrifugal Chiller?

Not if it's a McQuay Chiller



McQuay's new Distinction Series™ Dual Compressor Centrifugal Chiller

Varying water flow proportional to load through packaged chiller evaporators can be used to improve an air-conditioning system's efficiency and save owners money by reducing pump motor power draw. McQuay Centrifugal Chillers have been tested and found to be well suited for application in variable flow systems. Engineers can design systems around McQuay chillers for this type of energy savings with confidence.

Until extensive computer modeling and testing was completed by McQuay engineers, the effect of variable flow on the performance and stability of centrifugal chillers had not been fully understood. There was a perceived need to provide constant chilled water flow through the evaporators on variable flow systems.

McQuay's computer simulation and the test stand results were consistent with the theoretical considerations and demonstrated that chiller kW/ton is basically unaffected by evaporator flow reduction down to 50 percent of design flow (assuming flow reduction is in proportion to chiller load reduction with a constant Δt). In many cases it was found 25% of design flow would not cause problems depending on the initial full flow tube velocity. Reducing flow beyond 25%, however, could cause unstable operation to occur. For variable flow systems, when a small percent of full-load operation is anticipated, the evaporator can be selected for a high full-load velocity, thereby allowing a greater range of flow reduction before minimum values are reached. One caution, sudden flow changes can cause problems at any percent load. Allow no less than one minute of time for every 2% of reduction in flow. Consult with a McQuay Representative for your specific application considerations.

IN THIS ISSUE

McQuay International

Testing and Research

To determine the effect on the kW/ton (COP) and operating stability of centrifugal chillers under conditions of reduced evaporator flow, McQuay Engineers conducted extensive research and testing. Three levels of investigation were employed in the research and testing:

1. A technical review of the applicable heat transfer formulae and compressor performance parameters.
2. Computer simulation of chiller performance under varying flow conditions using a proven model.
3. Operating a unit under varying flow conditions on an ARI-certified test stand to correlate results with the computer studies and assess the operating stability.

In each scenario, flow through the evaporators was decreased in proportion to load, and a constant chilled water range was maintained.

Technical Review

As flow is reduced through a flooded evaporator (water on the tube side) at any given load, several interrelated changes occur. The chilled water temperature range increases inversely with flow, thereby increasing the LMTD (log mean temperature difference). The h_i (inside heat transfer coefficient) will vary directly to the 0.8 power of the flow. This will cause a reduction in the U value (overall heat transfer coefficient), but to a lesser degree than the change in h_i, since h_i is only one of five components in the overall coefficient.

$$\frac{1}{U} = \frac{1}{h_o} + R_{fo} + \frac{x}{k_w} + R_{fi}A_o/A_i + \frac{1}{h_i}A_o/A_i$$

As shown in the above formula, the influence of tube velocity and h_i on the overall heat transfer of the evaporator is dependent on the relative magnitude of h_o (outside tube coefficient), the tube characteristics and the fouling (R_{fo}).

A decrease in flow, and consequently a decrease in tube velocity, will reduce the evaporator's heat transfer rate and cause a decrease in evaporating temperature. This results in the compressor head increasing slightly for the same refrigeration capacity. The compressor efficiency may increase or decrease, but usually results in a small net increase in kW/ton (decrease in COP). The water pressure drop will vary as the flow to approximately the 1.8 power. The formula for this heat transfer can be written as: Q=(A)(LMTD)(U).

There are two questions raised by this review. First, to what extent does the increase in LMTD, due to the larger chilled water range, offset the lower heat transfer coefficient caused by the lower tube velocity when the chilled water flow rate is decreased at a given load? Second, what is the effect on evaporating temperature and, ultimately, on compressor power? The next phase of the investigation provided the answers to both of these questions.

Computer Simulation

In order to answer these questions, various chiller models were selected and run on McQuay's chiller performance simulation program. To check the effect of variable flow on evaporators, different size units for nominal 225 tons were selected to give a variety of evaporator approach temperatures. The effect (if any) on the initial LMTD was then investigated.

The units were run at full load, and then the evaporator flow rate was decreased proportionally with load at 75, 50 and 25 percent load points to maintain a constant 10°F water temperature range. Each load point was also run with the design full-load flow to compare the kW/ton value for each flow and load condition. The condenser flow and entering temperature were held constant throughout this phase as the performance of the tubes under very low flow rates and low compressor power requirements is not well documented.

The results of the computer runs with variable evaporator flow rates were very uniform. At any of the selected load points, the difference in kW/ton (COP) between full evaporator design flow and the reduced flow rate (equivalent to the percent load reduction) was insignificant. Most importantly, each flow condition had an identical kW/ton of 0.737 (4.8 COP). Water side pressure drops were proportional to the flow to the 1.8 power as predicted.

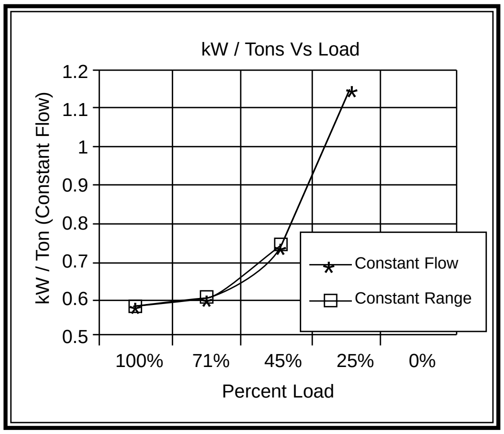
Test Stand Verification

To verify the computer simulation, a 225 ton (791 kW) centrifugal chiller was run on an ARI-certified test stand with a variety of load and flow conditions. During the tests, the unit was run at 100 percent load and flow, and then at approximately 75, 50, and 25 percent load points. At each load point, the original design evaporator flow was used and then reduced to a flow equal to the percent reduction in load to compare constant and variable flow performance. The condenser flow and entering water temperature were held constant.

Test stand results were similar to the computer simulation. At 100, 75 and 50 percent, the chiller efficiency remained within 1 percent when comparing full flow/variable Δt to variable flow/full Δt operation. At 25 percent load, however, while the full flow test ran very well, difficulties arose during the low flow test. The test stand controlled the entering evaporator water at a fairly constant temperature, but the leaving water temperature fluctuated 4°F in 15 to 30 second cycles. This indicated that instability in heat transfer was occurring, probably caused by a combination of the very low water velocity in the tubes and the overall low heat flux.

Conclusions

The results indicate that with proper care, and within certain boundaries, the flow rate of chilled water through centrifugal chillers can be reduced in proportion to load without penalizing unit efficiency or operating stability. Good news for anyone trying to save pump horsepower by using variable flow chilled water systems!



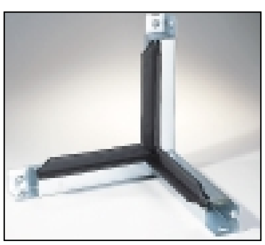
McQuay Vision™ Customized Air Handlers

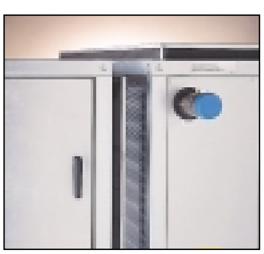
Flexibility to Build the Unit You Need

Vision customized air handlers are one of many McQuay products that offer you flexibility in meeting today's HVAC system demands. No other commercial air handler features as many pre-engineered solutions for virtually every energy, IAQ, sound, or installation challenge faced by design or consulting engineers, in new or retrofit applications.

Vision's flexibility begins with its patented, modular platform and construction. A patented, bolted frame channel allows for easy section-by-section removal and reassembly of the frame and side or top panels during installation, maintenance, or service. A patented splice collar assembly eliminates guesswork in guiding sections together during assembly, and extended coil and drain connections allow for easy connection without removing panels.

Factory-applied gasketing in the frame channel, external connections, and splice collars provide an airtight seal, making the units capable of leakage rates as low as .5 cfm/ft^2 at 5" static pressure. While this is comparable to fully-custom units, Vision air handlers are available at competitive prices.



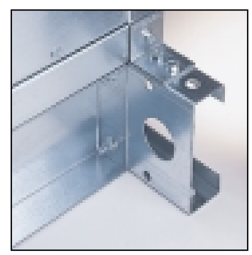


Fully gasketed frame channels, splice collars, and external connections give you comparable leakage rates to fully custom air handlers.

Multiple fan selections in multiple sizes allow you to select for the lowest possible BHP and sound requirements.

Using this platform, the design or consulting engineer can specify virtually limitless configurations, dimensions, sizes, component types, features, and options including:

- **Variable Sizes** - ranging from 3 to 77 ft^2 face area or 900 to 42,500 cfm.
- **Multiple Section Depths** - to match component sizes.
- **Access Sections** - in varying depths and between any section for spacing or field-installed components.
- **1" or 2" Insulation** - in ¾#, 1½#, or 3# densities.
- **Double or Single Wall Construction** - with solid galvanized or stainless steel, or galvanized perforated liners.
- **Full Perimeter Base Rails** - with heights ranging from 4"-12" to accommodate condensate trapping needs and eliminate the need for a housekeeping pad.
- **Airfoil or Forward Curve Housed Fans, Belt Drive or Direct Drive Plenum Fans, or BarryBlower® ESI Inline Fans** - in multiple sizes for each unit size to allow for flexible options with the lowest possible BHP and sound requirements.
- **Chilled Water, Hot Water, Steam, DX Evaporator, and Cleanable Coils** - provide application flexibility.
- **⅝" Coils** - with 1-12 rows and multiple fin spacings to precisely match load requirements.
- **Draw Through, Blow Through or 2 and 3 Deck Multi-Zone Coil Arrangements** - provide application flexibility.



Full perimeter base rails in variable heights allow you to accommodate condensate trapping.

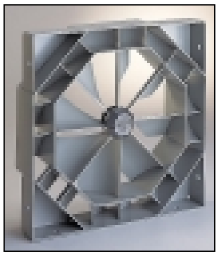
- **Sloped, Microbial-Resistant Galvanized or Stainless Steel Drain Pan** - in cooling coil section, with an option for the fan section. Drip pans are available in many other section types.
- **Multiple filter types and efficiencies** - including flat, angular, bag or cartridge filters with/without microbial-resistant treatments and ranging in efficiencies up to 95%.

Multiple filter types and efficiencies, with or without microbial-resistant treatments.

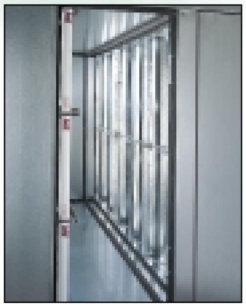
Continued on back page.

McQuay Vision™ Customized Air Handler continued from page 3.

- **Sound Attenuators** - in multiple lengths to meet acoustic, space, pressure drop, or initial cost requirements.
- **Air Blenders/Mixing Boxes** - in multiple widths to minimize stratification.
- **Face and Bypass Dampers** - both internal and external bypass with low leak dampers.



Air blenders/mixers factory sized to minimize stratification.



Sound attenuators factory sized to meet acoustic, space, pressure drop, and cost requirement.

- **Heat Recovery Sections** - for application flexibility.
- **Lights, Windows, and Doors** - available where desired throughout the unit.

All of these features and options are pre-engineered and factory-mounted - eliminating the costly design work or field assembly associated with incorporating them as ancillary equipment or sub-components.

Engineers can use McQuay's SelectTOOLS™ software to evaluate an infinite number of unit arrangements and generate drawings and specifications in minutes. The end result -a packaged solution, tailored to meet the energy, sound, and IAQ requirements of your application, at lower design and installed costs.

For more information, contact your local McQuay representative, or check out our website at www.mcquay.com/whatsnew for a free brochure.

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