Hydronic systems overview: Part 1

By **WILLIAM J. COAD**

Hydronics, for the purpose of this column, will be defined as single phase (liquid) energy transport systems, such as chilled or hot water systems. Over the past two decades, these systems have moved into the position of being the most commonly used heat transport and intermediate fluid transfer systems. If the reason for the shift to hydronics could be summed up in a single phrase, it would be *inherent ease of control.*

Although hydronic systems may lack some of the advantages of two-phase systems or all-air systems, their adaptability to multiple zones of load control with highly effective performance results has proved an overwhelming benefit. This benefit has had some backlash, in that the systems could be extemely forgiving of design or installation errors, such as oversizing of loads, sources, pumps, piping, etc., and the inherent control simplicity would correct for the deviations and still provide acceptable performance results.

Like most new and rapidly growing technologies, the development of hydronic systems "happened" more than it was planned; *i.e.*, much of the hardware development and system design evolution was to address prior problems. Three marketplace pressures are currently present that are forcing a reevaluation of the fundamental concepts of hydronic systems. They are:

- Awareness of energy economics has resulted in a consideration of the inherent process energy waste resulting from both overdesign and designs that do not take into account auxiliary systems and false loading burdens.
- The spiraling costs of construction and interest rates on investment money have exerted pressures upon the engineering profession to develop systems that can be installed at a minimum construction cost while still satisfying the other performance and design parameters.
- The relatively simple concepts employed in earlier, smaller systems were not reevaluated as the hydronic systems grew in magnitude and complexity. As a result, hydronic systems of a complexity that is virtually impossible to understand have been installed spanning large campus complexes and large, densely populated areas.

The last of these was recognized prior to the energy and cost implications, and its presence or recognition formed the basis for reevaluating the concepts. There are two fundamental aspects to a hydronic system that must be recognized if a systems analysis is to be performed: the *hydraulic analysis* and the *thermal analysis.* Although these are separate phenomena, they are intimately interdependent.

The vast majority of problems revealed by the large complex systems was due to the lack of recognition of the hydraulic phenomena. Simply, a hydronic system is a hydraulic system containing a noncompressible fluid. As such, any change in pressure or flow rate in one part of the system, no matter how small or remote, will affect the pressure or flow rate in *all other parts of the system.* The only element of compressibility is the compression tank, which has a fundamental role in the hydraulic analysis. The compression tank contains the liquid of the system and a compressable gas (with either a free interface or separated by a diaphragm). Its salient function is to establish the hydraulic constant pressure point in the system. Under operational dynamics, as valves change positions, pumps cycle on and off, and so on, the pressures at *all* other points will change, but at the point of the connection of the compression tank, it will be constant. This is analogous to the electrical concept of ground potential. Except for the ground in an electrical distribution and utilization system, all potentials are simply relative to one another, and an analysis of such a system is impossible to undertake without the ground reference. Similarly, in a hydronic system, any efforts at a hydraulic analysis cannot be undertaken effectively without establishing the ground, which in the analogy is the pressure at the compression tank.

This establishes the first cardinal rule in the hydraulic systems analysis: *no hydronic system, no matter how large or complex, should have more than one compression tank connection.* Multiple tanks can be used if they are piped to function as one vessel and connected to the main piping at a single point.

The second basic component of the system that must be addressed in the hydraulic analysis is the load. The load is the component that transfers thermal energy between the system and the conditioned space or the psychrometric system that conditions the space. Considering the load control from the standpoint of the hydronic system, the load is controlled (reduced from design quantities) by reducing the log mean temperature difference between the hydronic fluid and the air. This is accomplished in most systems by either reducing the flow rate of the hydronic fluid or by reducing the temperature difference between the entering fluid and the entering air (reducing the EWT in heating systems or increasing the EWT in cooling systems). Although the heat transfer rate (or load control) is a thermal analysis phenomenon, if it is accomplished by either of those two means, it affects the hydraulic analysis.

[Next month's column will address the load control impacts of the hydronic system on the hydraulic analysis.]

On this page each month, the author shares his engineering philosophy by exploring a wide range of topics, ranging from fundamentals to new frontiers, as they relate to building environmental systems. Mr. Coad is vice-president of Charles J. R. McClure & Associates and affiliate professor of mechanical engineering at Washington University, St. Louis, Mo.