RECENT ADVANCES IN HYDRONIC HEATING AND COOLING

By: J. W. Hall, Manager of Field Promotions, National-U.S. Radiator, Division of Crane Co.

INTRODUCTION

The topic of this section may bring up several questions, the first being “just what is meant by the term “Hydronics”? In 1956 a committee was formed by one of our very active industry associations to develop a name to replace and improve on the commonly used terms “wet heat” and “hot water heat”, terms which did not adequately describe the industry and which confused the public. After a good deal of work, including many consultations with a leading linguist, Dr. Bergen Evans, the word “Hydronics” was born. Of Greek derivation, Hydronics can be defined as “the science of heating and cooling with water”. In this section some of the past history of the hydronics industry will be covered, as well as some apparent trends for the future.

A second question that may occur is “of what particular interest is hydronic heating to a refrigeration service engineer?” The answer to this is that both heating and cooling have to do with the control of indoor climate which, in turn, vitally affects the health and comfort of people in general. Of the two, heating is required in most areas of our country over a greater period of the year than is cooling—some degree of warmth being needed in the home at least 60% of the year for the United States as a whole. Regardless of fluctuations in the weather throughout the long annual heating season, a quality heating system, properly installed and maintained, is indisputably the most essential item of home equipment so far as maintaining indoor comfort is concerned.

First, consider the history of residential heating practice. Most people have seen pictures of the highly artistic boilers and radiators from the period between 1889 and 1900. There was considerable progress in the period from about 1919 to 1930, with improvements in both round and square sectional boilers, the simplification of cast iron radiation and the emergence of the modern jacketed heating boiler.

The period from 1889 to 1930 was the hey-day of popularity of steam and hot water heating systems, both on commercial and residential installations. It may be recalled when, hotels and other public buildings proudly advertised that they were equipped with “steam heat” to insure the comfort of their patrons. Then came the Great Depression, bringing with it profound changes in our national way of life—including the types of heating systems that were installed. In the comparatively few large buildings that were built up to the onset of World War II, the traditional steam heating system and the increasingly popular forced circulation hot water heating system maintained their popularity. However, in the residential building field the depressed incomes of the few prospects for new homes changed the attitude regarding quality. The trend was definitely towards the use of less expensive building methods and materials, including less costly heating systems. The result was the emergence and eventual dominance of warm air heating systems in the field of residential heating. The forced circulation warm air furnace became increasingly popular, and furnace manufacturers vied with one another to produce these at lower and lower prices, made possible mainly by the use of cheaper and lighter materials.

During World War II, and for some period thereafter, the scarcity of homes and the consequent high demand enabled them to be sold readily without the buyer being inclined to be unduly critical of the materials and equipment provided in them. The results obtained with the “bargain priced” heating systems that were installed in the majority of these emergency-born houses were far from satisfactory. Mainly as the result of the price-cutting tactics that were almost universally adopted by the contractors who installed the heating plants, the old concept of the value of a heating system in a home was degraded. Whereas, before the war, it was a generally accepted rule that the cost of the heating system would represent approximately 10% of the cost of a home, these negative selling tactics have lowered this figure to less than 5% today, with a consequent decline in the performance, operating economy and useful service life of residential heating systems.
However, today’s home buyers are becoming more quality conscious—especially second and third time buyers—as a result of the unhappy experiences of those who have been saddled with sub-standard post-war homes. With improved quality as a goal, a better heating system is definitely a “must” in the modern home. Many prospects for new homes are also seriously considering the use of summer air conditioning equipment, provided either as original equipment or to be installed at a later date.

Changes in design and construction of modern homes have brought with them new problems in providing uniform and adequate heat. Figure 64F14 shows six of these commonly encountered problems:

1. Large picture windows.
2. Spread-out floor plans.
3. Finished basements.
4. Rooms over garages.
5. Split-level homes.
6. Living-sleeping areas requiring different temperatures.

The simplest and most practical solution to these difficult heating problems is the use of zoned heating systems, and it is noteworthy that hydronic heat enables this to be done more satisfactorily and with less complication than with any other type of heating system, as will be described later.

At this point let us consider briefly some of the facts concerning how the human body is heated and how this is affected by several types of typical residential heating systems. Contrary to popular belief, the function of a heating system is not to supply heat to the human body —your body manufactures its own heat with its own marvelous built-in heating system fueled by the food which you eat. Comfort actually depends upon the rate and manner in which heat escapes from the body. If it escapes too rapidly you feel chilly, if too slowly you are hot.
Furthermore, if the walls, ceiling, floor and furniture of the home are not kept at a satisfactorily high temperature, the body will send its heat out towards these colder surfaces and consequently the person will feel cold, even when the temperature of the air in the room is maintained at 75° or higher. This is illustrated in Figures 64F15A & 64F15B. The chief objective of comfort heating is to warm the cold outer walls, the floors, and especially the areas around the windows. Properly combined radiant and convected heat best achieve this. Since radiant heat rays pass from warm to cooler objects, the radiant heat loss from your body will be too great for comfort when walls are cold. Heating systems which provide inadequate radiant heat attempt to compensate by raising air temperature, but fail because the radiant heat loss still exceeds the desirable rate.

In general, heating systems can be divided into two categories — cold wall systems (in which the heat is released at points other than at outside walls) and warm wall systems (in which the heat distributors are located along the outside walls).

In considering the problem of maintaining indoor comfort during the heating season, it should be kept in mind that the greatest heat losses occur through outer walls and windows, 60 to 80% of the total loss in the case of an average residence.

Almost any heating system can generate enough heat in bulk to compensate for this loss. But unless the heat sources are properly located, and the heat of the right quality, your home cannot be comfortable. Sitting near a window under which there is no radiant heat source demonstrates this—the thermostat may read 72°, but you feel chilly.

Cold outer walls not only cause discomfort by increasing your body’s radiant heat loss, but in addition, cause drafts even though no window or door is open to admit outside air. Warm room air coming into contact with cold walls and windows is chilled and sinks to the floor. You literally wade in a pool of chilly air.

With a hydronic system the heat distributing units, such as baseboard panels, are placed along the cold outer walls and under windows. Here they warm the walls and prevent down drafts, surrounding your home with a ring of radiant warmth.

Figure 64F16 shows a typical forced warm air system of the general type that is installed in the majority of residences today, particularly in builder-constructed homes and prefabricated homes. Since the registers through which the warm air is delivered are located on inside walls and the return-air intakes on outside walls, this heating plant can be classed as the cold wall type.
Because of this characteristic of the conventional warm air system, there has been a trend towards the use of systems where the warm air registers are located at the outside walls, usually below the windows—these being known as warm air perimeter systems. Figure 64F17 shows a type often installed in basementless or "slab type" homes. Where a basement is provided, such systems are installed with elongated "diffusion type" warm air registers located beneath the windows.
Figure 64F18 shows a typical hydronics baseboard heating system. The baseboard type heat distributors extend almost completely around the entire perimeter of the home. Releasing the heat along the outer walls provides, in effect, a protective “insulating blanket” of warmed air which rises against the cold outer walls of the structure. Additional benefits are that the baseboard heat distributors warm the floor and give off comforting radiant warmth at ankle height.

*Figure 64F17*

*Typical warm-air perimeter heating system. The arrows indicate heat circulation.*
Methods of installing hydronic heating systems vary with the size and construction of the building to be heated, the type of heat distributors to be installed (whether baseboards, convectors or radiators) and other factors. Probably the most popular type used to date (especially with radiators, convectors and cast iron baseboards) is the one-pipe system. In the single circuit system, Figure 64F19, a single main runs around the perimeter of the basement ceiling, from which supply and return risers are run to each of the individual heat distributors. Usually, one of these connections is made with a “diverter tee” which has an internal scoop which directs a certain proportion of the water into the heat distributor.
Because of the savings in material cost and installation time that they provide, copper tubing and "sweat type" fittings are rapidly supplanting the use of steel pipe and screwed fittings on forced hot water heating systems. This is especially true when the increasingly popular non-ferrous type of baseboard heat distributor is used (the heating element of which consists of a copper tube with aluminum fins, which is enclosed by steel panels).
With non-ferrous baseboards, substantial savings in installation costs are achieved by using the series loop type of installation as shown in Figure 64F20. Since the baseboard heating elements serve as the main, only a limited amount of copper tubing needs to be installed to complete the installation. On small residential installations the very simple single circuit system can be used, on larger systems a double (or multiple) circuit is necessary.
Some of the savings achieved by using the series loop system are as follows:

Saves the cost of installing both a supply and return main.

Saves the cost of two run outs for each radiator.

Saves the cost of diverter tees.

Saves the cost of radiator valves.

Saves about half the usual cost of air vents.

Saves the cost of much of the work usually necessary in the basement.

Another important forward step in reducing the installation costs of residential size hydronic heating systems is the availability of automatic heating units that are completely assembled and wired at the factory. These can be supplied for either gas or oil firing, and of either cast iron or steel construction. They are usually equipped with a built-in water heater to supply domestic hot water the year round, as illustrated in Figure 64F21A. Such units are necessarily somewhat bulky and heavy to handle, but can be readily moved to the desired location by means of special handling equipment available.

![Figure 64F21A](image)

*Oil fired, factory assembled heating unit showing domestic hot water coil. Insets show tankless heater which is constructed of high-heat-transfer finned copper tubing; gas burner and oil burner.*
Already discussed have been recent trends in residential building design that have created new heating problems. A leading control manufacturer stresses the desirability of heating these homes with two or more zones. With warm air systems the use of two separate furnaces is advocated, which adds considerable complication and expense to the installation. With a hydronic heating system, two or more zones can be readily served by a single boiler through the use of suitable controls and accessories.

In the past it has been usual practice in the case of zoned hydronic systems to use a separate water circulator (with relay to operate it) for each zone served. However, inexpensive and reliable individual zone valves (each controlled by its own room thermostat) have recently been made available that have materially reduced the cost of multi-zone hydronic systems.

Simplification of piping (and consequent saving in pipe, fittings and labor) may be achieved by elimination of three separate return lines.

The use of zone valves (which are of the low voltage type) virtually eliminates the use of expensive line voltage wiring by the substitution of low voltage circuits.

In addition to steps taken to reduce the cost of boilers and heat distributors, considerable study has been devoted to reducing the cost of installing hydronic systems. Noteworthy among these efforts has been the investigation that was conducted at the Research Home of the Institute of Boiler and Radiator Manufacturers on the “Small Pipe Hydronic System”. The results obtained have been published in a report issued by the University of Illinois. This report states that by the use of smaller-than-usual diameter copper tubing, of a soft type (which is easy to bend, thereby eliminating the use of many elbows and reducing the resistance to the flow of water), it has been found possible to install a cast iron baseboard heating system with a sizable reduction in costs of pipe, fittings and labor over that required to install an equivalent system by conventional methods.

Pipe sizes used over the years on hot water heating systems have ranged from the 3” mains and 1-1/4” radiator branches used on the 1900 vintage gravity circulation system to the 1/2” mains and 1/4” radiator branches used on the 1958-1960 small pipe forced circulation system just described.

A summary of the savings realized is shown in Figure 64F22B. Note that these total up to a saving of 48% of that of a conventionally installed system. Incidentally, it was reported that this system gave highly satisfactory results during all of the comparatively severe heating season.

<table>
<thead>
<tr>
<th></th>
<th>SMALL-PIPE SYSTEM</th>
<th>CONVENTIONAL SYSTEM</th>
<th>SAVINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe</strong></td>
<td>323 feet</td>
<td>341 feet</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Fittings</strong></td>
<td>85 (number)</td>
<td>159 (number)</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Labor</strong></td>
<td>24 hours*</td>
<td>63 hours</td>
<td>60%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$171.73</td>
<td>$324.75</td>
<td>48%</td>
</tr>
</tbody>
</table>

*Estimated for new construction by installer of system in IBR Research Home.

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Figure 64F22B
Another unusual type of installation that created considerable interest this year was made on a builder operation in Topeka, Kansas, where a non-ferrous baseboard heating system was installed on the job by three men in only 52 minutes—being witnessed by more than 50 contractors. While several additional hours of prefabrication in the shop were also involved, this type of hydronic system was installed in all of the homes in this large development at a cost comparable with that of the usual type of warm air system.

Only simple tools are required for drilling of holes, placement of baseboard units, and attachment to the wall when installing prefabricated baseboard units. The connections to the main and boiler, using a special type of flexible connector, completes the assembly to the boiler.

Up to this point we have mainly discussed the advantages of various types of modern hydronic heating systems. When considering expense, bear in mind that a heating boiler is an investment that can be expected to serve its owner year after year for the same period in which he would have worn out approximately 15 automobiles.

The high quality economical performance and long life of modern hydronic systems have not been achieved by accident. There are a number of industry associations that are actively engaged in encouraging improvement of the products used in such systems, as well as in disseminating education and publicity concerning them.

The Institute of Boiler and Radiator Manufacturers is a long-established organization composed of members (who are manufacturers of boilers, radiators, baseboard, convectors and commercial finned tube radiation) and associate members (who are manufacturers of water heaters valves, controls and other accessory equipment). The major projects of the Institute are:

1. **To develop codes for determining performance of equipment.** They have a code which covers the testing and rating of cast iron heating boilers. (The testing and rating of Code-constructed and Code-rated steel heating boilers is covered by a similar code issued by the Steel Boiler Institute.) Similar I=B=R Codes are in effect for testing and rating of baseboards, commercial finned tube radiation and water heaters.

2. **To conduct research investigations to find the most efficient procedures for designing and installing heating equipment.** For this purpose an I=B=R Research Home was established at the University of Illinois in 1940. An important report on research on baseboard heating was responsible to a large extent for the growing popularity of this type of hydronic system. In 1957 an I=B=R Laboratory was also established at Urbana, Illinois to determine accurate and dependable ratings on baseboards and commercial finned tube radiation. In 1959 a new tri-level Research House was dedicated at the University of Illinois to permit further research to be conducted using a house representative of modern construction (with large glass areas, split level arrangement and provision for snow melting on walks and driveways).

3. **To publish literature which embodies the combined results of research and practical experience so that hydronic heating systems may be calculated, designed and installed with the maximum of comfort and the minimum of cost.**

4. **To conduct three-day I=B=R heating and cooling schools in cities throughout the country to encourage heating contractors and wholesalers to install more efficient and economical hydronic heating systems.**

5. **To develop a better understanding and appreciation of the comfort qualities of hydronic systems.** Supplementing the aims and activities of the I=B=R is another energetic industry organization known as the national Better Heating-Cooling Council. BHC is a constitutional, democratically run trade association whose members are leading manufacturers of hydronic heating and cooling systems. The sole and exclusive purpose of BHC, a marketing organization, is to promote the sale of hydronic heating and cooling equipment. One of the most important and successful of the activities of the Better Heating-Cooling Council is the establishment of Local Councils in some of the principal cities of the country to promote hydronics at the local level.
Some of the additional activities of the BHC includes providing a Speakers Bureau, supplying a Builder Sales Kit, maintaining an exhibit at the Housing Center in Washington, making available a number of helpful publications (including a promotional movie), obtaining publicity in magazines, newspapers and other publications and participating in an annual Women’s Conference on Housing.

The promotional activities of the I=B=R and BHC are supplemented by the efforts of many individual manufacturers in the industry.

So much for hydronic heating systems. Since most service engineers are active in air conditioning, some of the cooling systems that are used to supplement hydronic heating systems will be of interest.

First of all, it must be remembered that to do an effective cooling job requires the circulation of approximately 2-1/2 times as much air as is needed to properly heat the same residence with a warm air heating system. In many installations the duct sizes and blower capacity are such that no reserve exists to take care of the additional air handling capacity required for adequate cooling. The result is that air conditioning can be added as simply and inexpensively to a hydronic heating system as it can to many of the other systems.

Figure 64F25A shows a hydronic system which uses fan-equipped heating and cooling convectors, combined with a heating boiler and a water chiller.

![Fan-equipped Heating and Cooling Convectors System](image)

Figure 64F25A

Sketch shows combination heating-cooling fan-equipped convector units in each room of house. The units are hooked up to a piping system which circulates hot water during the winter supplied by the boiler and chilled water during the summer.
supplied by the water chiller each operating independently. A one or two pipe system may be used depending upon the recommendations of the manufacturer. Filtration, circulation and dehumidification of cooled air is provided. These convector units can be used for heating alone, in which case only a home heating boiler would be used. The chiller can be added at any time provided the piping is properly insulated.

Figure 64F25B shows a system using baseboards, radiators or convectors for heating and self-contained room units for cooling.

Baseboard, Radiator or Convector System with Self-Contained Room Cooling Units.

In this split system, baseboards or any other type of radiation are hooked up to the boiler for heating, while self-contained room units (console or cabinet) provide summer cooling. Each self-contained room unit has cooling, filtering, ventilating and dehumidifying apparatus. The self-contained cooling units may be installed when the house is built or any time later that the owner elects. Certain models may be built into a side wall or concealed in a book shelf or closet space.

Self-contained cooling units are also available equipped with heating coils which may be connected to the central heating system. Such units may be used to replace radiators in a presently existing system.
Figure 64F26A illustrates a system using baseboards, radiators or convectors for heating and a self-contained central unit for cooling.

In this split system, baseboards or any other type of radiation are hooked up to the boiler for heating. For cooling, a self-contained cooling unit may be installed in the attic or in a dropped ceiling chamber and connected by short duct work to ceiling diffusers or high wall registers located in rooms. Other locations may be preferred and a popular feature of certain designs provides for a remote condenser to be placed outdoors.
The system illustrated in Figure 64F26B uses baseboard, radiators or convectors for heating and fan-equipped units and a water chiller for cooling.

In this split system, baseboards or any other type of radiation are hooked up to the boiler for heating. For cooling, a water chiller supplies cold water to fan-equipped cooling coil units, connected to simple duct work located either in a dropped ceiling or in attic crawl space. Cool, filtered, dehumidified air is fed from this duct work into surrounding rooms through high wall registers or ceiling diffusers. Duct work can sometimes be eliminated depending upon house design.

As a final thought, remember some of the things that have been mentioned in this section concerning the advantages of a modern hydronic heating system. Don’t forget that “good living begins with good heating and includes air conditioning”.

Baseboard, Radiator or Convectors System with Chiller and Fan-equipped Cooling Coil Units.