AIRTITE™
Radiant Ceiling Systems

MetalWorks™ Airtite™ radiant ceiling systems circulate hot or cold water through concealed copper tubing, providing sustainable heating and cooling with minimal air ventilation requirements. Hydronic radiant ceiling systems heat and cool your space more efficiently than traditional heating and cooling systems, bringing comfort to all occupants. They can be incorporated in various ceiling solutions including lay-in and torsion spring, providing unrestricted floor space and layout flexibility.
AWARD WINNING PRODUCTION

Hydronic radiant ceilings and chilled beams perform efficiently while adding beauty and drama for ovation-worthy interiors.
BASIC CONCEPT OF RADIANT ENERGY
As radiant energy travels through the air and reaches objects, it is absorbed and is then converted into heat. This is not unlike the sun that sends out radiant energy in straight lines until it reaches a solid object where it is absorbed and warms that object.

All surfaces in a room receive and reradiate energy so that the floor is kept as warm as other surfaces. Panels installed in the perimeter of the ceiling provide a warm, draft-free environment. Radiant heat, unlike convection heat, does not rise.

THE BEGINNINGS OF RADIANT HEAT
Radiant heat got its start at the time of the Roman Empire. Many buildings at that time used underground tunnels where hot gases from fires were redirected into hollow masonry walls. Occupants were then warmed by radiant heat from the walls.

In the 1800s, hot water pipes in floors and ceilings were employed in Europe to heat castles and palaces.

These designs were comfortable, but not efficient due to poor conduction of both walls and floors. In the last century both hot water piping and electric cables were imbedded in floors and ceilings to radiantly heat homes and buildings. The comfort levels were excellent but the control of these systems was difficult due to the large thermal mass of the ceilings and floors having slow response times.

RADIANT ENERGY COMES TO AMERICA
In 1950, Airtite Contractors supplied and installed the first commercial aluminum radiant heating and cooling ceiling in the United States. This lightweight aluminum system had greater heat conduction to the panel surface with increased radiant output than previous systems. The
lighter panels provided quicker response to the temperature changes thus overcoming the slower response of older systems.

In the 1960s, technology was developed to metallurgically bond copper tubing to the aluminum ceiling panels.

In the early 1970s, extruded radiant ceiling panels were developed. Copper tubes were mechanically inserted into the extrusion’s heat transfer saddle. This new panel design increased panel output as well as lowered manufacturing and installation costs.

In 2014, the next generation of radiant heating was introduced which incorporated convection technology in the new AR-L and AR-C systems. We have continued to provide innovative designs including our integral linear air bar diffuser extruded panel which provides excellent air-side performance with increased output.
There are three basic types of heat transfer: conduction, convection, and radiation.

Radiant energy is the transmission of electromagnetic waves that travel in straight lines and are absorbed, heating objects that they strike. These objects reradiate to other colder surfaces.

The best example of radiant heat is provided by the sun. On a cold but sunny day, a person standing outside will absorb the sun’s radiant energy and will feel the warmth. However, the moment a cloud blocks the sun’s radiation and the body can no longer absorb the sun’s heat, that person will immediately feel cool, even though the air temperature has not varied.

The ability of a surface to emit or absorb radiant energy is known as emissivity. It is expressed as a decimal ratio of its ability to radiate and is compared to that of a “blackbody”. Blackbody radiation has an emissivity of 1.00. Practically, a surface that emits well will absorb well. Unpainted aluminum has a low emissivity ratio but painted aluminum surfaces will have an emissivity ratio from .91 to .96, depending on the type of paint. Therefore radiant panels that are made of extruded or formed aluminum must be painted to provide good radiant performance.

Radiant ceiling panels have surface temperatures that transmit radiant energy in the infrared portion of the spectrum to which glass is opaque. Radiant energy travels in straight lines heating solid objects such as walls, floors, furniture, people, etc. In turn, all these surfaces in the space reradiate to one another until equilibrium is attained.

ASHRAE defines thermal comfort as “that condition of mind which expresses satisfaction with the thermal environment.” The areas of a heating system that can affect human comfort are: room air temperature, air velocities, humidity, and mean radiant temperature (MRT) of surroundings. Over the years, studies have been done indicating that MRT strongly influences the feeling of comfort. Perimeter walls with significant amounts of glass will have much lower surface temperatures than the air temperature of the space. Forced convective air reheat systems are not able to effectively counteract discomfort due to large radiant losses of occupants to the outside wall.

In conclusion, the principal benefits of radiant heating in the ceiling are:

- Mean radiant temperature is achieved since all solid objects absorb radiant energy and re-release the energy until equilibrium is reached.
- Downdrafts from cold outside walls are reduced.
- The side of the human body adjacent to the outside wall receives direct radiant energy, offsetting heat loss to that surface.
**BENEFITS OF HYDRONIC RADIANT HEATING AND COOLING PANELS**

**OPERATING COSTS**
Hydronic systems generally require 20% of the energy used by all air systems. Recent studies by the New Building Institute on buildings remodeled using radiant heating and cooling systems have shown that energy efficiencies of 31% to 32% can be obtained. Since there are no moving parts in the radiant system, maintenance costs are minimal.

**SUPERIOR COMFORT**
Because surfaces are uniformly heated or cooled, occupant comfort is achieved at lower winter design temperatures and higher summer design temperatures.

**ENERGY CONSUMPTION**
Energy consumption is reduced by using hydronic heating/cooling and design temperatures as described above.

**AESTHETICS**
Panels provide excellent architectural appearance with a large array of existing and new design creations.

**FLEXIBILITY**
Hydronic radiant panels can be incorporated in various ceiling types: lay-in, drywall, soffits, and exposed structure ceilings, providing unrestricted floor space.

**DURABILITY**
Ceiling panels minimize the possibility of being scratched, bumped, or dented.

**CONTROL RESPONSE**
Efficient, lightweight, radiant panels will heat up and cool down quickly.

**INDOOR AIR QUALITY**
High-quality air filtration can be achieved due to reduced make-up air quantities (100% outside air) needed for ventilation and dehumidification.

**SPACE REQUIREMENT**
For cooling, slab-to-slab height can be reduced, resulting in smaller ducts, reduced plenum heights, and lower air flows. Mechanical equipment rooms are smaller and the radiant system is located in the ceiling giving full utilization of floor space.

**CONSTRUCTION SAVINGS**
Mechanical construction costs are reduced by utilizing smaller air handlers, smaller duct sizes, and elimination of VAV systems. In addition, reduced slab-to-slab heights are realized.

**LIFE CYCLE COSTS**
Radiant systems previously evaluated against other typical HVAC systems have shown to have a life cycle cost advantage.

**NOISE CONTROL**
Perforated panels with insulation can provide noise reduction levels that are lower than standard acoustical ceilings.

**GREEN BUILDING DESIGN**
A combined radiant panel cooling system designed with a dedicated outdoor air mechanical system offers the potential to earn LEED® certification points. Radiant heating and cooling systems can help with Living Building Challenge™ certification as well as Passive House certification.
The basic equation for radiation exchange is the Stefan-Boltzmann equation. This equation may also be expressed as:

\[ Q_r = 0.1713 F_a F_e \left[ \left( \frac{T_r}{100} \right)^4 - \left( \frac{T_p}{100} \right)^4 \right] \]

- **Q<sub>r</sub>** = Heat transferred by radiation, BTU per (hour) (sq. ft.)
- **T<sub>r</sub>** = Mean radiant temperature of unheated surface, Fahrenheit, absolute
- **T<sub>p</sub>** = Average surface temperature of heated panel, Fahrenheit, absolute
- **F<sub>a</sub>** = The configuration factor (dimensionless)
- **F<sub>e</sub>** = The emissivity factor (dimensionless)
- **0.1713** = Stefan-Boltzmann radiation constant, BTU per (hour) (sq. ft.)

[Rankin (absolute Fahrenheit) temperature to the fourth power]
The design of a radiant cooling/heating system should follow the usual guidelines of an air-water system. To create such a system, we need to find the following:

1. Establish inside room design dry bulb temperature, relative humidity, and dew point
2. Calculate the room’s internal loads (sensible and latent)
3. Calculate air side room requirements
4. Select mean water temperature
5. Determine panel area required
6. Check panel capacity for heating
7. Determine flow and pressure drop

**DESIGN EXAMPLE:**
Single Patient Hospital Room
Outside design conditions:
Summer: 95°F Dry Bulb, 78°F Wet Bulb
Winter: -10°F Dry Bulb

1. Establish inside room design conditions and parameters
   Room dimensions: 12' x 12' (144 SF)
   Glass: 25% of outside wall
   Toilet dimensions: 6' x 8' x 8'
   Inside design conditions:
   76°F Dry Bulb
   Relative humidity: 45%
   Dew point: 53°F
   Absolute humidity: 60 GR/LB of dry air
   Primary chilled water temp: 42°F

2. Internal Loads
   Sensible Load:
   Summer: 5200 BTUH gain
   Winter: 6800 BTUH loss
   Latent Load: 580 BTUH gain (people infiltration)

3. Calculate air side room requirements
   Air quantity must meet minimum code/design requirements.
   The air must handle the latent load and CFM/SF must be adequate for comfort and odor removal.

**Code Requirement**
Code requires 4 AC (air changes)/HR of outside air be supplied to the room and 10 AC/HR be exhausted from the toilets.

**Supply CFM**
\[
\text{Cfm} = \frac{144 \text{ SF} \times 9 \text{ ft. Ceiling} \times 4 \text{AC}}{60 \text{ min/hr}} = 86.4 \text{ CFM}
\]

**Toilet exhaust**
\[
\text{Toilet exhaust} = \frac{6' \times 8' \times 8' \times 10 \text{ AC}}{60 \text{ min/hr}} = 64 \text{ CFM}
\]

**Soiled Linen Cabinet Exhaust**
15 CFM  Total Exhaust = 79 CFM
For good air motion, use 0.6 CFM.
144 SF x .6 CFM/SF = 86.4 CFM
Code and comfort calculations indicate 86.4 CFM.
Design at 90 CFM

**Calculate Latent Capacity**
The internal moisture pickup with 90 CFM

\[
\text{IMP} = \text{Internal latent load} \times \frac{0.68}{\text{CFM conditioned}}
\]

\[
\text{IMP} = \frac{580 \text{ BTUH}}{90 \text{ CFM} \times 0.68} = 9.5 \text{ GR/LB}
\]

**Use 10 GR/LB** (grains of water/pound)
Determine the required delivered air conditioning to offset this 10 GR/LB pickup.
Grains maintained – Grains pick up =
Grains to be delivered
60 GR/LB – 10 GR/LB = 50 GR/LB
maximum in delivered air.

Referring to a psychrometric chart, air entering the air handling unit in the summer at 95°F DB, 78°F WB, has .118 GR/LB. Air leaving the unit has been cooled and dehumidified, leaving the coil at 52°F DB and 50°F WB having 50 GR/LB, allowing for ample latent load pickup. Air will be delivered to the room at 54-55°F.
4. Select the mean water temperature
The secondary supplied chilled water temperature to the
ceiling should be a minimum of 1° above the design dew
point of the room panels:

Room dew point of 53°F + 1°F = 54°F

**Supply Water Temp**
Normally a 4-6°F water temperature rise (WTR)
is used. For this example use a 5°F WTR.

\[ MWT = \text{Supply Water Temp} + .5 \times \text{design WTR} \]
\[ MWT = 55°F + 2.5°F = 57.5°F \]

5. Determine the panel area required
Refer to the Cooling Performance Table.
Room Air Temperature – MWT
76°F Dry Bulb – 57.5°F = 18.5°F difference

At 25% glass from the performance chart with an 18.5
difference panel capacity for above conditions = 44 BTUH/
SF (sensible cooling)

**Cooling**
Required panel cooling =
Total Sensible Cooling – Air Sensible Cooling

Sensible Cooling w/Air = Conditioned
\[ \text{CFM} \times 1.08° \times (\text{Room Air °F} – \text{Supply Air °F}) \]

\[ \frac{90 \text{ CFM} \times 1.08° \times (76 – 55)}{13.34} = 2041 \text{ BTUH} \]

Required cooling =
5200 BTUH – 2041 BTUH = 3159 BTUH

Panel area required =
\[ \frac{3159 \text{ BTUH}}{44 \text{ BTUH/SF}} = 71.8 \text{ SF} \]

6. Check panel capacity for heating
The radiant panel must pick up the winter design load plus
the air side reheat.

Air side reheat = 90 CFM \times 1.08° \times (76-55) = 2041 BTUH
Total load = 6800 BTUH + 2041 BTUH = 8841 BTUH

According to perimeter and interior performance tables,
a 150°F MWT is adequate for heating.

7. Determine the water flow (GPM) and pressure drop
(ft of water)
Refer to Pressure Drop Table for design data on pressure
drops for heating and cooling.

\[ \text{GPM} = \frac{\text{Total BTU for panels}}{500 \times \text{Water Temp. Difference}} \]
\[ \frac{500}{500 \times 5°F} = 1.26 \text{ GPM} \]
Use 1.3 GPM

Heating GPM = \[ \frac{8841 \text{ BTUH}}{500 \times 20°F} = .89 \text{ GPM} \]
Use 1.0 GPM

8. Pressure loss for copper tubing
Select the proper table for the type of pipe. Type K copper
pipe has the thickest wall and highest pressure ratings of
the common copper tubing types. In order of wall thickness,
common copper tubing types are Type M (thinnest), Type L,
and Type K (thickest).

Type L is commonly used for household plumbing. If you don’t
know what Type the pipe is, assume it is the thickest Type K.
Locate the proper column on the table for the pipe size.

Read down the column to the row for the flow rate (GPM)
in the pipe section. You will find a PSI loss value (given as
PSI/100).

Multiply the PSI loss value shown by the total length of the
pipe section, then divide the product by 100. (PSI loss on
these tables is given in PSI per 100 feet of pipe.)

Value \times \text{Length} / 100 = \text{PSI loss}

See next pages for water pressure loss in
copper tubing and pressure loss in metric tubing
(tables from Geberit Mapress Stainless Steel).
PRESSURE LOSS OF WATER DUE TO FRICTION IN TYPES K, L, AND M COPPER TUBE

(PSI PER LINEAR FOOT OF TUBE)

COPPER TUBE DIAMETER

<table>
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<tr>
<th>FLOW GPM</th>
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<th>1/2&quot;</th>
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<tr>
<td></td>
<td>K</td>
<td>L</td>
</tr>
<tr>
<td>1</td>
<td>0.036</td>
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<td>5</td>
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</table>

NOTES

1. Fluid velocities in excess of 5-8 feet per second are not recommended.
2. Friction loss values shown are for the flow rates that do not exceed a velocity of 8 feet per second.
3. Table based on the Hazen-Williams formula below:
   \[ P = \frac{452Q^{1.85}}{C^{1.85}}d^{4.87} \]
4. Calculations are theoretical

Where:
- \( P \) = friction loss, PSI per linear foot
- \( Q \) = flow, GPM
- \( d \) = average I.D. in inches
- \( C \) = constant, 150

\[ \text{MetalWorks™ Airtite™ AR-B radiant panels incorporated and Optima® Vector® 4' x 4' panels; Pomona College, Claremont, CA} \]
PRESSURE LOSS IN METRIC TUBING:

Pipe pressure gradient due to friction $R$ and calculated flow velocity $v$ as a function of peak flow rate $V_p$ at $T = 10^\circ$C

Copper pipes to DVGW Code of Practice GW 392/DIN EN 1057

$k = 0.0015$ mm

<table>
<thead>
<tr>
<th>NOMINAL SIZE</th>
<th>PEAK FLOW RATE $V_p$ (LITERS/SEC.)</th>
<th>$R$ (MBAR/M)</th>
<th>$V$ (M/S)</th>
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<td>D X T (MM)</td>
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<td>ID (MM)</td>
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<td>15 X 1.0</td>
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<td>13 DN12</td>
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<td>0.05</td>
<td>2.2</td>
<td>0.38</td>
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<tr>
<td>0.06</td>
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<td>0.07</td>
<td>4.0</td>
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<td>0.08</td>
<td>5.0</td>
<td>0.60</td>
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<td>0.09</td>
<td>6.1</td>
<td>0.68</td>
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<td>0.10</td>
<td>7.3</td>
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<td>0.15</td>
<td>14.8</td>
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<tr>
<td>0.20</td>
<td>24.5</td>
<td>1.5</td>
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<tr>
<td>0.25</td>
<td>36.2</td>
<td>1.9</td>
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<tr>
<td>0.30</td>
<td>49.9</td>
<td>2.3</td>
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<td>65.6</td>
<td>2.6</td>
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<td>0.40</td>
<td>83.1</td>
<td>3.0</td>
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<tr>
<td>0.45</td>
<td>102.4</td>
<td>3.4</td>
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<tr>
<td>0.50</td>
<td>123.6</td>
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<tr>
<td>0.55</td>
<td>146.5</td>
<td>4.1</td>
<td></td>
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<tr>
<td>0.60</td>
<td>171.1</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>0.65</td>
<td>197.5</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>0.70</td>
<td>225.5</td>
<td>5.3</td>
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</tbody>
</table>

NOTE: Calculations are theoretical
Radiant systems can be controlled the same as any perimeter hot water heating system. Radiant panels operate best with indoor/outdoor water supply temperature reset. This allows the radiant output to most closely match the perimeter load at design flow. When modulating control valves are used with a 20°F delta temperature, a 50% reduction in flow reduces the M.W.T. by 10°F with a corresponding 10% reduction in panel output.

Many systems supplied and installed have successfully operated with constant water flow and variable water temperature as shown in 1. In this arrangement the VAV box operating with supply economizer air modulates to meet the thermostat set point. The addition of a hydronic modulating valve as shown in 2 adds further control.

Schemes 3 & 4 utilize hydronic reheat coils in the VAV boxes. The control sequence must be that the radiant panels heat first and if additional heat is required then airside reheat is provided. If room temperatures rise above the thermostat set point, the flow to the airside hydronic reheat coil would first modulate down and lastly the water flow to the radiant panels. In all cases the radiant panel must be the first on providing heat and the last off.

Solenoid valves (on/off) are not recommended because they cycle, not allowing continuous radiant energy transfer to the walls, floors, furniture, and occupants for the best level of comfort.

NOTE: Only water-side control shown. VAV BOX airside control not shown.

1. Radiant Panel
   VAV Box
   Constant flow using indoor/outdoor reset for water temperature. No reheat in the air.

2. Radiant Panel
   VAV Box
   Variable flow using indoor/outdoor reset for water temperature. No reheat in the air.

3. Radiant Panel
   VAV Box
   Variable flow using indoor/outdoor reset for water temperature. Reheat in the air with two independent control valves. Sequence of operation is radiant panels first and only, then reheat in the air.
   This valve can be eliminated if variable temperature water is provided, based on an indoor/outdoor reset.

4. Radiant Panel
   VAV Box
   Variable flow using indoor/outdoor reset for water temperature. Reheat in the air with 3-way modulating valve. Sequence of operation is radiant panels first and only, then reheat in the air.
The AR-X hydronic extruded aluminum radiant panel is a well-tested, proven design. The panel has a very attractive fluted face and a highly efficient heat transfer saddle on the back of the panel. Copper tubes are mechanically reformed within the saddle providing superior tube contact. The panel efficiency is over 90% of a full-flooded hollow panel of the same width. Panels with larger tube diameters have been comparatively tested against this design and have shown no increase in performance. Panel widths from 8 to 24 inches in standard ceiling heights have provided excellent human comfort long associated with radiant systems.

A perimeter hot water radiant ceiling eliminates downdrafts and increases exterior wall surface temperatures providing a very comfortable thermal environment especially with perimeter walls having large glazed areas.

The unique, attractive design becomes an aesthetic enhancement to the overall architectural interior design while providing increased space utilization, flexibility, and lower first-installed costs. The elimination of perimeter baseboard with expensive architectural covers and other floor-mounted heating systems provide flexibility in design, full utilization of floor space, and unrestricted furniture location.

The MetalWorks™ Airtite™ AR-X radiant extruded aluminum panel can easily be integrated in lay-in ceilings, drywall ceilings, soffit rises, or drops—and no ceilings at all. This system lends itself to either new construction or retrofits.

Retrofits can be accomplished without shutting down multiple floors or large areas of the building that would cause loss of revenue due to interruption of occupancy.

Airtite AR-X extruded radiant panels have a higher STC rating than most acoustical ceilings minimizing sound transmission.

As with any hydronic system, fuel savings are realized through the highly efficient use of energy. Rising energy costs make this system very competitive in fuel savings, especially because comfort levels are excellent at air temperatures 3-4°F lower (thermostat set point) than conventional systems. The panels themselves are maintenance-free and lend themselves to lower life-cycle costs.

Perimeter radiant systems have been effectively used for over 50 years and have become a system of choice by both architects and engineers.
STANDARD AR-X EXTRUDED SECTIONS

ASSEMBLED RADIANT PANEL SECTIONS

Ceiling Opening Schedule
The radiant panels shown on drawings are stock lengths and are to be field-cut to fit the job site conditions. These conditions include miters, notches, etc. Consult the chart below for ceiling width opening requirements.

<table>
<thead>
<tr>
<th>NOMINAL PANEL WIDTH</th>
<th>CEILING OPENING WIDTH</th>
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<tbody>
<tr>
<td>12&quot;</td>
<td>12-1/4&quot;</td>
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<tr>
<td>18&quot;</td>
<td>18-3/16&quot;</td>
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<tr>
<td>24&quot;</td>
<td>24-1/8&quot;</td>
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<td>36&quot;</td>
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EXPLODED PANEL ASSEMBLY

Center Clips

Edge Clip

Cross Channel

Edge Clip

ASSEMBLED PANEL
<table>
<thead>
<tr>
<th>ROOM CONDITIONS AND PERCENT GLASS</th>
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<tbody>
<tr>
<td>INTERIOR ROOM</td>
<td>NO GLASS IN SUN OR FULLY SHADED GLASS AND WALL</td>
<td>25% CLEAR EXTERIOR WALL IN SUN</td>
<td>50% CLEAR EXTERIOR WALL IN SUN</td>
<td>75% CLEAR EXTERIOR WALL IN SUN</td>
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<tr>
<td>10</td>
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</tr>
<tr>
<td>28</td>
<td>49</td>
<td>55</td>
<td>60</td>
<td>65</td>
</tr>
</tbody>
</table>

Performance shown in BTUH/SF of Panel
NOTE: Calculations are theoretical
Total certified output shown is per lineal foot of panel at the perimeter of the space. Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T.), with one inch of 3/4” PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output (approximately 10-15%).
TYPICAL AR-X PANEL DESIGN
CONNECTION DETAILS

Standard panel tubing size is 0.544" OD – 0.504" ID ALLOY 122 COPPER and is rated at 400 P.S.I.G.

A Connection to Airtite panel tubing

1/2" O.D. soft copper tubing
No fitting required.

B Airtite return U-bend

1/2" O.D. return U-bend
No fittings required.

C Airtite 360° interconnect

For odd number tubing passes, hook-up supply, and return at opposite ends.
Long zones fed from risers.

Odd number tubing passes; opposite end connections

- 1/2” O.D. soft copper tubing (typical)
- Soldered connections. No fitting required.

Even number tubing passes; same end connections
- Maximum single-panel length = 16’
- Refer to architectural details for typical sections

Ceiling cross-tee molding

- For odd number tubing passes, hook-up supply and return at opposite ends.

1/2” O.D. soft copper tubing (typical)

- Parallel flow in even pass MetalWorks™ Airtite™ panels reduces pressure drop for long zones.

Airtite™ 360° interconnect

Return U-bend

- Refer to architectural details for typical sections

HWR
HWS

HWR
HWS
DESIGN PROCEDURE
The design of a radiant ceiling panel heating system should follow the usual guidelines of a closed water system. To design such a system, we need to find the following:

1. Calculate the heat loss per zone or room.
2. Determine the panel width.
3. Determine the panel layout and water flow.
4. Calculate the water pressure drop based upon piping arrangement.

DESIGN EXAMPLE: RECTANGULAR BUILDING
Given conditions:
- 100 ft. rectangular building
- 12 ft. floor-to-floor
- Inside design = 72°F Dry Bulb
- Supply Water Temp = 200°F
- Return Water Temp = 180°F
- Heat Loss for each floor = 170,000 BTUH
- Assume a 60 LF zone

Design A

1. Calculate the perimeter heat loss per lineal ft. and heat loss per zone.

   \[
   \text{Total Load} = \frac{170,000 \text{ BTUH}}{500 \text{ LF}} = 340 \text{ BTUH/LF}
   \]

   For 60 LF zone = 340 BTUH/LF x 60 LF = 20,400 BTUH

2. Determine Panel Width.

   From the performance tables, a 16"-wide 4-tube panel at 190°F MWT has an output of 343 BTUH/LF.

3. Determine panel layout and water flow.

   Based on either room size or zone length, panel lengths range from 8 LF to 16 LF. Therefore, a 60-ft. zone (circuit) without perimeter walls would have five @ 12 LF panels.

   \[
   \text{GPM} = \frac{\text{Total BTUH}}{500 \times \text{water temp. drop °F}}
   \]

   \[
   \text{GPM} = \frac{60 \text{ LF} \times 340 \text{ BTUH/LF}}{500 \times 20°F} = 2.04
   \]

4. Calculate the water pressure drop based upon piping arrangement.

   For this example, a 16"-wide 4-tube panel would have two parallel circuits at 1.02 GPM/each. Calculate the total linear foot of panel tubing.

   \[
   \text{LF of tubing} = 2 \text{ crts} \times 5 \text{ pns} \times 12 \text{ LF/section length} = 120 \text{ LF of panel tube}
   \]

   Each interconnect is equal to 1.5 LF of tube. Therefore 8 interconnects = 12 LF

   Total = 120 LF + 12 LF = 132 LF of tube.

   Per the pressure drop table at 1.0 GPM shows 3.26 ft. of W.P.D per 100 ft. of tube. Total pressure drop for this circuit:

   \[
   \frac{132 \times 3.26}{100} = 4.30 \text{ ft. of water}
   \]
Design B

Using the same example, if panels were between columns and there were six columns in the zone at 10" each, the load per LF of panel would increase.

1. Calculate the perimeter heat loss per lineal ft. and heat loss per zone.
   \[
   \text{Heat loss/LF of panel} = \frac{26,250 \text{ BTUH}}{55 \text{ LF}} = 371 \text{ BTUH/LF}
   \]

2. Determine Panel Width.
   From the performance tables, an 18 in. wide 4-tube panel at 90°F MWT has an output of 378 BTUH/LF.

3. Determine panel layout and water flow.
   This panel layout is as described below with the same GPM = 1.0 GPM

4. Calculate the water pressure drop based upon piping arrangement.
   \[
   \text{LF of tubing} = 2 \times 11 \text{ LF/panel} \times 5 \text{ panel sections} = 110 \text{ LF}
   \]
   \[
   \text{LF of 3/8 in. copper} = 10 \text{ LF/col.} \times 4 \text{ cols.} = 40 \text{ LF}
   \]
   Per the pressure drop table at 1.0 GPM shows 3.26 ft. of W.P.D per 100 ft. of tube.
   Pressure drop for panel tube on this circuit:
   \[
   110 \times 3.26 = 3.59 \text{ ft. of water}
   \]
   Per the pressure drop table for 3/8” L copper, at 1.0 GPM shows 7.07 ft. of W.P.D per 100 ft. of tube.
   Pressure drop for 3/8 in. copper:
   \[
   40 \times 7.07 = 2.82 \text{ ft. of water}
   \]
   Total pressure drop = 3.59 + 2.82 = 6.41 ft. of water
AR-D panels are a product which consists of a linear air bar diffuser integrated into an extruded aluminum radiant panel. This combination of air diffuser and radiant panel makes for a narrower, more aesthetic assembly, utilizing the sides of the radiant panel for the vertical sides of the diffuser. This unique assembly lends itself to longer, continuous extruded air bar/radiant panels, which in many cases extend wall-to-wall without joints. The combination increases the delivered air temperature and the heat output from the panel. There can be as much as a 35% increase in total heating capacity. The pattern controller can be located anywhere along the air slot with supply plenums installed directly above the diffuser section. Blank-offs are used where there is no diffuser giving a continuous slot appearance.

The integral air pattern controllers can be 12" to 60" long and will allow the airstream to be vectored for left, right, or vertical airflow distribution. As with other extruded radiant panels, the design is similar to AR-X systems, having the same piping advantages and flexibility. For radiant panel design, refer to the extruded design procedure outlined in the AR-X extruded panel section.

In conclusion, this combined product takes up less space, provides better comfort, and enhances the appearance of the ceiling. This combination diffuser panel can be provided and installed at lower costs than separate heating and linear air diffuser systems.

AR-D
Integral Diffuser Panel
AR-D DIFFUSER PANEL
WITH CENTER SLOTTED AIR DIFFUSER

Standard finish is white.
Nominal sizes with centered diffuser: 12", 20", 22", 24"

Integral pattern controllers are on 48" or 24" centers, which allow the air stream to be vectored left and right for horizontal and vertical air flow.
AR-D DIFFUSER PANEL
WITH OFFSET SLOTTED AIR DIFFUSER

Typical installation

Batt Insulation
Acoustical Ceiling Tile
Exposed T-bar Grid
Air Slot

MetalWorks™ Airtite™ Radiant Panel

Hanger Wire
Plenum Diffuser Assembly by Sheet Metal Contractor
Height: 10" minimum
Nominal Lengths: 24", 36", 48" & 60"

Plenum Inlet
8" Dia. minimum

3.82"
1.50"
5.20"
11.90"

4", 5", or 6"
4", 5", or 6"

Standard finish is white.

Integral pattern controllers are on 48" or 24" centers, which allow the air stream to be vectored left and right for horizontal and vertical air flow.
AR-D ENERGY EFFICIENCY:
PERIMETER HEATING OUTPUT (BTUH/LF)

Table performance values from certified curves. Total certified output shown is per lineal foot of panel at the perimeter of the space.

Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T) with one inch of 3/4" PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output.

FOR OFFSET DIFFUSER PANEL WITH 1-1/2" SLOT WIDTH

<table>
<thead>
<tr>
<th>MEAN WATER TEMPERATURE (°F)</th>
<th>PANEL WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>77</td>
</tr>
<tr>
<td>125</td>
<td>90</td>
</tr>
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<td>130</td>
<td>103</td>
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<td>210</td>
<td>315</td>
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<tr>
<td>215</td>
<td>329</td>
</tr>
<tr>
<td>220</td>
<td>332</td>
</tr>
</tbody>
</table>

For performance when air is being supplied through diffuser, use these multiplier values (delivered air temperature must be below room temperature):

- If air is delivered through 25% of total slot length, **multiplier is 1.20**
- If air is delivered through 50% of total slot length, **multiplier is 1.25**
- If air is delivered through 75% of total slot length, **multiplier is 1.30**
- If air is delivered through 100% of total slot length, **multiplier is 1.35**
**AR-D PERFORMANCE DATA:**
**SINGLE SLOT DIFFUSER PANEL**

Table performance values from certified curves. Total certified output shown is per lineal foot of panel at the perimeter of the space. Output is based on 70°F air temperature; 67°F average unheated surface temperature (A.U.S.T) with one inch of 3/4" PCF unfaced fiberglass batt insulation on top of the panel, and natural convection. Actual output with minimum ventilation significantly increases panel output.

<table>
<thead>
<tr>
<th>AIRFLOW (CFM)</th>
<th>40</th>
<th>70</th>
<th>100</th>
<th>130</th>
<th>160</th>
<th>190</th>
<th>220</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PRESSURE (IN./H2O)</td>
<td>0.008</td>
<td>0.025</td>
<td>0.051</td>
<td>0.087</td>
<td>0.130</td>
<td>0.183</td>
<td>0.254</td>
</tr>
<tr>
<td>STATIC PRESSURE (IN./H2O)</td>
<td>0.007</td>
<td>0.023</td>
<td>0.046</td>
<td>0.077</td>
<td>0.117</td>
<td>0.164</td>
<td>0.221</td>
</tr>
<tr>
<td>NOISE*</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>THROW**</td>
<td>3-7-13</td>
<td>3-8-16</td>
<td>4-11-17</td>
<td>5-14-18</td>
<td>6-16-21</td>
<td>7-19-24</td>
<td>8-21-26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AIRFLOW (CFM)</th>
<th>80</th>
<th>130</th>
<th>180</th>
<th>230</th>
<th>280</th>
<th>330</th>
<th>380</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PRESSURE (IN./H2O)</td>
<td>0.01</td>
<td>0.028</td>
<td>0.053</td>
<td>0.086</td>
<td>0.128</td>
<td>0.176</td>
<td>0.235</td>
</tr>
<tr>
<td>STATIC PRESSURE (IN./H2O)</td>
<td>0.008</td>
<td>0.019</td>
<td>0.030</td>
<td>0.058</td>
<td>0.085</td>
<td>0.120</td>
<td>0.160</td>
</tr>
<tr>
<td>NOISE*</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>15</td>
<td>22</td>
<td>28</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>THROW**</td>
<td>4-8-16</td>
<td>4-9-18</td>
<td>5-12-19</td>
<td>6-16-21</td>
<td>7-17-24</td>
<td>8-20-26</td>
<td>10-23-28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AIRFLOW (CFM)</th>
<th>90</th>
<th>150</th>
<th>210</th>
<th>270</th>
<th>330</th>
<th>390</th>
<th>450</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PRESSURE (IN./H2O)</td>
<td>0.001</td>
<td>0.027</td>
<td>0.054</td>
<td>0.089</td>
<td>0.132</td>
<td>0.186</td>
<td>0.246</td>
</tr>
<tr>
<td>STATIC PRESSURE (IN./H2O)</td>
<td>0.006</td>
<td>0.016</td>
<td>0.031</td>
<td>0.051</td>
<td>0.076</td>
<td>0.107</td>
<td>0.144</td>
</tr>
<tr>
<td>NOISE*</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>16</td>
<td>23</td>
<td>34</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>THROW**</td>
<td>4-19-17</td>
<td>5-10-18</td>
<td>6-14-20</td>
<td>7-17-23</td>
<td>8-18-25</td>
<td>9-22-27</td>
<td>11-24-29</td>
</tr>
</tbody>
</table>

* Noise criteria (NC) was obtained by subtracting 10 dB room effect from the sound power level data.
** Throw distances are given in feet and are for terminal velocities of 50, 100, and 150 FPM. The throw data values were obtained using isothermal air conditions.
**AR-M MODULAR PANELS**

MetalWorks™ Airtite™ AR-M modular panels are 2’ x 2’ and 2’ x 4’ formed metal .040-inch aluminum panels. These highly efficient lightweight radiant panels have a 4-pass sinuous coil inserted in 3” extruded aluminum heat sinks providing 80% active panel area.

The panels are sized to fit into standard ceiling grids and can be supplied in standard white, silk screened to match acoustical ceiling, or block-perforated. All panels come with a standard 1-inch-thick sheet of insulation.

**AR-B PERFORATED MODULAR PANELS**

The AR-B panels are architectural perforated metal ceiling panels that can be designed for various suspension systems such as Torsion Spring, Lay-In, etc.

The panels can be provided in various sizes, metal, thicknesses and perforation patterns. Typical panels are fabricated with aluminum which provides the best heat transfer that results in the best radiant performance.

The AR-B panels are activated by bonding aluminum extrusions (heat transfer rails) incorporating integral sinuous copper coils to the back of the panels. Fleece can be installed between the extrusions for both appearance and noise reduction. With the fleece or other insulation (such as encapsulated fiberglass or recycled cotton), these architectural perforated panels can achieve high NRC values that exceed typical standard mineral tile ceilings. Flexible braided SST hoses with oxygen barrier and push fit fittings (ideal for installation and facilities personnel) are used to interconnect the panels and connect to the piping supply and return.

**AR-M AND AR-B MODULAR PANELS**

The panels can be installed in acoustical ceilings, recess-mounted in drywall or surface-mounted. In acoustic ceilings, the grid itself is able to support the panels which weigh less than 2 lbs. per square foot when filled with water without additional suspension. The panels are piped with 12 mm copper tubing. The use of longer interconnecting piping allows for the panels to be pushed up out of the grid and moved over to gain access to the plenum above.

The highly durable polyester powder coat paint finish is scratch-resistant and easily cleaned.
AR-M AND AR-B SCHEMATIC AND FINISHES

FOUR-PASS SINUOUS COIL ON BACK OF PANEL –
AR-M MODULAR PANEL

Panel supply and return points (2x per panel)

AR-M Modular Panel Section View 6” O.C.

AR-B Modular Panel Cross-Sectional Detail

PANEL ACTIVATION DETAIL –
AR-B MODULAR PANEL

Sinuous Copper Tube
Extruded Saddle (Copper)

0.47” Copper Tubing
0.03” Wall Thickness
AR-M Radiant Panel

Metal Thickness
23-5/8” 3-1/2” 23-5/8”

47-5/8”

23-5/8” 3-1/2” 23-5/8”

47-5/8”
### AR-B HEATING PERFORMANCE

**Heating performance**

AR-B panel performance based on 98% active surface area

Water flow rate at 1.47 GPM average

| Water inlet temp, degrees F | 104 | 111 | 94 |
| Water outlet temp, degrees F | 95 | 100 | 88 |
| Floor surface temp, degrees F | 75 | 75 | 75 |
| Air temp, degrees F | 72 | 72 | 72 |

Perimeter (exterior) condition considered for outside wall to 15' into room space

Emissivity of coating is at or greater than 0.93

<table>
<thead>
<tr>
<th>PANEL SIZE AND LOCATION</th>
<th>PERIMETER 2' x 4'</th>
<th>INTERIOR 2' x 4'</th>
<th>PERIMETER 2' x 2'</th>
<th>INTERIOR 2' x 2'</th>
</tr>
</thead>
<tbody>
<tr>
<td>110*</td>
<td>54.5</td>
<td>58.0</td>
<td>55.7</td>
<td>57.7</td>
</tr>
<tr>
<td>115*</td>
<td>64.5</td>
<td>63.7</td>
<td>65.2</td>
<td>63.6</td>
</tr>
<tr>
<td>120</td>
<td>75.0</td>
<td>70.0</td>
<td>75.0</td>
<td>70.0</td>
</tr>
<tr>
<td>125</td>
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<td>76.9</td>
<td>86.3</td>
<td>77.0</td>
</tr>
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<td>84.4</td>
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<td>108.8</td>
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</tr>
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<td>98.8</td>
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<td>153.8</td>
<td>120.0</td>
<td>153.8</td>
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<td>160</td>
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<td>128.1</td>
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<td>150.0</td>
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<td>150.0</td>
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<td>180</td>
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<td>185</td>
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<td>190</td>
<td>231.3</td>
<td>171.9</td>
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<td>202.0</td>
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<tr>
<td>215</td>
<td>288.8</td>
<td>–</td>
<td>288.8</td>
<td>–</td>
</tr>
<tr>
<td>220</td>
<td>300.0</td>
<td>–</td>
<td>300.0</td>
<td>–</td>
</tr>
</tbody>
</table>

* Results extrapolated from actual test data.

Performance shown in BTUH/SF.
AR-B COOLING PERFORMANCE:

Cooling performance for modular panels
AR-B panel performance based on 98% active surface area
Water flow rate at 0.75 GPM average
Water inlet temp, degrees F  62.4  58.8  67.8
Water outlet temp, degrees F  66.2  63.5  69.3
Floor surface temp, degrees F  79.0  79.0  79.0
Air temp, degrees F  79.3  79.3  79.3
Perimeter (exterior) condition considered for outside wall to 15' into room space
Emissivity of coating is at or greater than 0.93

<table>
<thead>
<tr>
<th></th>
<th>INTERIOR ROOM</th>
<th>NO GLASS IN SUN OR FULLY SHARED GLASS &amp; WALL</th>
<th>25% CLEAR EXTERIOR WALL IN SUN</th>
<th>50% CLEAR EXTERIOR WALL IN SUN</th>
<th>75% CLEAR EXTERIOR WALL IN SUN</th>
<th>100% CLEAR EXTERIOR WALL IN SUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOM AIR TEMPERATURE (MINUS MWT °F)</td>
<td>10</td>
<td>17</td>
<td>21</td>
<td>28</td>
<td>35</td>
<td>38</td>
</tr>
<tr>
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Performance shown in BTUH/ SF.
AR-M HEATING PERFORMANCE

Heating performance
AR-M panel performance based on 88% active surface area
Water flow rate at 1 GPM average

| Water inlet temp, degrees F | 195.3 | 165.0 | 135.0 |
| Water outlet temp, degrees F | 186.0 | 156.0 | 125.4 |
| Floor surface temp, degrees F | 75.0 | 75.0 | 75.0 |
| Air temp, degrees F | 71.0 | 71.0 | 71.0 |

Perimeter (exterior) condition considered for outside wall to 15' into room space
Emissivity of coating is at or greater than 0.93

<table>
<thead>
<tr>
<th>MEAN WATER TEMPERATURE (DEGREES FAHRENHEIT)</th>
<th>PANEL SIZE AND LOCATION</th>
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<td>PERIMETER 2' x 4'</td>
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<td>220</td>
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* Results extrapolated from actual test data.
Performance shown in BTUH/SF.
AR-M COOLING PERFORMANCE:

Cooling performance for modular panels
AR-M panel performance based on 88% active surface area
Water inlet temp, degrees F  | 62.4 | 58.8
Water outlet temp, degrees F | 66.2 | 63.5
Floor surface temp, degrees F | 79.0 | 79.0
Air temp, degrees F          | 79.3 | 79.3
Perimeter (exterior) condition considered for outside wall to 15' into room space
Emissivity of coating is at or greater than 0.93

<table>
<thead>
<tr>
<th>ROOM CONDITIONS AND PERCENT GLASS</th>
<th>INTERIOR ROOM</th>
<th>NO GLASS IN SUN OR FULLY SHADED GLASS &amp; WALL</th>
<th>25% CLEAR EXTERIOR WALL IN SUN</th>
<th>50% CLEAR EXTERIOR WALL IN SUN</th>
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</tbody>
</table>

Performance shown in BTUH/SF.
### PRESSURE DROP TABLE

**Pressure Drop**

Both panels and connecting tubing pressure drops must be included in the circuit pressure drop calculation.

Flow rated below .5 GPM are not recommended.

**WATER PRESSURE DROP**
*(SHOWN IN FT/PANEL EXCEPT FOR CONNECTING TUBE)*

<table>
<thead>
<tr>
<th>GPM PER CIRCUIT</th>
<th>PANEL TUBING</th>
<th>3/8&quot; TYPE LF/100FT.</th>
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<tr>
<td>1.5</td>
<td>1.73</td>
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</tr>
</tbody>
</table>
AR-B AND AR-M PANEL DESIGN

COOLING 2290 BTUH 72 SF 1.3 GPM
HEATING 8841 BTUH @ 150 MWT 1.0 GPM
MAX $\lambda P$ @ TWO CIRCUITS 0.65 GPM/CRT

At 0.65 GPM, pressure drop per modular panel is 0.37 ft. of water.
At 0.65 GPM, 3/8" L CU is 3.2 ft. of water/100' CU

$\lambda P = 5$ panels: 5 @ 0.37 GPM/panel + 22' -3/8" L CU x 3.2 ft. of water/100' CU = 2.55 ft. of water
1.85 ft. of water + 7.04 ft. of water = 2.55 ft. of water

$\lambda P = 4$ panels: 4 @ 0.37 GPM/panel + 35' -3/8" L CU x 3.2 ft. of water/100' CU = 2.66 ft. of water
1.48 ft. of water + 1.12 ft. of water = 2.6 ft. of water

Perimeter 2' x 4'
@150° MWT
1140 BTUH/panel
3 panels
3420 total BTUH

Interior 2' x 4'
@150° MWT
905 BTUH/panel
6 panels
5430 total BTUH
AR-B AND AR-M TYPICAL PANEL LAYOUTS

Typical single panel hook-up

Typical two panel hook-ups

Typical multiple panel hook-ups
DESIGN PROCEDURE

The design of a radiant ceiling panel heating system should follow the usual guidelines of a closed water system. To design such a system, we need to find the following:

1. Calculate the heat loss per zone or room
2. Determine the number of 2' x 2' or 2' x 4' modular panels
3. Determine the panel layout and water flow
4. Calculate the water pressure drop based upon panel layout and piping arrangement

DESIGN EXAMPLE: RECTANGULAR BUILDING

Given conditions:
- 100 ft. x 150 ft. floor plan
- 12 ft. floor-to-floor
- Inside design = 72°F Dry Bulb
- Supply Water Temp = 180°F
- Return Water Temp = 160°F
- Heat loss for each floor = 175,000 BTUH

1. Calculate the heat loss per zone per lineal foot of perimeter, and per zone.

   Heat loss/LF of perimeter = \(\frac{175,000 \text{ BTUH}}{500 \text{ LF}}\) = 350 BTUH/LF
   50 LF zone heat loss = 50 LF x 350 BTUH/LF = 17,500 BTUH

2. Determine the number of panels.

   The ceiling has a 2' x 4' grid layout. The perimeter performance of a 2' x 4' modular panel at 170°F mean water temperature = 1500 BTUH per panel.

3. Determine panel layout and water flow.

   Based on either room size or zone size, determine modular arrangement. Therefore, a 50-ft. zone (circuit) without perimeter walls would have 12 – 2' x 4' modular panels in series.

   \[
   \text{Total GPM} = \frac{\text{Total BTUH/zone}}{500 \times \text{water temp. drop °F}}
   \]

   \[
   500 = 8.34 \text{ lbs/gal} \times 60 \text{ min/hr}
   \]

   \[
   \text{GPM} = \frac{17,500 \text{ BTUH}}{500 \times 20°F} = 1.75 \text{ GPM}
   \]

   This zone will be divided up into two circuits of six – 2' x 4' modular panels.

4. Calculate the water pressure drop based upon piping arrangement.

   Each circuit of six – 2' x 4' modular panels would have a flow of .9 GPM per the pressure drop table.

   Per the pressure drop table, at .9 GPM shows .67 ft. of W.P.D. per panel.

   Pressure drop for the panels on this circuit:

   \[
   6 \times .67 = 4.02 \text{ ft. of water}
   \]

   Per the pressure drop table, for 3/8" L copper at .9 GPM shows 5.81 of WPD per 100 ft. of tube.

   Per example below, there will be 45 LF of 3/8" L copper:

   \[
   45 \times 5.81 = 2.61 \text{ ft. of water}
   \]

   Total pressure drop = 4.02 + 2.61 = 6.63 ft. of water
The AR-L and AR-C are high-capacity radiant-cooling linear systems based on the principles of radiant technology. By separating the linear radiant elements with a gap, the AR-L and AR-C couples the radiant cooling effects of standard radiant panels with a convective component. Chilled AR-L and AR-C ceilings create natural convection by cooling the surrounding air as it passes over the surface facing the plenum.

As the denser air falls into the occupied zone, warmer air is pulled over the element, incorporating convective cooling capacity of the AR-L and AR-C with the radiant capacity of the cool surface (see below). The approximate breakdown of heat transfer of the chilled radiant system is 30% by thermal radiation and 70% by natural convection.

When used for heating, the AR-L and AR-C transfers heat mainly through thermal radiation with room surfaces, where it increases the average unheated surface temperature of the room. As warmer air rises past the heated sails, natural convection occurs, which results in warmer return air.

ENERGY EFFICIENCY

The specific heat capacity of water is four times higher than air. This means that the energy 1-cubic-foot of water can remove requires an equivalent of 3,480-cubic-feet of air (due to the density of water versus air). Therefore, to remove a given amount of heat from a building, less than 25% of the transport energy is required to remove the same amount of heat compared to an all-air system. Because AR-L and AR-C are water-only systems, they can handle the sensible portion of a building load and must be paired with a fresh air system for ventilation and latent load removal.

MODELS

The AR-L and AR-C profiles cover both a flat and a concave face as shown at left. The surface profile is dependent on the application, the need for excellent aesthetics, and broad design flexibility. Contact us for more information on which profile to use for your application.

AR-L and AR-C are designed to allow air movement through openings between the slats, increasing the capacity of the unit and providing an effective means of dealing with sensible cooling loads. AR-L and AR-C can be installed in a variety of applications including full or cloud ceiling areas.
The visible surfaces of the aluminum extrusion and bracing are usually painted white. Optional custom colors are available which meet the emissivity requirements.

**TYPICAL DESIGN**

The precision extruded aluminum profiles are optimally formed with one or two conduction rails to accommodate copper tube and provide cooling fins which are rounded off at the outer end. The extruded profiles are 5” wide with a typical length of 160” long.

The gap between the extruded profiles is typically 1.0 inches with up to 8 profiles wide per assembled unit. The copper tube is press-fit into the conducting rails of the extrusion, ensuring continuous contact between the copper and the aluminum along the entire length and providing optimal heat transfer. Copper tubing with a 0.625” O.D. (1/2” nominal) is used in the fabrication of the system.

The connections between the modules and the distribution lines can be made via copper tubing and/or flexible metal hoses with stainless steel sheathing. After installation, the entire system must be checked for leaks. The cold water inflow temperature should be selected so that this never falls below the dew point, which would create condensation. It is recommended that a dew point sensor be incorporated in the overall design of the system to adjust the water temperature.

Special design options such as folding modules, sprinklers, lighting openings, air intake, etc. are available.

**ACCESS PANEL DESIGN**

Panels can be designed into the AR-L and AR-C modules to allow access to the plenum area. The access panels are designed with torsion springs allowing the panel to be pulled straight down without any special tools and swung out of the way. Access panels can have the same radiant heating and cooling capacity as a fixed panel, or be a non-active panel and can be placed within the ceiling system, where needed.
Testing conducted to Test Specifications EN 14037-5

Testing is considered an interior application, increased performance will be achieved if condition is considered an exterior application.
Test results are based on active area
Flow Rate at 1.365 GPM
Installation area 80.29 SF
Active area 68.33 SF (85% active area ratio)
Two sails connected in a series
Water inlet temp, degrees F 107.9 88.9 127.5
Water outlet temp, degrees F 101.0 85.5 116.6
Interior Surface Temp, degrees F 64.6 66.2 63.0
Surface Temp at Floor, degrees F 64.6 66.2 63.0
Air temp at 5.6', degrees F 68.4 68.4 68.2

AR-L AND AR-C HEATING PERFORMANCE CHART

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<thead>
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<th>DELTA T °F</th>
<th>SPECIFIC HEATING CAPACITY IN BTUH/SF</th>
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Testing conducted to Test Specifications EN 14240

Testing is considered an interior application, increased performance will be achieved if condition is considered an exterior application.
Test results are based on active area
Flow Rate at 1.541 GPM
Installation area 80.29 SF
Active area 68.33 SF (85% active area ratio)
Two sails connected in a series
Water inlet temp, degrees F 62.3 66.5 58.6
Water outlet temp, degrees F 66.0 69.4 63.2
Interior Surface Temp, degrees F 78.5 78.5 78.4
Surface Temp at Floor, degrees F 78.5 78.4 78.3
Air temp at 5.6', degrees F 78.9 79.3 79.0

AR-L AND AR-C COOLING PERFORMANCE CHART

<table>
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<th>DELTA T °F</th>
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TAKE THE NEXT STEP

1 877 276 7876
Customer Service Representatives
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Monday through Friday

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