

Microchannel Heat Exchangers – Quick Facts

Background

Microchannel heat exchangers were first applied in the automotive industry in the late 1980's, driven primarily by the need to switch from CFC-12 to HFC-134a. Other drivers like weight, dimensions, and refrigerant charge contributed to the design of microchannel.

Microchannel technology proved successful in automobiles which experience extreme vibrations from the engine and road conditions, high impact from debris, chemicals from road salt, de-icers, and oils, air contaminants and pollutants, and extreme temperatures. Four out of five automobiles on the road today have microchannel heat exchangers.

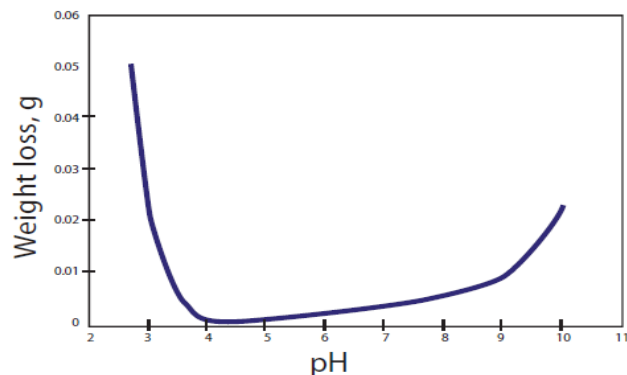
Stationary HVAC vs. Automotive Applications

The great reliability in automotive applications gave HVAC manufacturers confidence to incorporate the technology into stationary equipment with the assumption that the heat exchangers would experience less extreme conditions than those present in automobiles, however that didn't turn out to be the case.

Early installations highlighted key application differences, with important implications, between stationary HVAC and those in automobiles:

- Stationary HVAC heat exchangers are wet much longer than automotive applications
 - Automotive coils have high face velocity that helps remove moisture
 - Automotive applications stay warm/hot under the hood causing moisture to evaporate
 - Automotive coils stay shielded from precipitation
- Stationary HVAC applications are seasonal and remain exposed to outdoor conditions, but are non-operational for several months during the year

Early generation microchannel heat exchangers applied the same braze flux material used in automotive applications. The braze flux created high pH conditions when exposed to moisture for extended time periods. The high pH created a corrosive environment that directly attacked the aluminum.



Graph 1: Weight loss due to corrosion plotted by pH

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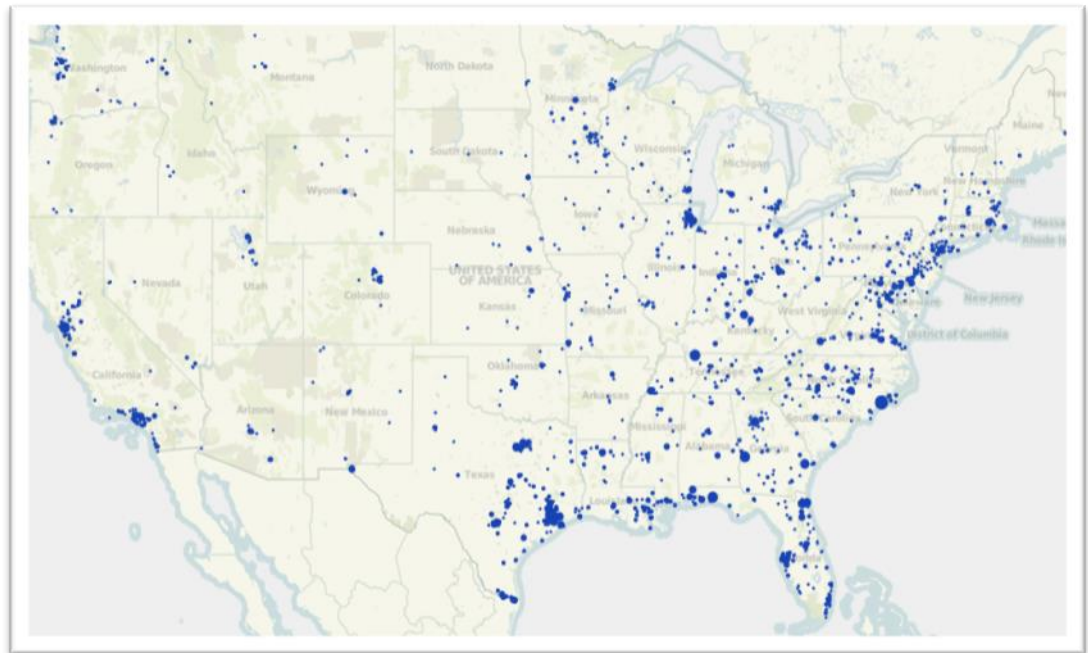
The automotive-designed microchannel heat exchangers had relatively thin tube wall thicknesses designed for low weight and better automobile fuel economy. They also used lower grade aluminum alloys to hit aggressive cost targets needed in the automobile industry.

Less corrosion-resistant alloys and thinner wall tubes increased opportunity for tube failure, especially in coastal and industrial climates.

Johnson Controls Microchannel Heat Exchangers

Johnson Controls created a Center of Excellence in Engineering (COEE) that focused entirely on heat exchanger technology and microchannels. The team consisted of PhDs in materials and heat transfer engineering. The COEE set standards and performance requirements for microchannel, specified tube alloy materials, wall thickness, fin alloy material, and braze flux material. The expert team inspected, approved and audited heat exchanger production facilities and conducted extensive, on-going testing of heat exchanger technologies and production samples.

Johnson Controls has been shipping YLAA air-cooled scroll chillers with microchannels since 2007 and YVAA air-cooled screw chillers since 2010, with more than 70,000 microchannel heat exchangers installed worldwide. The field installations have proven the high reliability of the Johnson Controls microchannel design.



Graph 2: Johnson Controls microchannel installation sites by location in the U.S., concentrated around coastal and industrial cities

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With the utilization of the Johnson Control Microchannel Heat Exchangers, the chiller is able to maintain its efficiency levels when compared to the round tube and perforated fin heat exchangers, but decrease in weight and refrigerant charge of the overall unit. Table 1 below depicts the differences between the use of round tube and perforated fin condenser coils and Johnson Controls internal design Microchannel coils.

	Conventional A/C Screw Chiller w/ RTPF*Condenser	YVAA w/ Microchannel Condenser Coil	% Difference
Capacity (tons)	300	300	-
Rigging Weight (lbs)	21306	18334	13.9%
Refrigerant Weight (lbs)	1116	580	48.0%

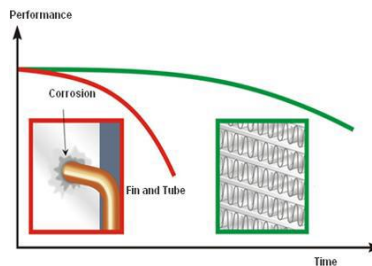
*RTPF: Round Tube and Perforated Fin

Table 1: Depicts the benefits of the microchannel coil over the round tube and perforated fin coil in terms of weight and overall refrigerant quantity within the unit.

By comparing the rigging weight of the Conventional air-cooled screw chiller that utilizes the round tube and perforated fin condenser coil to the YVAA, which utilizes the Johnson Controls microchannel coil, there is approximately a 14% reduction. This can help with positioning the chiller in the mechanical space due to a smaller crane (or other lifting devices). This can also save on the rental of a crane (or other lifting devices) that is not on site (due to the size of the crane). Also, with the use of the Johnson Controls microchannel coils there is a significant reduction in refrigerant charge. On a 300 ton chiller with equivalent performance there was approximately a 48% reduction in refrigerant within the chiller. This can help gain LEED credits and help with any needed refrigerant for the life of the chiller.

Johnson Controls Microchannel Reliability

With the initial design of heat exchangers being constructed out of copper tube and aluminum fin, over time these heat exchangers would lose efficiency and reliability. Due to the two materials being in contact for a long period of time, the materials would begin to corrode one another, which is called galvanic corrosion. The Johnson Controls microchannels are constructed with the same tube and fin material. With the use of common metals within the design, the microchannel preserves the efficiency and the reliability of the heat exchanger over the life of the chiller. This can be seen in the chart below.



Graph 3: Depicts performance of a tube and fin heat exchanger and microchannel coil over time

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With Johnson Controls patented design of the microchannel heat exchangers that are used on the YLAA (Air-Cooled Scroll Chiller) and YVAA (Air-Cooled Variable Speed Screw Chiller) product lines, we have seen that there is a failure rate less than 0.1% of all microchannel panels over the past 2 years.

Johnson Controls Microchannel Testing

Johnson Controls COEE used four methods to evaluate accelerated corrosion:

- ASTM G85-A4 (Salt + SO₂)
 - Salt, sulfur dioxide gas, pH ~2.8-3.0 (Typical pollutant from coal and oil power plants)
- ASTM G85-A3 (SWAAT)
- Sea salt, acetic acid, pH ~2.5-3.0 (Common test for aluminum corrosion)
- Severe coastal, high chloride site testing
- Severe pollution and coastal site testing

The Sea Water Acetic Acid Test (SWAAT), ASTM G85-A3, is the industry standard test used for validating aluminum heat exchangers. The test is a cyclic fogging test with pH of 3 that's a modification of the ASTM B117 Salt Spray (Fog) Testing.

The team also performed extensive field testing in locations around the world that resulted in the extremely high confidence Johnson Controls' has in our products and microchannel heat exchangers.



Graph 3, Left: Tianjin, China (identified as city with top 10 worst air pollution). Right: New Smyrna Beach, FL (Severe subtropical marine environment, category C4/C5 corrosive environment (ISO 9223))

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Optional Microchannel Coating

Optional microchannel coating provides an electro-deposited and baked flexible epoxy polymer coating (e-coat) uniformly applied to all heat exchanger surface areas without material bridging between fins. The coating process ensures complete heat exchanger encapsulation and a uniform dry film thickness on all surface areas including fin edges. Johnson Controls factory-applied e-coating offers the best resistance to corrosion for microchannel heat exchangers.

For those applications that are within 5 miles of the coast or near a corrosive environment, we do have a standard option to coat the microchannels in a protective material. This coating provides an electro-deposited and baked flexible epoxy polymer coating (e-coat) uniformly applied to all heat exchangers surfaces areas without material bridging between fins. The coating process ensures complete heat exchanger encapsulation and a uniform dry film thickness on all surfaces areas including fin edges. Johnson Controls factory-applied e-coating offers the best resistance to corrosion for microchannel heat exchangers. Table 2 below, lists the rated corrosion resistance of each type of coil and coil protection according to the ASTM Salt Spray Tests.

Condenser Coil Type	Corrosion Coating Type	Reliability Test Hours
RTPF*	None	600 hours
RTPF*	Pre-Coat	1000 hours
RTPF*	Epoxy Coating	5000 hours
Microchannel	None	1000 hours
Microchannel	Epoxy Coating	5000 hours

*RTPF: Round Tube and Perforated Fin

Table 2: Indicates the corrosion resistance level of each condenser coil type with the associated coating type.

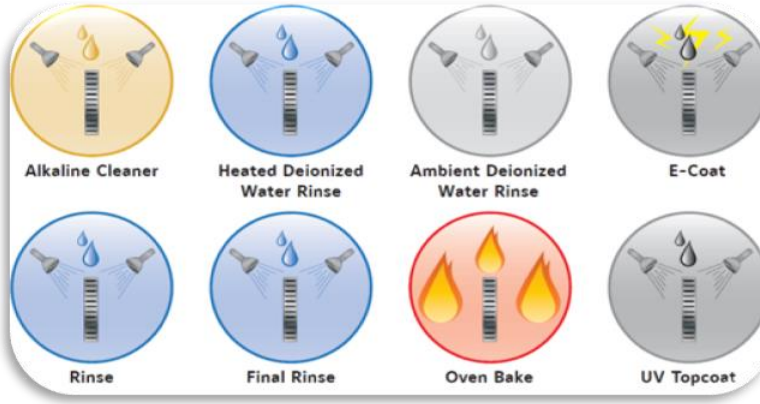
By evaluating the corrosion resistance levels of each configuration, the standard microchannel coil has the same corrosion resistance level as the round tube and perforated fin coil w/ a pre coating applied to the coil. However by evaluating the standard microchannel coil with the standard round tube and perforated fin coil, from the table above, the microchannel is far superior when evaluating the corrosion resistance level. This is a very important variable that some customer and applications should be aware of.

E-coating is recommended for the most aggressive corrosion applications such as:

- Industrial: Sulfur Dioxide (SO₂), Nitrogen Dioxide (NO₂) pollution; low pH acid rain (sulfuric or nitric acid); heavy dust (fossil fuel burn – iron & sulfur)
- Coastal: within 5 miles (8 km) of coast, or in prevailing wind (chloride)
- Other: High pH (pH>9) from cement dust, Agricultural operations

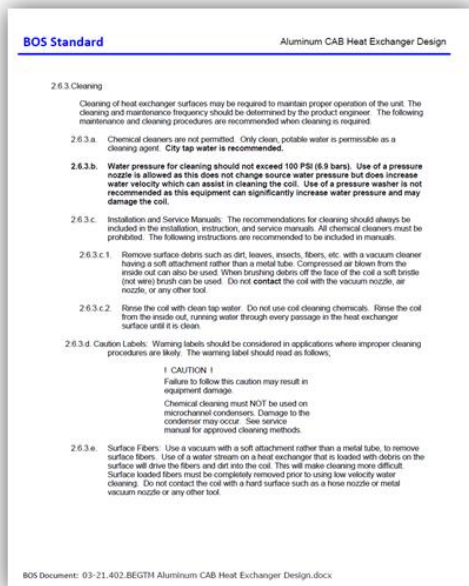
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Graph 5: e-coat process

Microchannel Cleaning Requirements



Graph 5: BOS Standard describing cleaning requirements

Cleaning of heat exchanger surfaces may be required to maintain proper operation of the unit. The following cleaning procedures are recommended when cleaning is required:

- Surface fibers, leaves, etc. should be vacuumed with a soft attachment (non-metallic) or blown out with compressed air
- Coils can be cleaned with potable water. Cleaning agents should never be used as they can cause damage to the heat exchanger.
- Maximum water pressure for cleaning is 100 psi. Pressure washers should not be used as they can damage the heat exchanger.
- If brushing coils, a soft bristle, non-metallic brush must be used.

Conclusion

Microchannel heat exchangers have immense advantages that make the technology

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an excellent fit for stationary HVAC equipment. The high efficiency, reliability, reduced refrigerant charge, and reduced size, weight, and carbon footprint are all reasons making microchannel a good choice for chiller condensers.

Johnson Controls microchannels use specially developed materials to help ensure high reliability and corrosion resistance, and have been carefully designed and tested for the unique conditions of the HVAC stationary application. Our microchannel heat exchangers have lab and field proven reliability for stationary HVAC applications around the world in various climate types and corrosion levels.

Heat exchanger e-coating is advised for more corrosive environments, especially industrial and coastal locations where traditional copper/copper coils have been typically used.

For additional information refer to the white paper on microchannel heat exchanger technology, [BOS 03-01.801.EGTM v2](#).