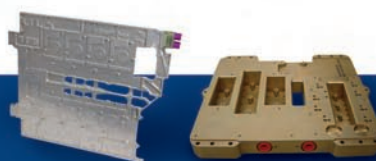


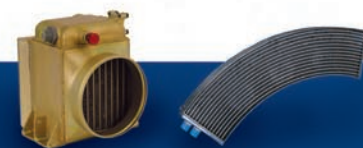
Innovative Design & Manufacturing Excellence



CHILLERS & COOLING SYSTEMS



COLD PLATES



HEAT EXCHANGERS



# Thank you

Thank you for choosing Lytron. We're proud to be the premier supplier of liquid cooling products to Original Equipment Manufacturers (OEMs) around the world. Partnering with our customers, we develop cost-effective thermal solutions that range from single components, to value-added subassemblies, to fully customized cooling systems for the most demanding applications.

During the last 15 years, Lytron has enjoyed significant growth. I believe this growth is a testament to our ability to deliver the highest quality systems and components at the best value. Our goal is to exceed your expectations for product performance, quality, reliability, and on-time delivery for every project.

Since its founding in 1958, Lytron has developed thousands of cooling systems and components. We design and manufacture custom chillers, cooling systems, cold plates, chassis, and heat exchangers, as well as offer 15 standard product lines. Our products provide thermal solutions primarily to OEMs in the medical, semiconductor, military, aerospace, power generation, traction, laser, and data center industries.

In June of 2011, Lytron acquired Lydall Industrial Thermal Solutions, Inc. ("Affinity"). With this acquisition, we significantly expanded our capabilities and service offerings for our OEM customers. The Affinity team brought with them vast expertise in the design and manufacture of low and high temperature chillers, systems that are compatible with dielectric fluids, rack-mounted chillers, and liquid cooling systems. In addition, joining service organizations has expanded our global service network, the result of which is improved responsiveness and equipment uptime.

With extensive experience designing cooling systems and components for diverse markets, our combined engineering organization can solve the most challenging thermal requirements. Our design engineers use their expertise in thermal design, analysis, verification, prototype development, and project management to meet all of your requirements, while our manufacturing engineers ensure that your product is Designed-for-Manufacturability (DFM).

Supporting our product design and development are Lytron's state-of-the-art factories. We continually invest in our facilities, including updating our equipment with the latest technologies. With lean, just-in-time manufacturing and numerous systems assembly lines, we're able to supply the highest quality cooling systems while meeting your individual delivery requirements. Also, virtually all of the critical cold plate and heat exchanger manufacturing operations, such as machining, fin making, vacuum brazing, torch brazing, welding, and testing, are performed in-house. As a result, Lytron is able to offer you greater flexibility and responsiveness while guaranteeing the highest quality products.

We look forward to partnering with you on your upcoming projects and programs.

Sincerely,



Craig Carswell  
President & CEO





*Lytron offers all the thermal components in a liquid cooling loop. By performance-matching individual components, we provide the most cost-effective and innovative solution.*

Company  
Overview

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Custom  
Cooling Systems

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Standard  
Cooling Systems

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Custom  
Cold Plates

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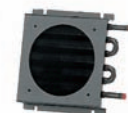
Standard  
Cold Plates

**Page 35**



Custom  
Heat Exchangers

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Standard  
Heat Exchangers

**Page 47**

Technical  
Reference

**Page 62**



## We're liquid cooling experts with the experience and ingenuity to solve your most demanding thermal challenges

To meet all of your requirements, Lytron harnesses more than 50 years of liquid cooling knowledge, an experienced engineering team, quality manufacturing, and strong customer service to deliver high performance, reliable, and cost-effective thermal solutions. Our product range encompasses all the thermal components in a liquid cooling loop, including cooling systems, cold plates, and heat exchangers. This understanding of the complete thermal system allows us to performance-match the individual cooling loop components, resulting in more innovative and economical thermal solutions for your equipment.

### The Ideal Partner for Supplying Mission Critical Thermal Solutions

Lytron supplies liquid cooling and thermal management solutions to Original Equipment Manufacturers (OEMs) in many markets including:

- Power Electronics
- Diagnostic Equipment
- Semiconductor Equipment
- Power Generation
- Traction
- Commercial Aerospace
- Medical and Industrial Lasers
- Defense
- Telecommunications
- Analytical Instrumentation
- Data Centers
- Machine Tools
- Supercomputers

### Unparalleled Engineering Expertise for an Optimized Technical Solution

Partnering with its customers, Lytron becomes an extension of your engineering team. Our thermal management expertise is unrivaled. We optimize designs as well as assist in finalizing designs to meet your overall requirements. Our engineers can make significant contributions, including trade-off studies and specification development, at project inception to minimize your development time.

Our design engineers use an extensive toolbox of specialized software including thermal modeling software, analytical tools, solid modeling, and Failure Mode and Effects Analysis (FMEA) to design high performance and cost-effective solutions to meet your heat transfer challenges. We combine these software tools with an empirical database containing over 50 years of data and a design philosophy that fully integrates engineering and manufacturability.





Manufacturing engineers work closely with thermal engineers early in the design phase to ensure that products are Designed-for-Manufacturability (DFM) and serviceability. Our concurrent engineering philosophy guarantees we balance thermal and mechanical performance requirements with cost, delivery, and quality requirements. This team approach allows Lytron to quickly transition prototypes into production.

### Vertically Integrated Manufacturing for Quality and Reliability

Lytron's 115,000 ft<sup>2</sup> (10,700 m<sup>2</sup>) manufacturing facility in Woburn, MA, 70,000 ft<sup>2</sup> (6,500 m<sup>2</sup>) manufacturing facility in Ossipee, NH, and 10,000 ft<sup>2</sup> (930 m<sup>2</sup>) manufacturing facility in Changzhou, China are designed to be flexible and agile for maximum throughput of custom cooling systems and components. Our lean manufacturing principles, vertical integration, and cellular organizational structure make this possible.

Our in-house manufacturing and test capabilities include:

- Systems assembly with several lines dedicated to custom liquid cooling products
- CNC machining, EDM, CNC tube bending, and high-speed fin making
- Advanced metal joining including torch brazing and TIG welding
- Vacuum brazing, including an environmentally-controlled room, multiple vacuum furnaces, and a heat treat furnace
- Quality Assurance (QA) testing in our well-equipped QA lab which includes Coordinate Measuring Machines (CMMs), hardness testing equipment, an optical comparator, and photo-micrograph capabilities
- Performance testing in our extensive engineering lab, which includes wind tunnels, test stands, flow meters, leak detectors, and much more

Since all performance-critical processes, such as fin-forming, machining, vacuum brazing, and tube bending, are carried out in-house, we can guarantee that your product will perform as predicted. Equally important, production is in the same facilities as our designers and our engineering test laboratories. As a result, we maintain control from initial concept to completion, so you can be sure that all products are built exactly as the engineers intended.

Our manufacturing strategy focuses on optimizing manufacturing processes and continuous improvement through employee involvement. We have been ISO 9001 certified since 1996 and utilize Six Sigma and zero-defect manufacturing for the highest quality products and the fastest delivery. Our investments in capital equipment have enabled us to increase production capacity, reduce costs and lead times, and produce the highest quality products. Our self-managed work cells take full responsibility for product quality, on-time delivery, and cost reduction efforts.



In addition to ISO 9001: 2008 certification, Lytron's quality program conforms to military inspection standard MIL-I-45208A. Lytron maintains a welding program with operators certified in accordance with Navsea S9074-AQ-GIB-010/248, SAE-AMS-STD-1595, and AWS D17.1. Vacuum furnace and torch brazing processes are performed in full compliance with ANSI/AWS C3.7.

In our engineering laboratory we can test any cooling system or component that we manufacture in order to validate designs or test finished product. Our well-equipped, in-house test facility includes wind tunnels (up to 21,000 ft<sup>3</sup>/min or 594 m<sup>3</sup>/min), an IGBT/cold plate test stand, system and system component reliability test stands, an environmental test room, refrigeration test equipment, a vibration test stand, particle counters, microstructure analysis system, and various flow, temperature, and pressure instruments.

### Supply Chain Management for Value and On-Time Delivery

As a global supplier of chillers, cooling systems, cold plates, and heat exchangers, Lytron is able to leverage its extensive purchasing power to offer you more options and the best overall value. Lytron's supply chain management program is supported by a team of supplier quality engineers and includes an efficient and effective process for approving new suppliers, evaluating the performance of existing suppliers, and monitoring risk in the supply chain. We evaluate and measure our suppliers on quality, on-time delivery, capacity to ramp up for production volumes, and more. Our "Verification of Purchased Product Procedure" also ensures purchased products meet specifications.

### Worldwide Service for Maximum Uptime

Lytron understands the importance of ensuring the maximum uptime for your system. We operate a worldwide service network dedicated to supporting and servicing your equipment. Our service centers in North America, Europe, and Asia are staffed with factory-certified technicians who can provide service at our centers or at your facility. We also offer 24-hour, 7-day per week phone access to field service engineers for trouble shooting assistance. Please see page 12 for more information about our systems service.

### Visit Us

We welcome visits from our customers. Please contact our sales department to set up a facility tour or to discuss your liquid cooling requirements.





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*Outsourcing your cooling loop to a company that builds thousands of cooling systems per year guarantees a quality product and enables you to focus your engineering efforts on your own area of expertise. Turnkey systems also accelerate the design process, reduce inventory levels, and simplify production. End users prefer integrated systems because they are easy to install and simple to operate.*

*Our three types of cooling systems can be tailored to your precise requirements with a range of standard options or completely custom designed. Lytron's cooling systems are used in a variety of applications including semiconductor equipment, diagnostic equipment, medical and industrial lasers, analytical instruments, oncology machines, data centers, electron microscopes, printing equipment, plasma etch systems, and solder reflow ovens.*



## Custom Chillers and Cooling Systems for Maximum Uptime

Lytron specializes in the design and manufacture of custom chillers, liquid-to-liquid cooling systems, and liquid-to-air cooling systems for semiconductor equipment, medical equipment, lasers, wind turbines, trains, and other mission critical applications. We're able to meet your most challenging thermal and mechanical specifications.

Our systems engineering team works with our cooling system and heat exchanger technologies to arrive at the optimum solution for your application. We can custom design and manufacture the heat exchanger and select the best pump for your system. In addition, our systems manufacturing engineers ensure that your cooling system is Designed-for-Manufacturability (DFM) and serviceability.

We ship thousands of cooling systems every year, and all of our custom systems are built at Lytron in the same facility where they were designed. Our integrated approach to design, supply chain management, and production allows us to control the entire manufacturing process, from the selection of components to assembly and test, resulting in excellent quality.

Our capabilities include but are not limited to the following:

- -85°C to 200°C (-121°F to 392°F) Process Temperatures
- ¼ hp to 40 hp Refrigerated Units with Cooling Capacities up to 150 kW
- Liquid-to-Liquid Cooling Systems with Cooling Capacities up to 300 kW
- $\pm 0.1^\circ\text{C}$  Temperature Stability
- Cascade Refrigeration Systems
- Single, Dual, Triple, and Quadruple Cooling Loops
- Fluids Compatibility (Water, EGW, PGW, Fluorinert™, HFE, Galden®, PAO, Silicone Oils, etc.)
- Communications (Ethernet/TCP-IP Mod Bus, RS232/RS485, Dry Contacts, 4-20 mA, 0-10 Volts, etc.)
- Industry Standards and Certifications (IEC 60601-1, IEC 61601-1, SEMI S2, S8, F47, UL, MET, CE certified, WEEE, RoHS, etc.)
- Custom Configurations and Sizes Including Rack Mount, Mobile, and Skinless for Integration into Your Equipment
- Air-Cooled or Water-Cooled
- Companion Assemblies
- Design for Quiet Operation/Reduced Acoustic Levels
- Class 7 Cleanroom Compliance



*Custom LCS pump stand for cooling medical equipment features a reduced acoustic emissions design (<60dBA), a deionization purity sensor, an airflow sensor, IEC 60601-1 compliancy, and an electrical box and pump on slides for serviceability*



*Custom water-cooled chiller for semiconductor equipment features custom communications and dual rated electrical configuration*

## Recirculating Chillers

Recirculating chillers can provide precise temperature control and cooling below ambient temperature. They can be designed as stand-alone systems or designed for integration within a larger system. With extensive experience designing chillers for front-end and back-end semiconductor equipment, medical equipment, lasers, and more, Lytron can meet all of your chiller requirements.



*"Copy exact" -85°C cascade chiller features a VFD pump, programmable pressure controller, dual voltage, and SEMI S2 and F47 compliance*



*Recirculating chiller compatible with dielectric fluid features a custom turbine pump to support high supply pressure applications, 15-pin interlock, and other customizations*



*Semi-frameless chiller designed to fit in a tight space inside of a larger piece of equipment features RS232 communications, dual voltage, and a custom condenser designed and built by Lytron*



*Water-cooled chiller designed to SEMI S2 and F47 with dual voltage, numerous alarms, a low flow and low level shutdown, and more*

## Liquid-to-Liquid Cooling Systems

When a large amount of heat needs to be removed and chilled facility water is available, a Liquid-to-Liquid Cooling System (LCS) may be the solution. An LCS, also known as a water-to-water heat exchanger, can reduce energy consumption and save a significant amount of money over air cooling. LCSs offer precise temperature control of process water ( $\pm 0.5^{\circ}\text{C}$ ) and transfer the waste heat to facility water.



*Skinless, 25kW LCS pump stand designed to cool four independent heat sources and be integrated into larger equipment*



*LCS for medical imaging contains two liquid cooling and one air cooling loop—all managed by the cooling system controller*



*LCS with dual voltage and MET and CE certification designed for use in printing industry*



*"Copy exact" LCS featuring two separate cooling loops,  $\pm 0.1^{\circ}\text{C}$  temperature stability, interlock 10/100 Ethernet communications, a VFD for enhanced pump performance, and a drip tray for leak detection*



## Liquid-to-Air Cooling Systems

A liquid-to-air cooling system, also known as an ambient cooling system or Modular Cooling System (MCS), provides cost-effective cooling for applications that don't require a recirculating chiller, tight temperature control, or cooling below ambient temperature. An MCS consists of a heat exchanger, a fan, a pump, a reservoir, and a controller. MCSs can be customized in numerous ways to meet challenging thermal and mechanical requirements.

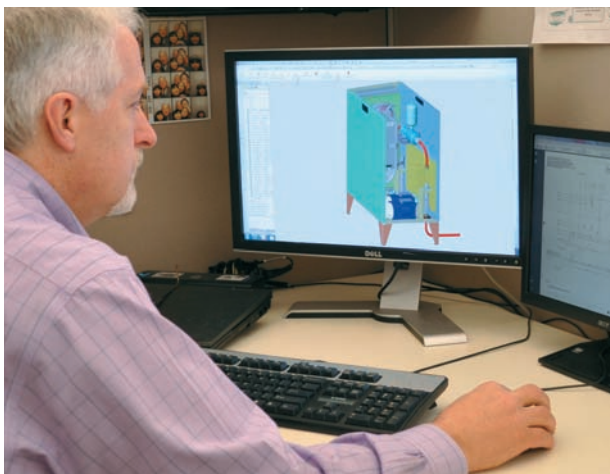


*Built-to-specification MCS for a medical equipment application, with two standard Lytron heat exchangers and a stainless steel centrifugal pump*



*MCS for a medical application with a custom aluminum flat tube heat exchanger, an accumulator, and an automatic air purge device*

## System Design and Quality



*Your Lytron cooling system design team can serve as an extension of your engineering team, providing specification development, thermal, electrical, and mechanical design, prototype development and testing, and full production.*



*Our manufacturing engineers and supplier quality engineers work closely with our key suppliers to ensure we deliver to you the highest quality products on time to your exact specifications.*

## Worldwide Service and Support

Lytron understands how important it is to ensure that your chiller or cooling system maintains the absolute maximum up time, which is why our systems are backed by outstanding service and support. We recognize that most custom systems are integrated into equipment that may end up anywhere in the world, so we offer support when and where you need it: a worldwide network of service centers for installation support, commissioning, service, and maintenance, and access to in-house service technicians 24 hours per day, 7 days per week. Partnering with our customers, we can set up additional service capabilities where needed, including on-site service and service contracts. Our service and support capabilities include:

- Specialized test facilities with factory-trained and certified technicians
- In-house and/or onsite services for repairs, exchanges, or upgrades
- Installation, commissioning, and start-up assistance
- Precision tuning and system optimization
- Custom preventative maintenance plans
- Tailored refurbishment management plans
- Extended warranty programs

### Service Centers

Lytron has an extensive service operation. In addition to our three USA service centers located in Massachusetts, New Hampshire, and California, we also offer service in 18 countries to support our Europe, Asia, and North America customers. Our service centers stock a broad inventory of spare parts and are staffed by factory-certified technicians. System diagnosis is usually completed within 24 hours of receipt of the unit and repairs are carried out within 48 hours of service authorization.

### Training Programs

Since chillers and cooling systems are often sold as sub-systems in OEM equipment, Lytron offers OEMs customized training programs so your service engineers can provide front-line support. The trainings can be conducted either at your facility or at one of our service centers.



Lytron offers three types of cooling systems—compressor-based chillers, liquid-to-liquid cooling systems, and ambient cooling systems. Each unit can be modified with a wide range of options, and, for OEM volumes, we will design and manufacture unique features on standard systems or totally custom systems. Our standard cooling system technologies include:



### Recirculating Chillers (Kodiak®)

*Cooling capacities up to 11 kW (150 kW for custom)*

Kodiak compressor-based recirculating chillers are an ideal solution when you need precise temperature control ( $\pm 0.1^{\circ}\text{C}$ ) and cooling below ambient temperature. Applications include semiconductor equipment, medical equipment, medical and industrial lasers, electron microscopes, analytical instrumentation, and printing equipment.



### Liquid-to-Liquid Cooling Systems (LCS™)

*Cooling capacities up to 150 kW (300 kW for custom)*

Liquid-to-liquid cooling systems offer precise temperature control of process water and transfer the waste heat to facility water. They are ideal for high heat load applications where precise temperature control ( $\pm 0.5^{\circ}\text{C}$  or  $\pm 1.0^{\circ}\text{C}$ ) is needed and chilled facility water is available. Applications include medical equipment, data center equipment, industrial machine tools, printing equipment, semiconductor equipment, and cabinet cooling.



### Modular Cooling Systems (MCS™)

*Cooling capacities up to 3.5 kW (20 kW for custom)*

Modular cooling systems, or ambient cooling systems, are non-refrigerated, liquid-to-air cooling systems. They are a cost-effective alternative to recirculating chillers for applications where precise temperature control and cooling below ambient temperature are not required. Applications include analytical equipment, cabinet cooling, medical equipment, and laser systems.





Kodiak compressor-based recirculating chillers are the ideal solution when you need precise temperature control or cooling below ambient temperature. Kodiak chillers offer outstanding performance and high reliability as well as quiet operation and ease-of-use.

- **Precise temperature control:** Our custom PID controller and advanced refrigeration control circuit ensure that the Kodiak maintains  $\pm 0.1^{\circ}\text{C}$  ( $0.2^{\circ}\text{F}$ ) stability.
- **Quiet operation:** The components inside the Kodiak have been performance-matched for quiet operation. In addition, vibration-isolation of the compressor (and pump in RC006–RC045) and foam padding on panels minimize vibration noise.
- **Many options and features:** The Kodiak was designed for flexibility—a wide variety of pumps, controllers, and additional safety and monitoring features allow you to tailor a Kodiak to your specific application.
- **High reliability:** We are so confident that our Kodiak chillers will provide years of trouble-free operation that we offer a 2-year warranty.
- **Advanced ergonomic design:** Our chillers look as good as the equipment they cool. Our industry-leading industrial design is as functional as it is attractive.
- **CE certified and ITSNA tested to UL 61010A-1 (RC006 – RC045) or MET tested to UL 1995 (RC095–RC115)**

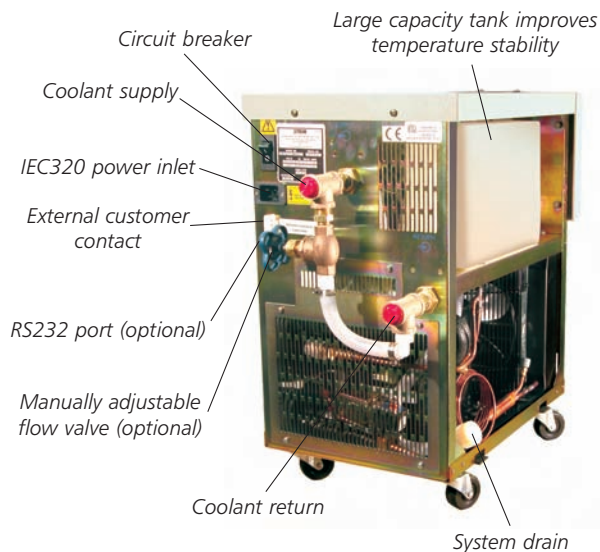
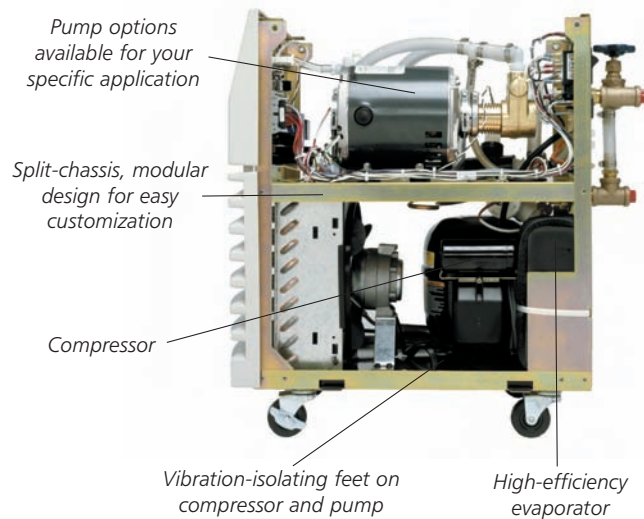
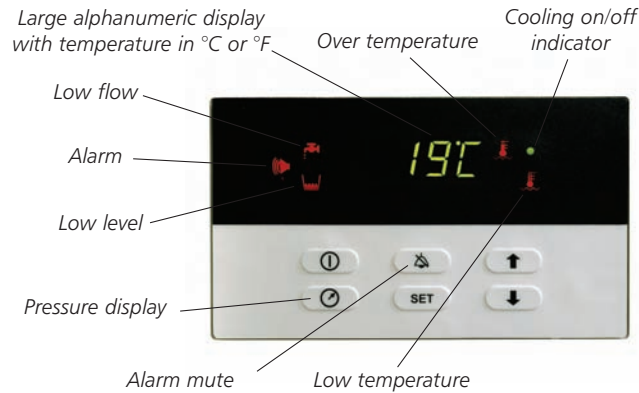
#### Custom Spotlight:

Lytron's custom products leverage existing standard products as well as previously designed custom products. Using these industry-proven technologies, we can reduce your time to market while giving you the customizations, quality, and reliability you need. This custom water-cooled chiller handles specialty cooling fluid and is MET and CE compliant.

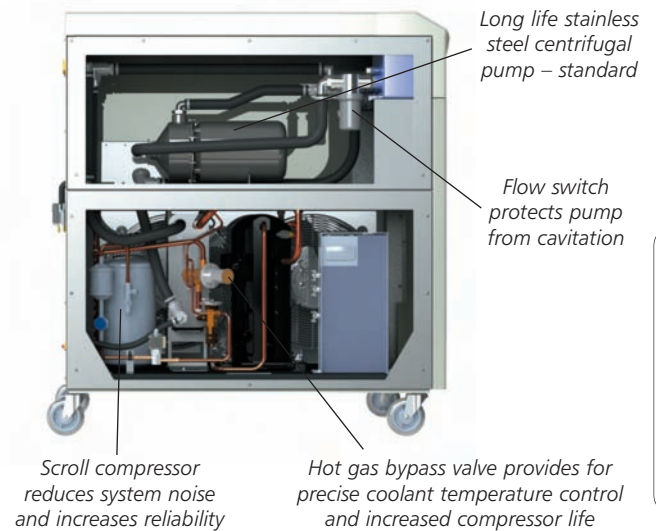
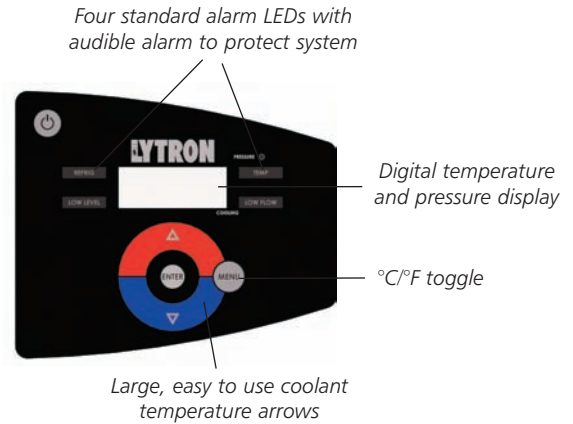
See page 8 for more custom cooling systems.



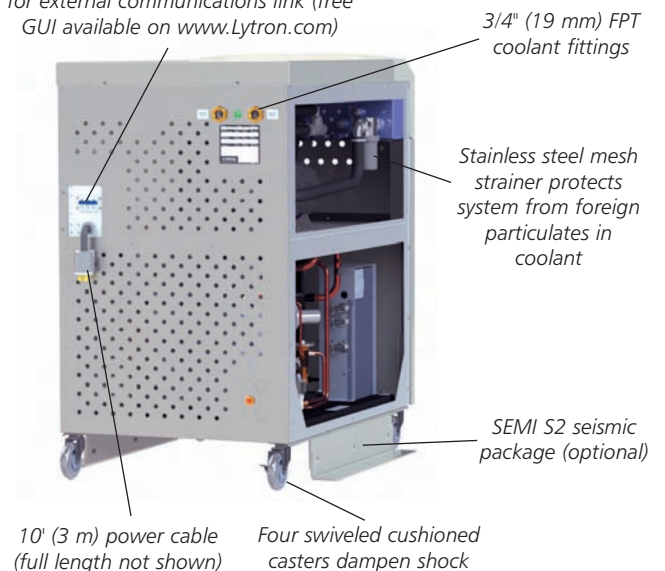
## RC006 – RC045



## RC095 – RC115

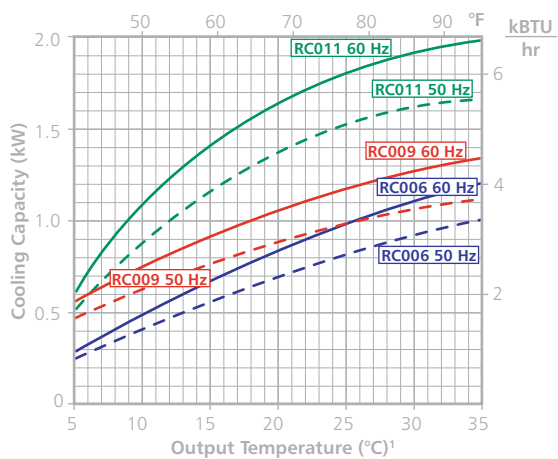


Optional 9 or 25 pin D-sub connectors for external communications link (free GUI available on [www.Lytron.com](http://www.Lytron.com))

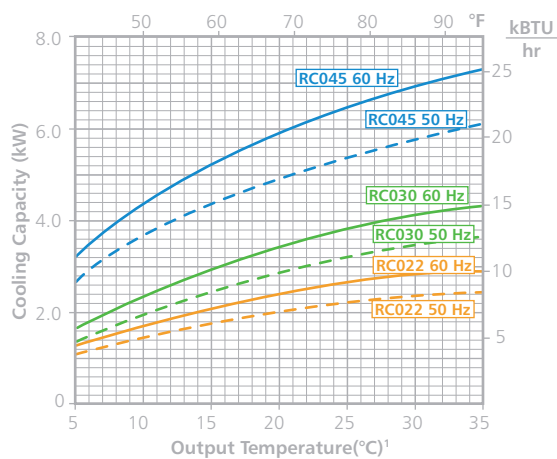


### Thermal Performance Graphs

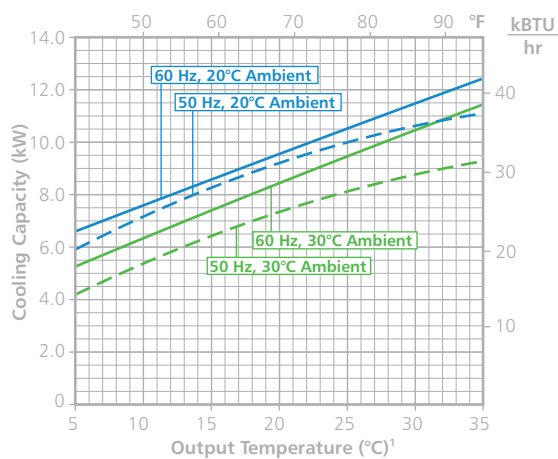
RC006-RC011 Performance



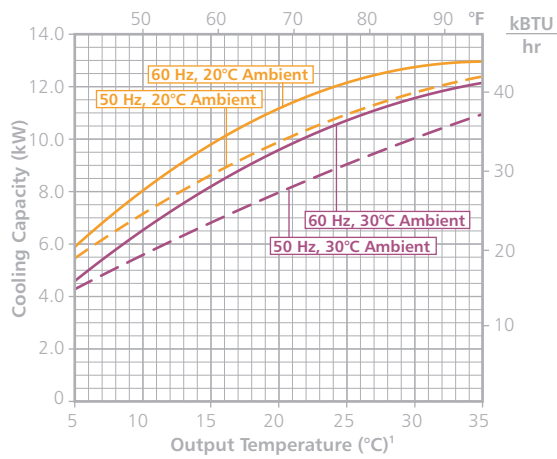
RC022-RC045 Performance



RC095 Performance



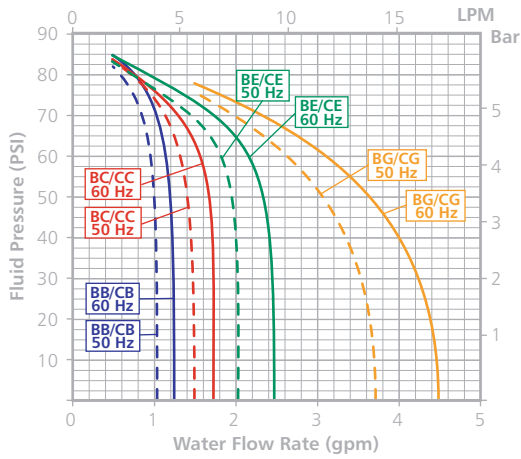
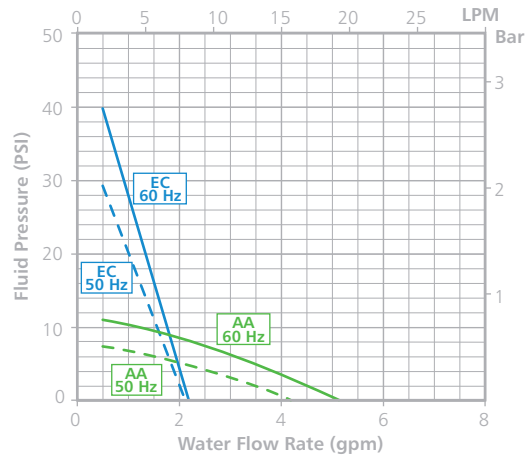
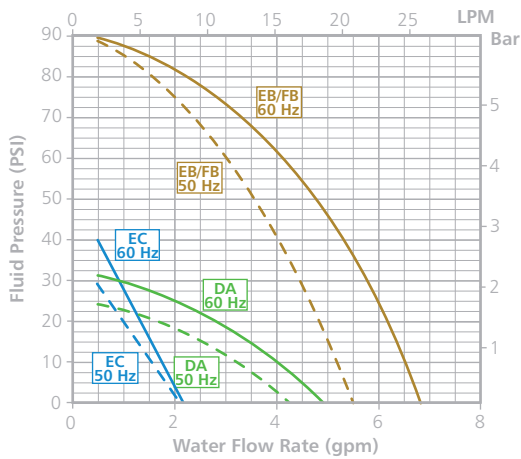
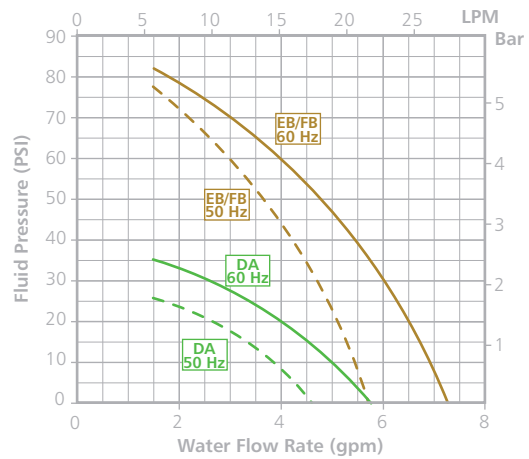
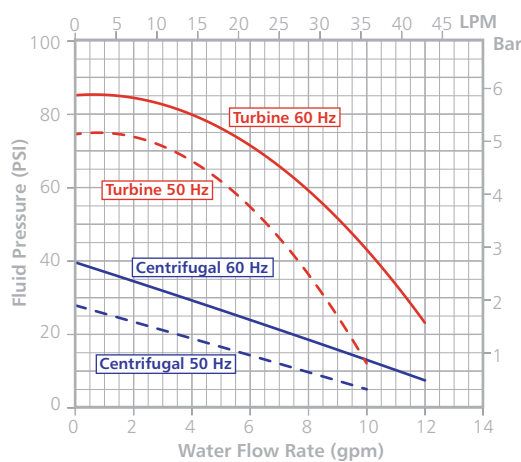
RC115 Performance



<sup>1</sup> Temperature represents output temperature of water assuming 20°C ambient air conditions. Performance subject to change due to variations such as fluid type or operating conditions.



## System Pump Graphs<sup>1</sup>

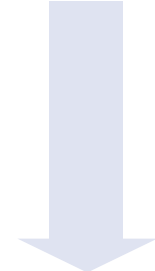
**Kodiak Positive Displacement Pumps<sup>2,3</sup>**

**RC006-RC009 Centrifugal and Turbine Pumps**

**RC011-RC022 Centrifugal and Turbine Pumps**

**RC030-RC045 Centrifugal and Turbine Pumps**

**RC095-RC115 Centrifugal and Turbine Pumps**


<sup>1</sup> Includes pressure drop through chiller. See pumps overview on [www.Lytron.com](http://www.Lytron.com) for guidance on selecting a pump.

<sup>2</sup> Pressure relief is factory set at 90 psi (6.2 bar). Other settings available upon request.

<sup>3</sup> BG/CG pumps can be operated at flow rates as low as 0.5 gpm (1.9 lpm) for the RC011 and RC022.

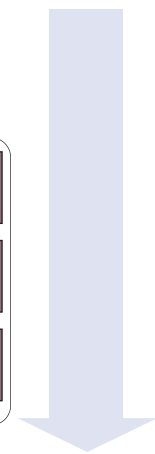
First select your model number



Next, pick an electrical configuration



Now, select a pump



Continue on next page

		RC006	RC009	RC011	RC022	RC030	RC045	RC095	RC115
Cooling capacity <sup>1</sup>	W kBTU/Hr	825 2.8	1050 3.6	1650 5.6	2400 8.2	3450 11.8	5900 20.1	9600 32.7	11000 37.5
Compressor capacity	HP	¼	½	¾	¾	1	1½	3½	
Temperature stability <sup>1, 2</sup>		± 0.1°C							
Fluid connections		½" FNPT						¾" FNPT	
Reservoir capacity		1 gal/4 liters		2 gal/8 liters		6 gal/23 liters		1.75 gal (6.5 liters)	
Coolant temperature range		40°F to 95°F/5°C to 35°C						39°F to 95°F/4°C to 35°C	
Ambient temperature range		50°F to 95°F/10°C to 35°C						41°F to 95°F/5°C to 35°C	
Dimensions (W x D x H)	inches mm	12.5 x 19.0 x 22.0 318 x 483 x 559		14.8 x 24.5 x 26.5 376 x 623 x 673		21.4 x 27.8 x 31.9 543 x 705 x 810		32.0 x 43.0 x 45.0 813 x 1092 x 1143	
Weight	dry lbs (kg)	97 (44)	100 (45)	122 (55)	166 (75)	260 (118)	270 (122)	517 (235)	
Electrical configurations and full load amperage <sup>3</sup>									
G03:	115V, 60 Hz, 1ph	Amps	9.9	12.2	14.3	n/a	n/a	n/a	
H03:	230V, 50 Hz, 1ph	Amps	4.5	5.3	6.3	9.5	13.7	17.2	
J03:	208/230V, 60 Hz, 1ph	Amps	n/a	5.8	7.4	10.0	14.5	19.6	
M01:	200-220V, 50 Hz, 3 ph; 208-230V, 60 Hz, 3 ph	Amps						22.2	22.2
R01:	460V, 60 Hz, 3 ph	Amps						11.0	11.0
T01:	380V, 50 Hz, 3 ph	Amps						11.0	11.0
Pump options (visit <a href="http://www.Lytron.com">www.Lytron.com</a> for guidance on selecting a pump; refer to page 17 for system pump graphs)									
BB:	PDP <sup>4</sup> , Brass, 1.3 gpm/4.9 lpm	●	●	●	●				
BC:	PDP <sup>4</sup> , Brass, 1.8 gpm/6.8 lpm	○	○	○	○				
BE:	PDP <sup>4</sup> , Brass, 2.3 gpm/8.7 lpm	○	○	○	○				
BG:	PDP <sup>4</sup> , Brass, 4.3 gpm/16.3 lpm			○	○	●	●		
CB:	PDP <sup>4, 5</sup> , Stainless Steel, 1.3 gpm/4.9 lpm	○	○	○	○				
CC:	PDP <sup>4, 5</sup> , Stainless Steel, 1.8 gpm/6.8 lpm	○	○	○	○				
CE:	PDP <sup>4, 5</sup> , Stainless Steel, 2.3 gpm/8.7 lpm	○	○	○	○				
CG:	PDP <sup>4, 5</sup> , Stainless Steel, 4.3 gpm/16.3 lpm			○	○	○	○		
AA:	Centrifugal, ⅛ HP <sup>6</sup>	○	○						
DA:	Centrifugal, ¼ HP <sup>6</sup>			○	○	○	○		
DF:	Centrifugal, 1.5 HP <sup>6</sup>							●	●
EC:	Turbine, ⅛ HP <sup>6</sup>	○	○	○	○				
EB:	Turbine, ½ HP <sup>6</sup>			○	○	○	○		
ED:	Turbine, Bronze, 1.5 HP <sup>6</sup>							○	○
FB:	Turbine, Stainless Steel, ⅛ HP <sup>6</sup>			○	○	○	○		
FD:	Turbine, Stainless Steel, 1.5 hp <sup>6</sup>							○	○



Select your controller

	RC006	RC009	RC011	RC022	RC030	RC045	RC095	RC115
<b>Controller options (visit <a href="http://www.Lytron.com">www.Lytron.com</a> for a full description of these options)</b>								

<b>Package 1:</b> Digital temperature display, calibration offset, low flow shut-off, auto-restart, °C/°F toggle.	○	○	○	○	○	○		
<b>Package 2:</b> Package 1 plus digital pressure sensing, low level, low/high temperature, pressure display, audible alarm and alarm mute, fault shut-off (toggle on/off), relay contacts.	●	●	●	●	●	●		
<b>Package 3:</b> Package 2 plus RS232.	○	○	○	○	○	○		
<b>Package 4:</b> Digital temperature and pressure display, low level, low/high temp, low/high refrigerant pressure visual/audible alarms, low coolant flow and low refrigerant pressure shut off, auto-restart, and °C/°F toggle.							●	●
<b>Package 5:</b> Same as Package 4 plus 25 pin D connector with DC signal for low flow, low level, low/high temperature alarms.							○	○
<b>Package 6:</b> Same as Package 4 plus 9 pin D connector with RS-232 communication.							○	○
<b>Package 7:</b> Same as Package 5 with RS-485 communication.							○	○
<b>Package 8:</b> Same as Package 5 with 4-20mA remote set point and retransmission.							○	○
<b>Package 9:</b> Same as Package 5 with 0-10VDC remote set point and retransmission.							○	○
<b>Package A:</b> Same as Package 4 plus RJ45 connector with Ethernet communication.							○	○

Add any additional options

<b>Available options (visit <a href="http://www.Lytron.com">www.Lytron.com</a> for a full description of these options)</b>								
External flow valve	○	○	○	○	○	○	○	○
External pressure relief valve	○	○	○	○	○	○	○	○
Anti-siphon system	○	○	○	○	○	○	○	○
Air filter	○	○	○	○	○	○	●	●
5 micron coolant filter <sup>8,9</sup>	○	○	○	○	○	○	○	○
Heater <sup>10</sup>			○	○	○	○		
Internal insulation package	○	○	○	○	○	○	○	○
Low temperature operation <sup>11</sup>		○	○	○	○	○	○	○
Water-cooled condenser			○	○	○	○	○	○
0.1°C set point	○	○	○	○	○	○		
Deionization package <sup>8,12</sup>	○	○	○	○	○	○	○	○
High purity plumbing	○	○	○	○	○	○	○	○
PAO compatibility			○ <sup>10</sup>	○	○	○		
Remote start <sup>13</sup>	○	○	○	○	○	○	○	○
SEMI S2 and F47 compliance							○	○

● = standard ○ = available option <sup>1</sup> At 20°C setpoint, 20°C ambient, 60Hz input supply <sup>2</sup> Assumes stable load <sup>3</sup> With standard pump  
<sup>4</sup> PDP = Positive Displacement Pump <sup>5</sup> Only available with high purity plumbing <sup>6</sup> Actual flow rate depends on system pressure drop. See pumps overview on [www.Lytron.com](http://www.Lytron.com) for information on how to calculate flow rate <sup>7</sup> 5 piece min order <sup>8</sup> Not available with AA and DA pump <sup>9</sup> For RC095 and RC115, ships loose to allow protection of the chiller or customer's equipment <sup>10</sup> Not available in G03 electrical configuration <sup>11</sup> Requires internal insulation package <sup>12</sup> Recommended when selecting higher purity option <sup>13</sup> Included in controller packages 5-9 and A

To arrive at a part number

**RC011 G03 BB 2 M**

RC011 chiller with G03 (115V, 60 Hz, 1ph) electrical configuration, a BB pump, and controller package 2  
 Customization options (A 4 digit option code will be assigned at time of order, based on selected options. Leave blank if no additional options selected.)

Use our product selector at [www.Lytron.com](http://www.Lytron.com) to automatically select the right chiller based on your specifications.



Reservoir-level indicator

Split-chassis, modular design  
for easy customization $\pm 0.5^{\circ}\text{C}$  temperature  
stabilityHigh-efficiency counterflow  
heat exchanger

Wide variety of pump options

Heavy-duty casters  
(two locking)

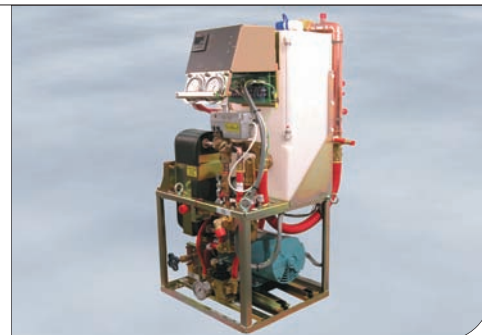
Lytron's Liquid-to-Liquid Cooling System (LCS20) offers precise temperature control of process water and transfers the waste heat to your facility water via a liquid-to-liquid heat exchanger. It is an excellent solution for high heat-load or high ambient temperature applications where chilled facility water is available.

- **Large cooling capacity in a compact package:** An LCS is a great solution for high heat loads where space is at a premium. With 20 kW of cooling, our LCS20 provides over three times the capacity of a comparably-sized recirculating chiller.
- **Tight temperature control:** We maintain the fluid temperature to within  $\pm 0.5^{\circ}\text{C}$ , despite fluctuations in the facility water temperature and flow rate. Our PID controller varies the facility water flow rate through the heat exchanger based on the process water temperature to achieve this stability.
- **Contamination-free:** The process cooling loop of the LCS is isolated from the facility water. This separation protects your equipment, keeping it free from facility water contaminants. It also eliminates the risk of condensation near your equipment if the facility water is below the dew point.
- **Reliable, quiet, and energy efficient:** The LCS system contains very few moving parts—this makes it inherently reliable and quiet. The only components requiring power are the pump, motor, and controller, so it is also extremely energy efficient.
- **ITSNA tested to UL 61010A-1 and CE certified**

**Custom Spotlight:**

A customer had a total heat load of 25 kW and access to facility water. They needed to cool four independent heat sources and wanted the cooling system integrated into their machine. Lytron provided a fully-engineered skinless system that included integrated temperature and pressure sensors and was designed for serviceability.

See page 8 for more custom cooling systems.



Controller with digital temperature, flow, and pressure display; mixing valve status reporting; lock-out protection and RS232 (Ethernet available) communication

Redundant pump with user defined secondary pump test frequency and duration

Visual alarms for low/high temperature, low flow, dew point (optional), pump, power, or sensor failure; relay contacts for each alarm

Isolation valves allow for hot swapping of pump

Accommodates dual power feeds

Control to local dew point available



The increasing heat load densities in datacom equipment centers require ever more sophisticated approaches to cooling, including liquid cooling. Designed for data center cooling, the LCS50 is a 150 kW liquid-to-liquid cooling system that supplies precise temperature-controlled coolant to your liquid cooled racks and transfers the waste heat to facility water.

- **High reliability:** The LCS50 is designed to be extremely reliable. Redundant pumps ensure the system always provides coolant to your racks. The controller tracks the actual operation hours for each pump and the backup pump is tested periodically to guarantee its operation if needed. The controller warns you of any system problems via various alarms and offers lockout protection and communication packages for remote monitoring.
- **Protection and isolation of datacom equipment:** According to ASHRAE, the benefits of an LCS for liquid cooling include "preventing condensation by delivering coolant to the rack, equipment, or electronics above the dew point," "isolating the electronics from the harsher facility water," and "minimizing the coolant volume near the technology so that a coolant leak would be less catastrophic."<sup>1</sup>
- **Easy to install:** The unit is equipped with casters for easy mobility and leveling feet that disengage the casters. The inlets and outlets of the facility (primary) and process (secondary) coolant loops can be configured for a raised floor or overhead plumbing.
- **Energy efficient and quiet:** Liquid cooling the electronics cabinet is significantly more energy efficient than air cooling.
- **UL/CE/CSA and RoHS**

<sup>1</sup> American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2006). *Liquid Cooling Guidelines for Datacom Equipment Centers*. Atlanta.

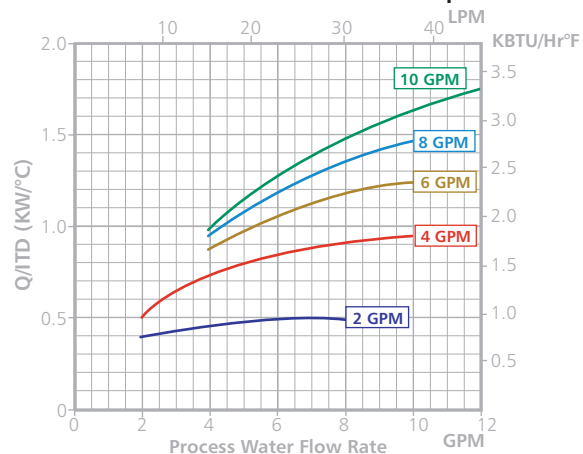


#### Custom Spotlight:

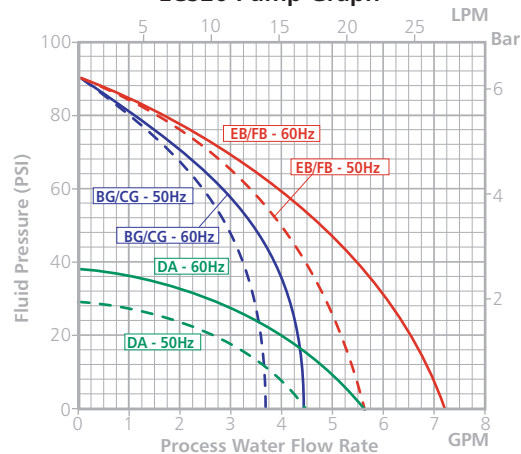
A customer needed a liquid-to-liquid cooling system for medical imaging equipment. This custom unit contains three separate cooling loops, two liquid cooling and one air cooling, all managed by the unit's controller.

See page 8 for more custom cooling systems.

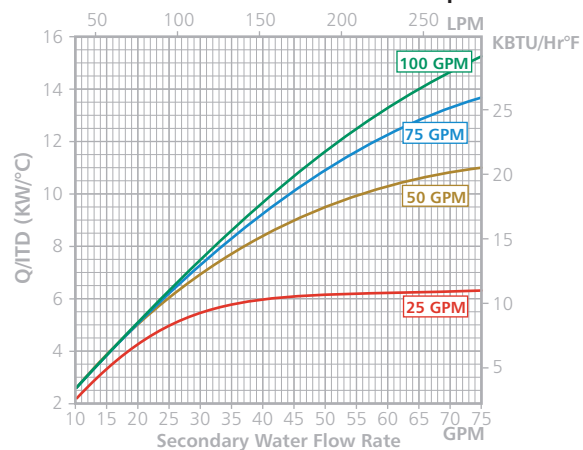
LCS20 Thermal Performance Graph<sup>1</sup>



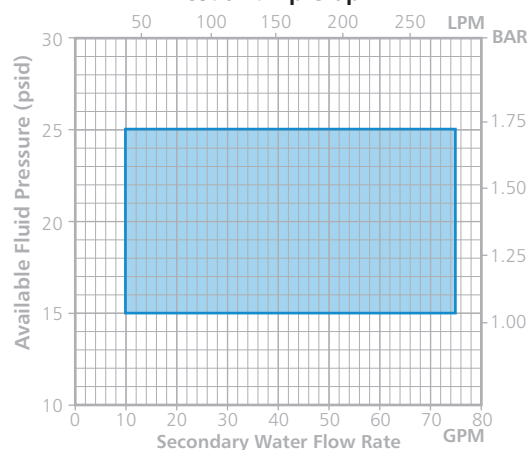
LCS20 Pump Graph<sup>2,3</sup>



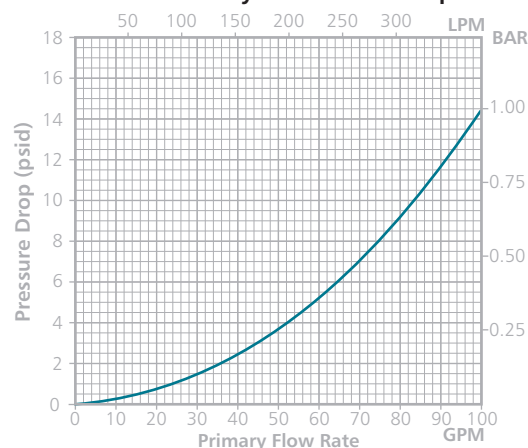
LCS50 Thermal Performance Graph<sup>1</sup>



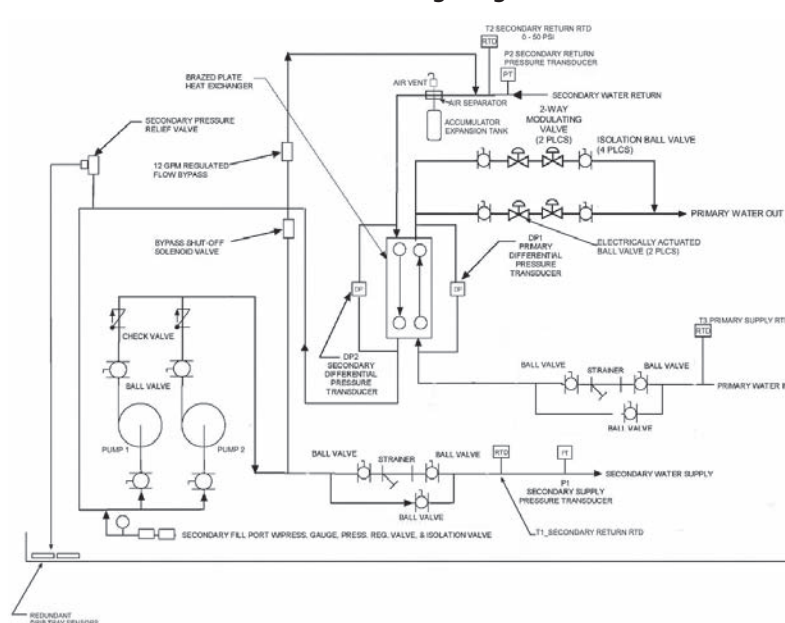
LCS50 Pump Graph<sup>3</sup>



LCS50 Primary Side Pressure Drop



LCS50 Plumbing Diagram<sup>4</sup>



<sup>1</sup> Facility side flow rates are represented by curves.

<sup>2</sup> Pressure relief is factory set at 90 psi (6.2 bar). Other settings available on request.

<sup>3</sup> Includes pressure drop through system. See LCS specifications and options for pump descriptions.

<sup>4</sup> See [www.Lytron.com](http://www.Lytron.com) for larger plumbing diagram.



First select your  
model numberNext, pick an  
electrical  
configurationNow, select  
a pumpAnd select your  
controllerAdd any  
additional  
optionsTo arrive at a  
part number

		LCS20	LCS50
Cooling capacity		20 kW (68 kBTU/Hr) at 4.3 GPM process and 10 GPM facility and 20°C Initial Temperature Difference (ITD)	150 kW (512 kBTU/Hr) at 75 GPM process and 100 GPM facility and 10°C Initial Temperature Difference (ITD)
Temperature stability		± 0.5°C	± 1.0°C
Fluid connections		¾" FNPT	2" copper flange terminated at bottom of unit
Reservoir capacity		6 gal/22 liters	N/A
Coolant temperature range		50°F to 140°F/10°C to 60°C	41°F to 95°F/5°C to 35°C
Facility water temperature range		50°F to 95°F/10°C to 35°C	39°F to 54°F/4°C to 12°C
Ambient temperature range		41°F to 104°F/5°C to 40°C	
Facility flow rate		2 to 10 gpm/8 to 38 lpm	25 to 100 gpm/95 to 379 lpm
Facility pressure		100 psi/7 bar max	100 PSI/ 7 bar max
Facility pressure drop		15 psi/1 bar at max flow	See Pressure Drop Graph
Dimensions (W x D x H)	inches mm	21.4 x 27.8 x 31.9 543 x 705 x 810	24.0 x 48.0 x 76.3 610 x 1219 x 1938
Weight	lbs kg	140 64	900 408

**Electrical configurations and full load amperage<sup>1</sup>**

<b>G01:</b> 100-120V, 50/60 Hz	Amps	7.2	N/A
<b>J01:</b> 200-240V, 50/60 Hz	Amps	3.6	N/A
<b>L01:</b> 208-230 VAC, 50/60 Hz, 3ph	Amps	N/A	18
<b>P01:</b> 460 VAC, 50/60 Hz, 3ph	Amps	N/A	9

**Pump options (visit [www.Lytron.com](http://www.Lytron.com) for guidance on selecting a pump; refer to page 22 for system pump graphs)**

<b>BG:</b> PDP <sup>2</sup> , Brass, 4.3 gpm/16.3 lpm	●	
<b>CG:</b> PDP <sup>2,3</sup> , Stainless Steel, 4.3 gpm/16.3 lpm	○	
<b>DA:</b> Centrifugal, ¼ HP <sup>4</sup>	○	
<b>EB:</b> Turbine, ½ HP <sup>4</sup>	○	
<b>FB:</b> Turbine, Stainless Steel, ½ HP <sup>3,4</sup>	○	
<b>DE:</b> Centrifugal, 3 HP, 2 per system		●

**Controller options (visit [www.Lytron.com](http://www.Lytron.com) for a full description of these options)**

<b>LCS20 Only Package 1:</b> Digital temperature display, °C/°F toggle, over-temperature indicator, calibration offset	●	
<b>LCS20 Only Package 2:</b> Package 1 plus low level indicator, low flow indicator, analog output	○	
<b>LCS50 Only Package 3:</b> RS232 controller with digital temperature, flow, and pressure display; modulating valve status reporting; visual alarms for low/high temperature, low flow, pump, power, or sensor failure; relay contacts for each alarm; and lock-out protection.		●
<b>LCS50 Only Package 4:</b> Package 3 plus visual alarm and relay contacts for dew point; option to control set point based on dew point offset or on fixed temperature with user defined dew point override.		○
<b>LCS50 Only Package 5:</b> RS232 and Ethernet controller with digital temperature, flow, and pressure display; modulating valve status reporting; visual alarms for low/high temperature, low flow, pump, power, or sensor failure; relay contacts for each alarm; and lock-out protection.		○
<b>LCS50 Only Package 6:</b> Package 5 plus visual alarm and relay contacts for dew point; option to control set point based on dew point offset or on fixed temperature with user defined dew point override.		○

**Available options (visit [www.Lytron.com](http://www.Lytron.com) for a full description of these options)**

External flow valve	○	
External pressure relief valve	○	
5 micron coolant filter <sup>5</sup>	○	
DI water cartridge <sup>5</sup>	○	
High purity plumbing	○	
Heater <sup>6</sup>	○	
Internal insulation package	○	●
80 mesh coolant filters on process and facility sides		●
Dual modulating valves		●

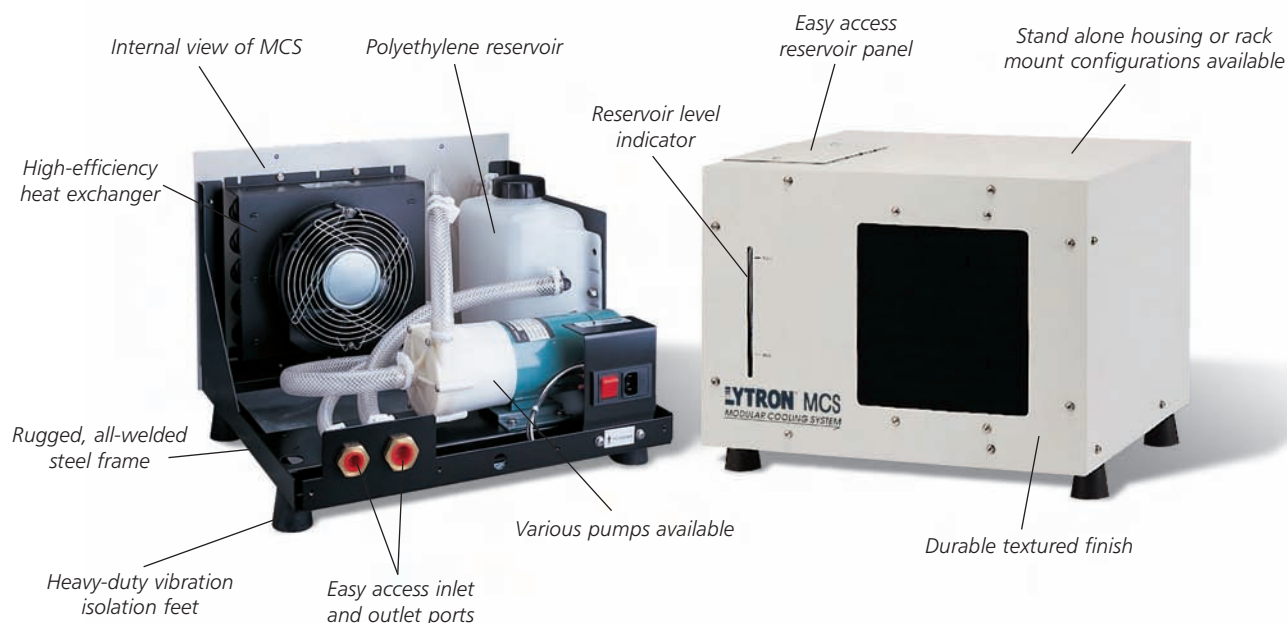
● = standard ○ = available option <sup>1</sup>With standard pump <sup>2</sup>PDP = Positive Displacement Pump (J01 only). <sup>3</sup>Only available with high purity plumbing.  
<sup>4</sup>Actual flow rate depends on system pressure drop. <sup>5</sup>Not available with DA pump. <sup>6</sup>Not available with G01 electrical configuration.

**LCS 20 G01 BG 1 M**

An LCS20, 100-120V, 50/60 Hz, with BG pump and controller package 1

Customization options (A 4 digit option code will be assigned at time of order, based on selected options. Leave blank if no additional options selected.)





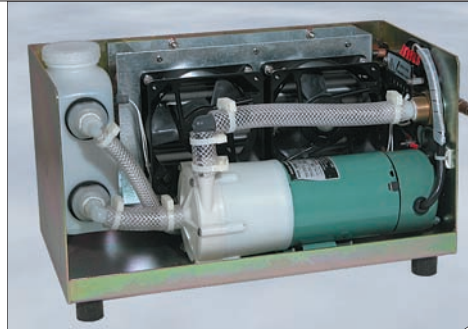
A Modular Cooling System (MCS) is a cost-effective and reliable alternative to refrigerated chillers for applications where precise temperature control and cooling below ambient temperature are not required. It consists of a high performance Lytron heat exchanger integrated with a fan, pump, and tank in a durable metal chassis.

- **Extremely efficient:** All components are performance-matched for maximum cooling capacity. Lytron has more than 50 years of experience in thermal design, so you can be sure that the most critical component of the MCS, the heat exchanger, is designed for optimum performance.
- **Easy-to-operate:** This easy-to-use, turnkey cooling package takes the guesswork and effort out of building a cooling loop. All you need to do is fill the tank and flip the switch.
- **Compatible with a range of coolants:** We offer systems with copper heat exchangers for use with water, stainless steel heat exchangers for use with deionized water, and aluminum heat exchangers for use with oil or Ethylene Glycol/Water (EGW) mixture. This ensures that we have a product optimized for virtually any cooling fluid.
- **19" (48 cm) rack mount version available:** Integration into your system is simple with our rack-mounted versions (MCS20 and MCS30).
- **Extremely reliable:** All components in the MCS have been designed for long life and high reliability—a Lytron MCS will provide years of trouble-free operation.
- **ITSNA tested to UL 61010A-1 and CE certified**

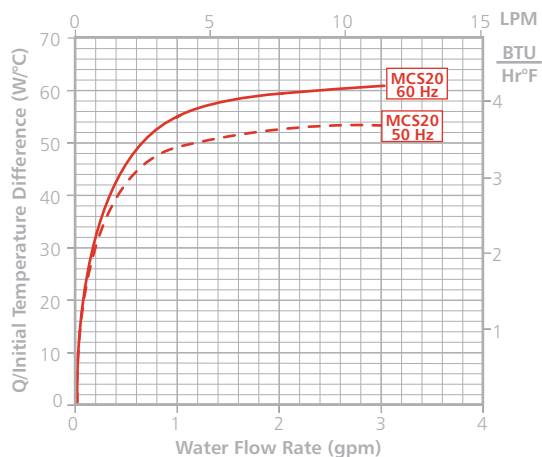
#### Custom Spotlight:

A customer needed a tightly packaged MCS to integrate into their system. Lytron engineers selected a high-efficiency OEM Coil heat exchanger, a long-life centrifugal pump, and a compact reservoir for the unit.

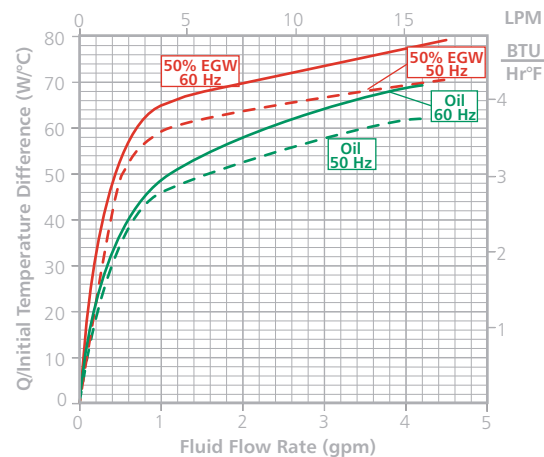
See page 8 for more custom cooling systems.



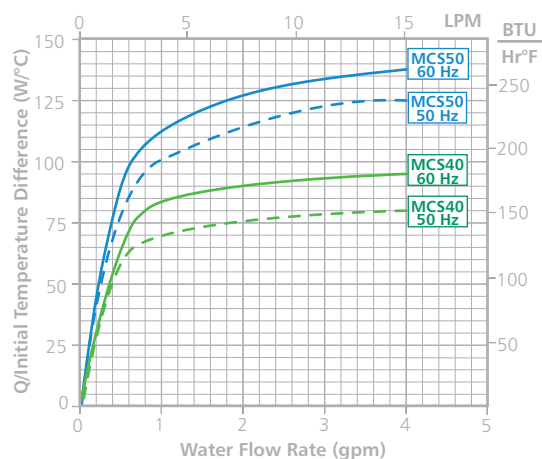
MCS20 Thermal Performance



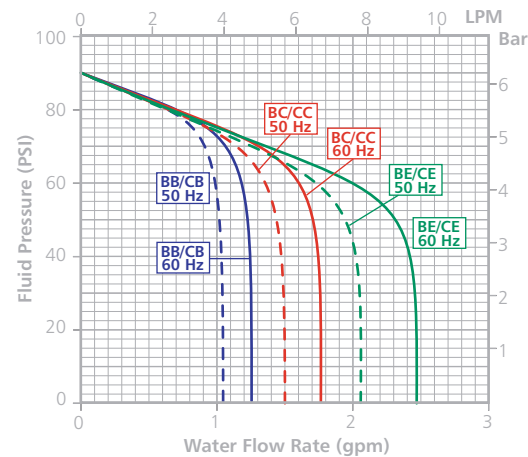
MCS30 Thermal Performance<sup>1</sup>



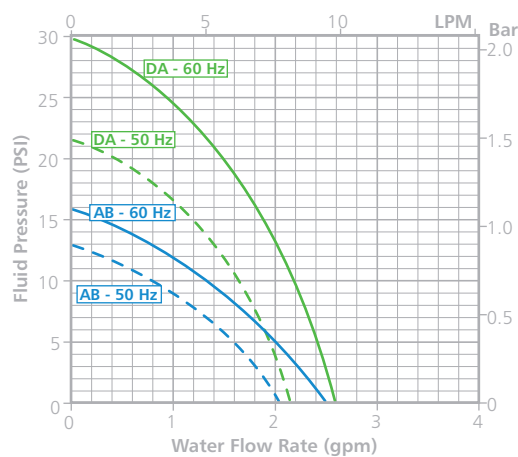
MCS40 and MCS50 Thermal Performance



MCS Positive Displacement Pumps

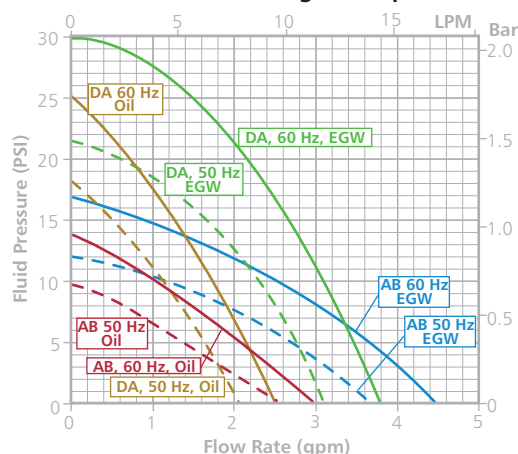
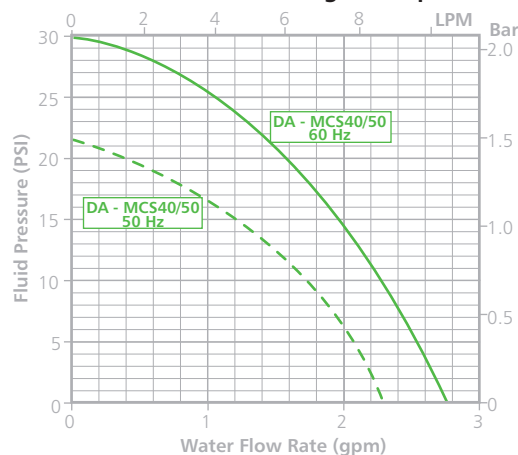


MCS20 Centrifugal Pumps<sup>2</sup>



<sup>1</sup> Oil @ 70°F, 50/50 EGW <sup>2</sup> Includes pressure drop through system. Visit [www.Lytron.com](http://www.Lytron.com) for guidance on selecting a pump.



MCS30 Centrifugal Pumps<sup>1,2</sup>MCS40/50 Centrifugal Pumps<sup>2</sup>

First select your model number

Next, select an electrical configuration

Now, select a pump

Add the ambient package

Add any additional options

To arrive at a part number

		MCS20	MCS30	MCS40	MCS50
Cooling capacity using water, 25°C initial temperature difference	W BTU/Hr	1300 4,450	2100 7,150	2400 8,200	3500 12,000
Fluid Inlet Connections		½" FNPT	½" Barb	½" FNPT	½" FNPT
Fluid Outlet Connections		½" FNPT	½" Barb	½" FNPT	½" FNPT
Reservoir capacity		0.75 gal/2.8 liters			
Maximum liquid temperature		131°F/55°C			
Dimensions (W x D x H)	inches mm	17.3 x 15.1 x 13.3 439 x 384 x 338		15 x 15 x 24 381 x 381 x 610	
Rack Mount Dimensions (W x D x H)	inches mm	19 x 15.1 x 12.3 482 x 384 x 312		n/a	
Weight – stand alone	lbs (kg)	35 (16)	37 (17)	60 (27)	65 (29)
Weight – rack mount	lbs (kg)	23 (10)	25 (11)	n/a	n/a
Recommended coolant		water	oil, EGW	water	water

Available electrical configurations and full load amperage<sup>3</sup>

G01: 115V, 60Hz, 1ph	Amps	5.3	5.3	n/a	n/a
G02: 115V, 60Hz, 1ph	Amps	n/a	n/a	5.6	5.8
H01: 230V, 50/60 Hz, 1ph	Amps	2.5	2.5	n/a	n/a
J02: 230V, 50/60 Hz, 1ph	Amps	n/a	n/a	2.7	2.8

Pump options (visit [www.Lytron.com](http://www.Lytron.com) for guidance on selecting a pump; refer to page 25 & 26 for system pump graphs)

BB: PDP <sup>4</sup> , Brass, 1.3 gpm/4.9 lpm	●	●		
BC: PDP <sup>4</sup> , Brass, 1.8 gpm/6.8 lpm	○	○	●	●
BE: PDP <sup>4</sup> , Brass, 2.3 gpm/8.7 lpm	○	○	○	○
CB: PDP <sup>4,5</sup> , Stainless Steel, 1.3 gpm/4.9 lpm	○			
CC: PDP <sup>4,5</sup> , Stainless Steel, 1.8 gpm/6.8 lpm	○			
CE: PDP <sup>4,5</sup> , Stainless Steel, 2.3 gpm/8.7 lpm	○			
AB: Centrifugal, ⅓ HP <sup>6</sup>	○	○		
DA: Centrifugal, ¼ HP <sup>6</sup>	○	○	○	○

## Package Options

Package 1: Ambient Package	●	●	●	●
----------------------------	---	---	---	---

## Additional Options

M002: Heavy duty casters	○	○	○	○
M062: Rack mount configuration	○	○		
M004: High purity plumbing (stainless steel heat exchanger, nickel-plated bulkhead fittings)	○			
M063: Rack mount configuration and high purity plumbing	○			
M055: High purity plumbing and heavy duty casters	○			

● = standard ○ = available option <sup>1</sup> Oil @ 70°F, 50/50 EGW <sup>2</sup> Includes pressure drop through system. Visit [www.Lytron.com](http://www.Lytron.com) for guidance on selecting a pump. <sup>3</sup> With standard pump <sup>4</sup> PDP = Positive Displacement Pump <sup>5</sup> Only available with high purity plumbing <sup>6</sup> Actual flow rate depends on system pressure drop. See [www.Lytron.com](http://www.Lytron.com) for information on how to calculate flow rate.

**MCS20 G01 BB 1** MCS20, 115V, 60 Hz operation, with BB pump and no additional options  
 or  
**MCS40 G02 BC 1 M002** MCS40, 115V, 60 Hz operation, with BC (brass) pump, and heavy duty casters

## Selecting a Recirculating Chiller

Selecting the proper recirculating chiller is a function of four factors:

1. Heat load generated by the device being cooled ( $Q$ )
2. Maximum acceptable temperature of the fluid exiting the heat source ( $T_{OUT}$ )
3. Fluid flow rate ( $\dot{V}$ )
4. Ambient operating conditions

Often, an equipment manufacturer will specify the cooling capacity, set point temperature, and flow rate of the required chiller. In this case, selecting a chiller is easy. Simply mark the intersection of the desired cooling capacity and the set point temperature on the chiller graph. Any chiller with a performance curve above or equal to this point will provide enough capacity. Next, use the pump graph to select a pump that meets the desired flow rate.

### Example:

A chiller needs to supply 2 gpm at 20°C to an x-ray tube that generates 2,000 W of heat. The power supply is 60 Hz. Marking this point on the chiller graph (Fig 1) we can see that an RC022 would be an appropriate choice. From looking at the pump curves (Fig 2) we see that a BE pump would provide the necessary flow rate. For more examples, please visit [www.Lytron.com](http://www.Lytron.com).

Fig 1: RC022-RC045 Performance

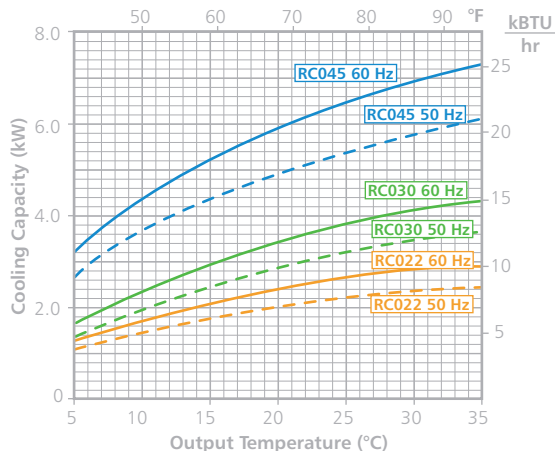
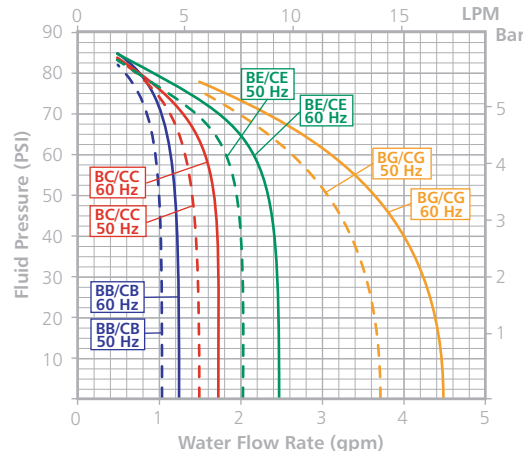


Fig 2: Kodiak Positive Displacement Pumps



## Selecting a Liquid-to-Liquid Cooling System

In most LCS sizing applications, we know the temperature of the facility water ( $T_F$ ), the desired process set point temperature ( $T_p$ ), the flow rate through the process ( $\dot{V}_p$ ) and the heat load of the process,  $Q$ . To determine the required capacity,  $Q/ITD$ , we first need to calculate the change in temperature,  $\Delta T$ , through the process. We can do this either by using the heat capacity graphs found on [www.Lytron.com](http://www.Lytron.com) or by solving the heat capacity equation:

$$Q = \dot{m} C_p \Delta T$$

Next, we calculate  $Q/ITD$  to find the required cooling capacity.  $Q$  is the process heat load.  $ITD$ , the Initial Temperature Difference, is the difference in temperature between the warm return water, ( $T_p + \Delta T$ ), and the cold facility water ( $T_F$ ).

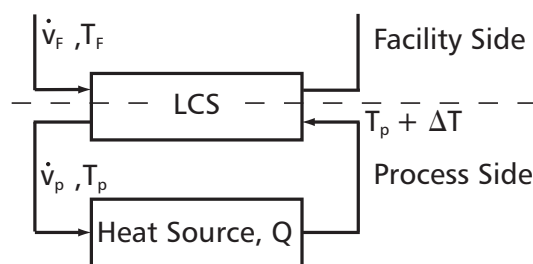
$$\frac{Q}{ITD} = \frac{\dot{m} C_p \Delta T}{T_p + \Delta T - T_F}$$

Finally, refer to the LCS performance graph to determine the facility process flow rate required to achieve the calculated  $Q/ITD$ .

### Example:

A solder reflow oven requires a process set point of 20°C. The heat load is 10 kW and the process water flow rate is 5 gpm. The facility water is at 10°C.

Using heat capacity graphs, which can be found on [www.Lytron.com](http://www.Lytron.com), we find that the  $\Delta T$  through the process is approximately 7.6°C for the condition 10 kW at 5 gpm.

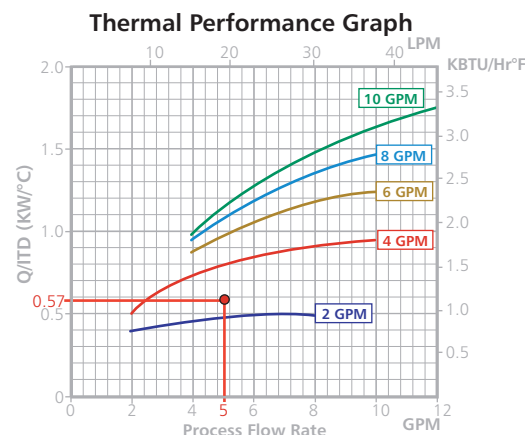
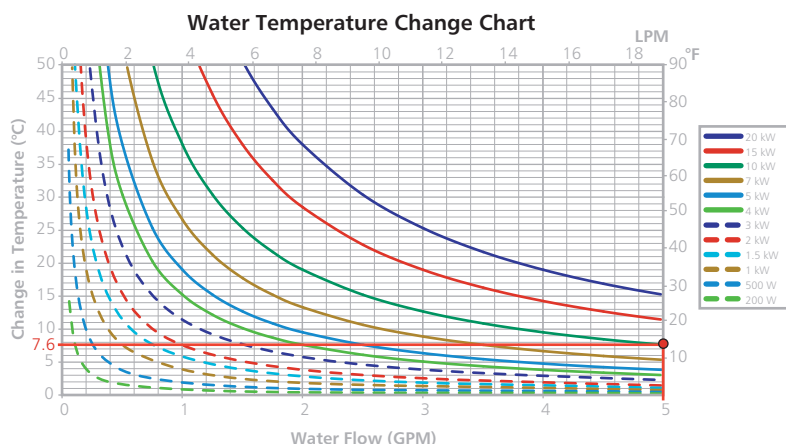


## Selecting a Cooling System

We can now solve for Q/ITD as follows:

$$\frac{Q}{ITD} = \frac{10 \text{ kW}}{20^{\circ}\text{C} + 7.6^{\circ}\text{C} - 10^{\circ}\text{C}} = 0.57 \frac{\text{kW}}{^{\circ}\text{C}}$$

Referencing the LCS performance graph, we can see that a facility flow rate above 2 gpm will meet the required performance.



### Selecting a Modular Cooling System (MCS)

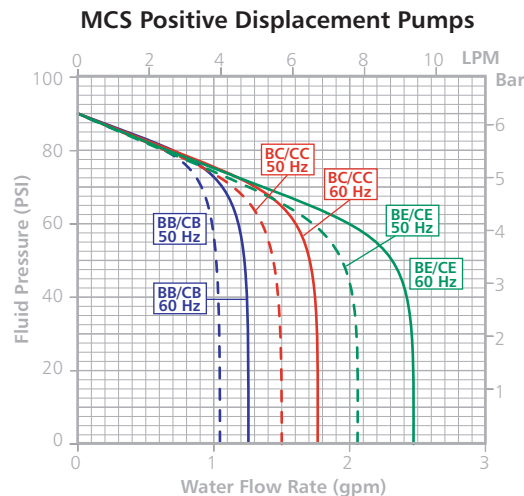
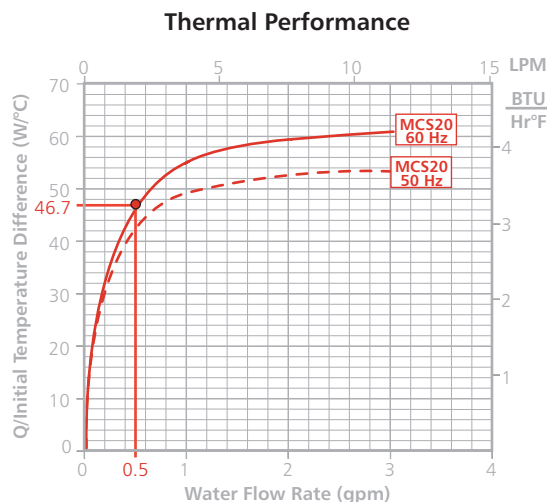
To select the correct MCS, you first need to determine Q/ITD. Q is the heat load, and ITD is the Initial Temperature Difference, or the difference between the MCS liquid inlet temperature and the ambient air temperature. Then, using the MCS performance graph, draw a horizontal line at the calculated Q/ITD value and a vertical line at the process flow rate. If the intersection of those is on or below the system curve, it will meet the required thermal capacity. Finally, check that the pump will provide sufficient flow rate.

#### Example:

A laser produces 700 W of waste heat. The water temperature exiting the laser should be less than 35°C. Ambient room temperature is 20°C. The laser equipment requires a flow rate of at least 1 gpm. Which MCS system should be selected? First, determine Q/ITD:

$$Q/ITD = 700 \text{ W} / (35^{\circ}\text{C} - 20^{\circ}\text{C}) = 46.7 \text{ W/}^{\circ}\text{C}$$

Using the thermal performance graph, you can see that at flow rates above 0.5 gpm, the MCS20 will provide adequate performance. The standard BB pump offers a flow rate of 1.3 gpm so it will work well.







#### Contents:

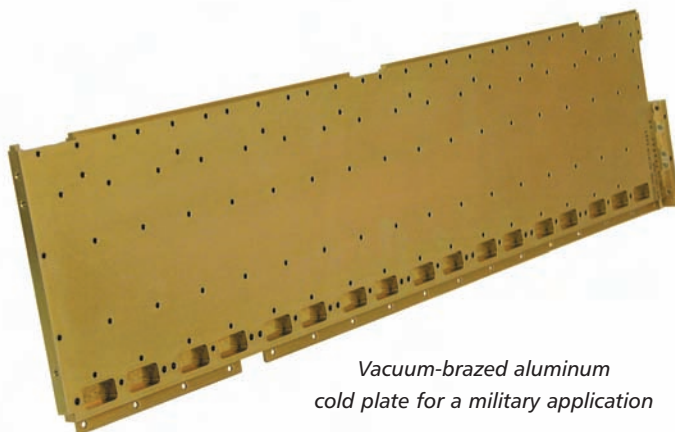
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*In a world of compact designs with increasing power densities, cold plates are satisfying demanding contact cooling requirements in applications as diverse as high-powered electronics, power generation, medical equipment, military and aerospace, and lasers. For high watt densities, when air-cooled heat sinks are inadequate, liquid-cooled cold plates are the ideal high-performance heat transfer solution.*

*Lytron is at the forefront of cold plate innovation, offering three different cold plate technologies. With full custom design and build capabilities, plus over 15 standard product lines, Lytron can solve all your thermal challenges.*

## Custom Cold Plates for Mission Critical Power Electronics Cooling

The drive towards higher power and more compact packages is making liquid cooling a necessity in many applications. Partnering with Original Equipment Manufacturers (OEMs), Lytron supplies custom cold plates for electronics cooling and other applications where high performance and high reliability are essential. Our cold plates, which include vacuum-brazed and Friction Stir Welded (FSW) performance-fin cold plates and chassis, flat tube cold plates, and tubed cold plates, can be found in medical equipment, wind turbines, trains, semiconductor equipment, aircraft, lasers, data centers, and other mission critical equipment around the world.

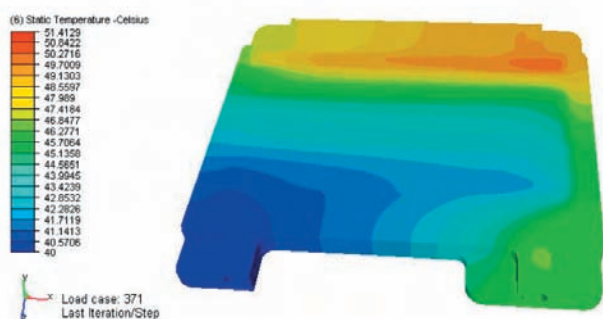


*Vacuum-brazed aluminum cold plate for a military application*

During the cold plate prototype development process, we use our vast experience in thermal performance, material compatibility, and fluid dynamics to optimize your design. To perform advanced thermal analysis, our engineers use state-of-the-art simulation software developed by Lytron that includes more than 50 years of empirical data. Lytron utilizes the performance data collected from every prototype to continuously improve the accuracy of its thermal and fluid dynamics models. We also use other industry leading tools as needed, such as CFD and structural analysis software.

In addition to providing expert thermal and mechanical design engineering, Lytron ensures that your cold plate is Designed-for-Manufacturability (DFM). All proposed cold plate designs are reviewed with our production engineering team to ensure that your cold plate can be built to your exact specifications as well as meet your delivery schedule. With fin manufacturing, machining, tube bending, vacuum brazing, and heat treating processes all performed in-house, Lytron has total control over your finished product. As a result, we're able to offer higher quality, greater flexibility, and shorter lead times.

To validate and verify your cold plate's design, Lytron can also leverage its extensive, in-house engineering laboratory. We offer thermal testing, maturity testing, flight certification testing, and system qualification testing to our OEM customers.



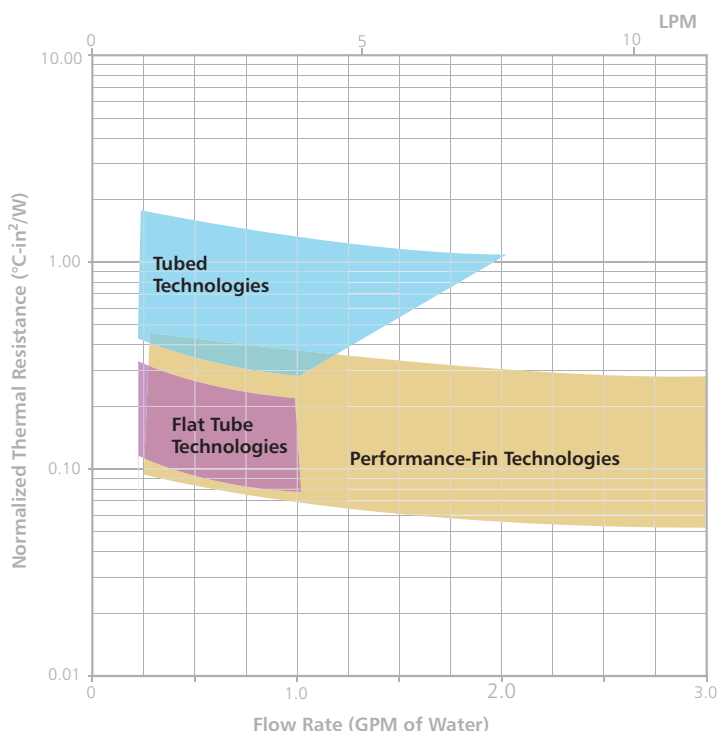
*We're experts at build-to-specification cold plate design and manufacturing. We perform thermal analysis using advanced simulation software as well as use CFD and structural analysis software.*



*Every custom product design is supported by a team of engineers, such as a project manager, a senior design engineer, and a manufacturing engineer. This ensures the successful design and manufacture of your prototypes as well as your production parts.*

### Performance comparison

This graph compares the normalized thermal resistances of different cold plate technologies, enabling thermal performances to be compared independently of the part geometries. The better the performance, the lower the thermal resistance. Since many cold plates are customized, a range of typical values is shown for each technology. All performances are compared using water as the cooling fluid. A normalized performance chart for our standard cold plates can be found on page 39.



### Performance-Fin Cold Plates & Chassis

Lytron's performance-fin cold plates and chassis offer superior heat transfer. Internal fin increases surface area for heat transfer as well as creates turbulence, minimizing the fluid boundary layer and further reducing thermal resistance. Cold plates and chassis may be vacuum-brazed or Friction Stir Welded (FSW). Cold plates and chassis that are vacuum-brazed are assembled and brazed in an environmentally controlled room to ensure the highest quality, most reliable brazes. We use numerically controlled vacuum brazing ovens and proprietary fixture designs to maintain tight tolerances and ensure complete metallurgical bonding between the fins and the cold plate or sidewalls of the chassis. This guarantees ruggedness and leak-free operation. Lytron's vacuum brazing ovens allow for brazing of parts up to 10 feet (3.05 m) long and 3 feet 2 inches (0.97 m) wide.



*Vacuum-brazed aluminum cold plate with extensive machining for use in a semiconductor application*



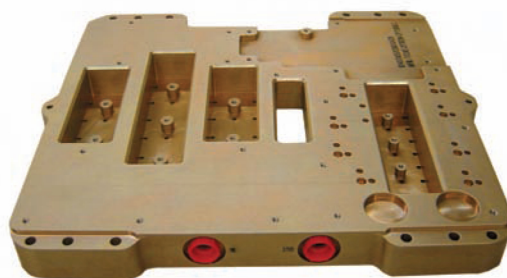
*Ruggedized, aluminum, liquid-cooled chassis for electronics cooling in a military application*



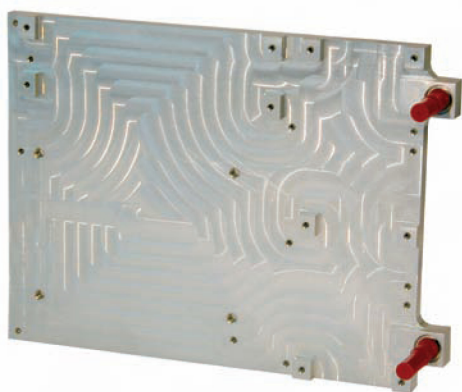
*Copper cold plate designed and manufactured by Lytron for electronics cooling is about the same size as a cell phone*

## Cold Plates

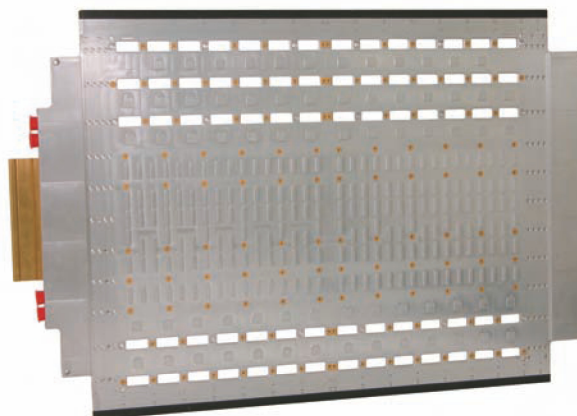
Performance-fin aluminum and copper cold plates offer nearly unlimited customization opportunities. They can be precisely engineered to match your performance, pressure drop, and dimensional requirements. Since Lytron manufactures its own fin, we can customize the internal fin as well as the cold plate's fluid path, allowing us to engineer a truly optimized cold plate. In addition, Lytron provides surface machining and drilling that meets tight tolerances.



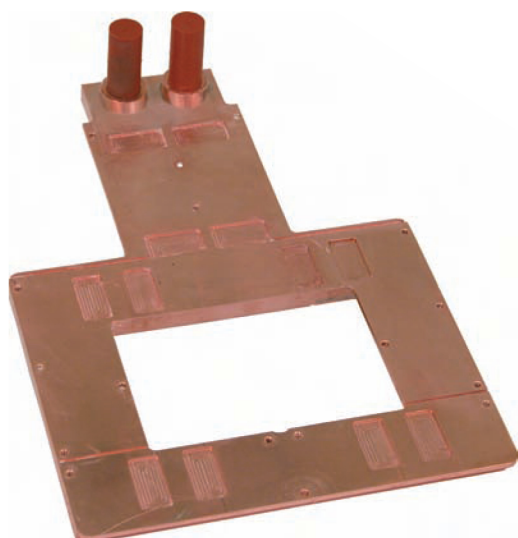
*Vacuum-brazed aluminum cold plate for power electronics cooling in a military application*



*Performance-fin aluminum vacuum-brazed cold plate for power electronics cooling in a traction application*



*Vacuum-brazed cold plate with machining and gold inserts designed for use in the computer industry*



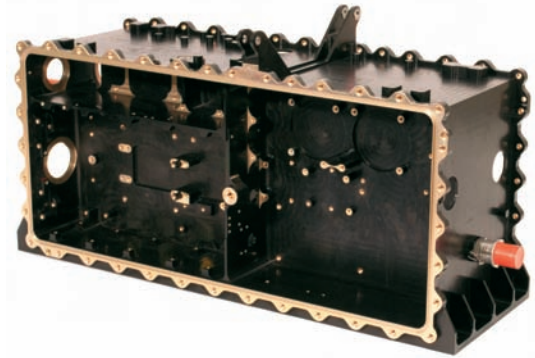
*Copper cold plate for cooling diodes in the telecommunications industry*



## Liquid-Cooled Chassis

Liquid-cooled chassis are used in military, aerospace, and other high performance applications because they offer excellent heat transfer in a ruggedized, lightweight package. They are manufactured from aluminum cold plates that have aluminum fin vacuum-brazed or Friction Stir Welded (FSW) into the sidewalls.

Since all of Lytron's liquid-cooled chassis are custom designed, we can supply you with the most efficient, compact, and lightweight part possible. The inlet and outlet locations, the fluid path, and the slot widths and configurations are all custom designed to your specifications.



*Vacuum-brazed, black anodized chassis with dual sided mounting designed for electronics cooling on a commercial aircraft*

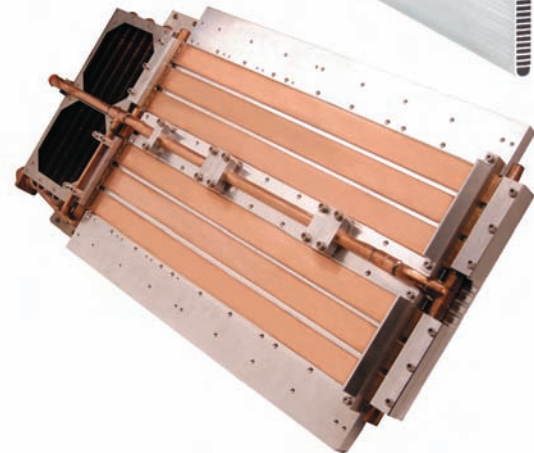
## Flat Tube Cold Plates

Flat tube cold plates offer very low thermal resistance and are ideal for cooling high watt-density components. The tubes, which are available in aluminum or copper, contain internal fin to increase performance. Whereas the aluminum flat tube has straight microchannels, the copper flat tube features a unique, criss-crossed fin. Since coolant flows below the entire surface of the tubes, the flat tube cold plates offer excellent thermal uniformity.

Copper flat tubes are compatible with water and many other common coolants and provide higher performance than the aluminum flat tube. However, when using viscous or poor heat transfer fluids, such as oils, Fluorinert®, and Polyalphaolefin (PAO), aluminum flat tube may be preferred because of its very low pressure drop.

Both the aluminum and copper flat tube technologies can be manufactured in any length, assembled in a ladder configuration, or integrated into a base plate for large area cooling. The aluminum flat tube can also be curved into a radius as tight as 1/4" (6.35 mm) without buckling for cooling cylindrical or curved objects.

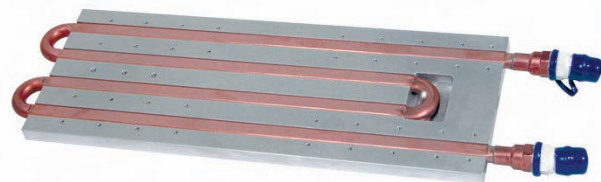
*Aluminum flat tube*



*Copper flat tube (CP25 technology) cold plate and heat exchanger assembly*

## Tubed Cold Plates

Tubed cold plates offer good bulk heat removal for low-to-medium watt density heat loads. Custom tubed cold plates are available based on our CP10, CP12, and CP15 Press-Lock technologies. Their size, shape, and fluid path can be customized for optimal thermal performance. Custom coatings, machining, drilling, and tapping may also be incorporated.



*CP12-style cold plate with custom size, tube diameter, fluid path, and fittings and an internal tube bend*

## Value-Added Cold Plate Assemblies

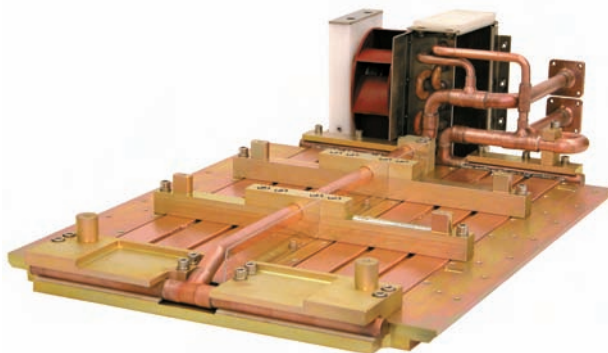
Our expertise goes well beyond components. We understand what is needed for seamless integration of your component into your system. An assembly can be as simple as a cold plate with hoses, or as complex as a cold plate with a heat exchanger, fans, and more. Value-added components may include:

- Fittings/connectors
- Hoses/tubing
- Thermal interface material
- IGBT integration/bolting
- Orifices (for tight pressure drop tolerances)
- Valves
- Heat exchangers
- Pumps and reservoirs
- Drain ports
- Wiring harnesses
- Shock isolators

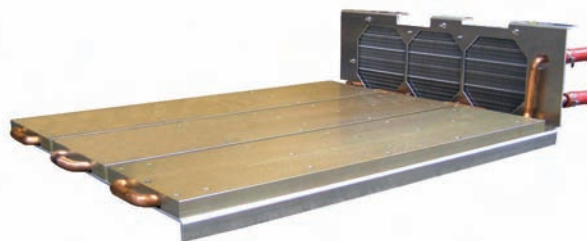
We source the components for value-added assemblies through our robust supply chain management program or work with customer supplied components so that your cold plate integration goes as smoothly as possible. By working with Lytron on the design and manufacture of your assembly, you can achieve:

- An innovative, high quality cold plate assembly
- A reduction in suppliers and part numbers
- A reduction in subassembly costs due to Lytron's purchasing power and efficient manufacturing
- Faster time to market
- More time for you to focus on your final product

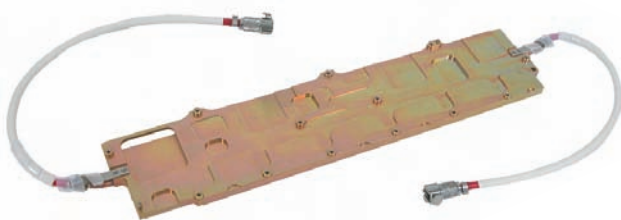
Please contact Lytron today to discuss your requirements.



*Value-added assembly consisting of copper flat tube, a heat exchanger, and a fan*



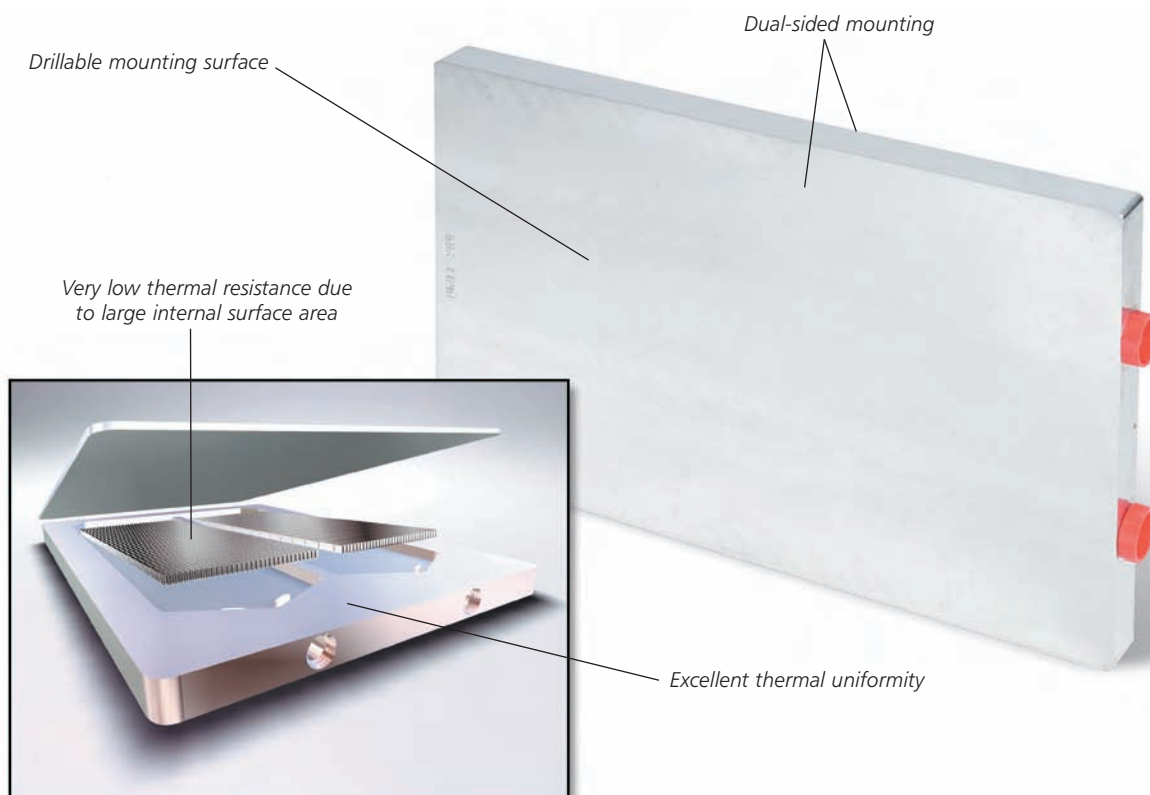
*Power supply cold plate consisting of three custom tubed cold plates and one heat exchanger with fan plates*



*Cold plate with custom surface machining, fittings, and hoses*



*Large 5' (1.5 m) vacuum-brazed cold plate supplied with fittings and hoses*



The CP30 aluminum vacuum-brazed cold plate offers a large 7.8" x 11" (198 mm x 279 mm) mounting area so it is ideal for both board and multiple component cooling in high heat load applications. The standard CP30 is designed for prototyping purposes; most volume applications require customized parts tailored to precisely match the performance and geometric requirements.

- **Excellent performance:** The CP30 contains high performance corrugated aluminum fin brazed into the cavity beneath the mounting surface of the cold plate. The fin creates turbulence, which minimizes the fluid boundary layer and reduces thermal resistance.
- **Ideal for prototyping:** The CP30 is a standard part designed for prototyping purposes. The cold plate is flat on both sides to allow dual-sided mounting, and the surface on one side is 0.5" (13 mm) thick to enable machining, drilling, and tapping for board/component attachment.
- **Highly reliable and leak-free:** Lytron's state-of-the-art vacuum-brazing process guarantees reliable and leak-free cold plates.

Please see our specifications table on page 39 to review the cold plate options, including configurations and fittings.

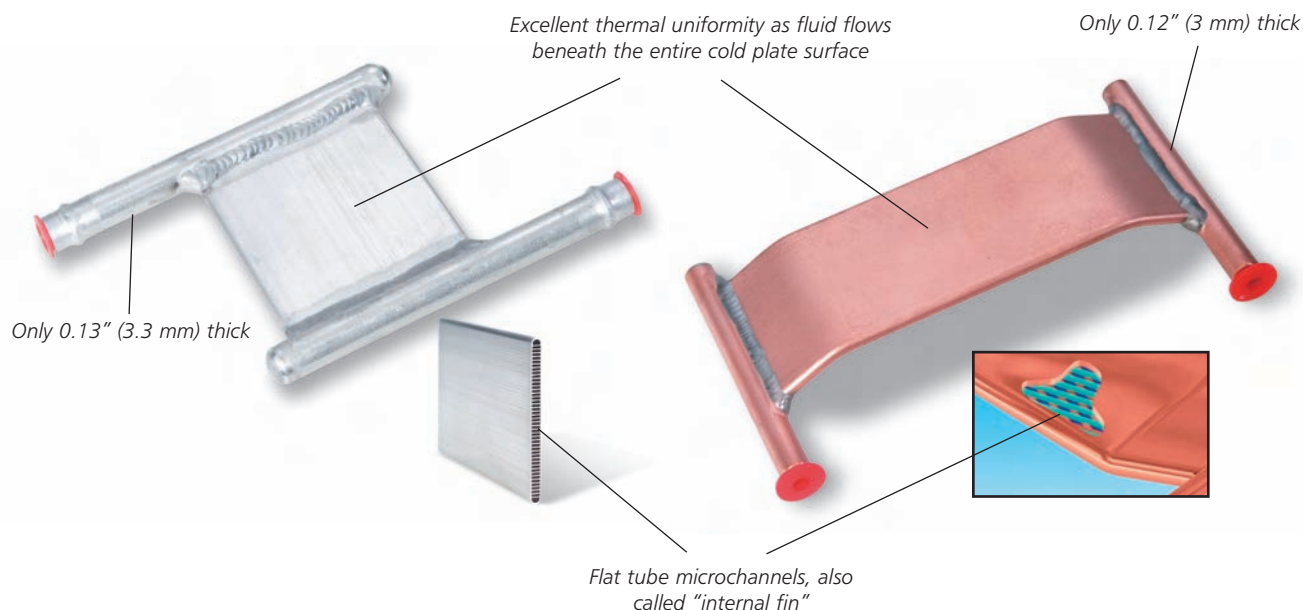
Custom vacuum-brazed cold plate with extensive surface machining.



## Customization options:

The majority of vacuum-brazed cold plates are custom parts. Vacuum-brazed cold plates can be manufactured in virtually any size and shape, and surface machining and drillable areas can be added. The inside of the cold plate is also customized—Lytron manufactures over 30 different types of internal fin to precisely match the cold plate's fluid path to the thermal requirements of the application.

See page 30 for more custom cold plates.



Flat tube cold plates are compact cold plates that offer extremely low thermal resistance. They contain internal fin to increase performance and offer excellent thermal uniformity as coolant flows below the entire surface. They are ideal for cooling small, high watt-density components such as thermoelectric modules. We offer both an aluminum solution (the CP20) and a copper solution (the CP25, or Ascent™).

- **Extremely high performance and thermal uniformity:** The CP20 and CP25 cold plates' extremely low thermal resistance is achieved by thin mounting surfaces and internal fin, which create a large surface area for heat transfer. Coolant flows below the entire cold plate surface, offering excellent thermal uniformity. The CP25's thermal resistance at 1 gpm (3.8 lpm) is just 0.05°C-in²/W (0.33°C-cm²/W), which is achieved by using an all-copper construction with a unique criss-crossed fin structure. The internal micro-channels create turbulence, which minimizes the fluid boundary layer and reduces thermal resistance. The CP20's thermal resistance is also very low – just 0.13°C-in²/W (0.84°C-cm²/W) at 1 gpm (3.8 lpm).
- **Very thin, compact, and lightweight:** The CP20 is only 0.13" (3.3 mm) thick and 0.1 lbs (0.05 kg) and the CP25 is only 0.12" (3 mm) thick and 0.2 lbs (0.09 kg), making them ideal for applications where space is limited.
- **Compatible with a range of coolants:** The CP20 cold plate's large internal surface area combined with its low pressure drop makes it ideal for use with viscous and poor heat transfer fluids such as EGW, oils, Fluorinert®, and Polyalphaolefin (PAO), while the CP25's all-copper construction makes it compatible with untreated water and other common coolants.

Please see our specifications table on page 39 to review the cold plate options, including configurations and fittings.

#### Customization Options:

The CP20 and CP25 are easily customized for OEM applications. The length can be varied and several pieces of flat tube can be assembled in a ladder configuration with a common header. The CP20 can also be curved for cooling cylindrical objects. For large area cooling applications, the flat tube can be integrated into larger assemblies.

See page 30 for more custom cold plates.

Curved CP20 in a ladder configuration for cooling a motor





Single tube with no joints  
ensures leak-free operation

Available with straight or  
beaded fittings

Drillable plate for  
component mounting

Press-Lock™ technology  
locks tube into channeled  
aluminum extrusion without  
performance-limiting epoxy

Lytron's standard tubed cold plates provide cost-effective thermal solutions for component cooling applications where the heat load is low-to-moderate. Our tubed cold plates consist of copper or stainless steel tubes pressed into a channeled aluminum extrusion.

- **Superior thermal performance:** Our tubed cold plates are manufactured using Lytron's proprietary Press-Lock technology, which mechanically locks the tubes into the aluminum plate. Press-Lock technology eliminates the need for performance-limiting epoxy between the tube and the plate, resulting in superior thermal performance. Compared to similar tubed cold plates, the CP12 cold plate offers 30% better performance and the CP15 offers 40% to 50% better performance.
- **Compatible with water and a range of coolants:** Copper tubes are compatible with water and most other common coolants, while stainless steel tubes can be used with deionized water or corrosive fluids.
- **Reliable and leak-free:** Each tubed cold plate has a single tube with no joint, ensuring leak-free operation.
- **Dual-sided mounting option:** The tubes of the CP12 and CP15 cold plates are coplanar with the plate to allow for dual-sided mounting. The cold plate's tube side offers higher performance as the copper tubes are in direct contact with the component being cooled.

Model	Tube Material	Configuration	Mounting	Tube Diameter
CP10	Copper or Stainless Steel	2-Pass or 4-Pass	Single-Sided	3/8" (9.5 mm) OD Tubing
CP12	Copper	4-Pass	Dual-Sided	3/8" (9.5 mm) OD Tubing
CP15	Copper	6-Pass	Dual-Sided	1/4" (6.4 mm) OD Tubing

Please review our specifications table on page 39 for complete standard tubed cold plate model numbers.

≡ Press-Lock cold plate with custom machining and custom tube configuration



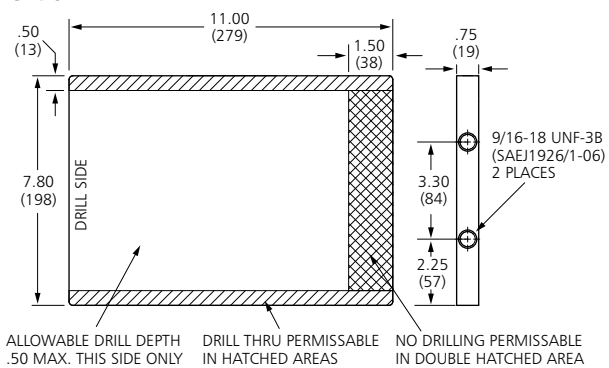
#### Customization Options

The CP10, CP12, and CP15 tubed cold plates can be drilled, tapped, or surface-machined according to your requirements. Other customizations, such as variations in dimensions, fittings, and tubing configuration, are available for OEM volumes.

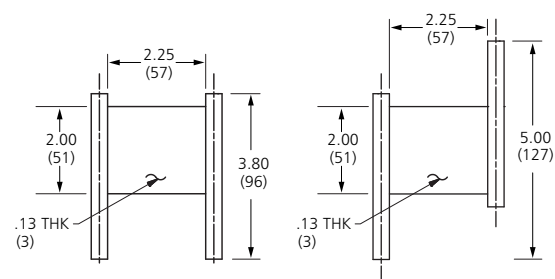
See page 30 for more custom cold plates.



**CP30**

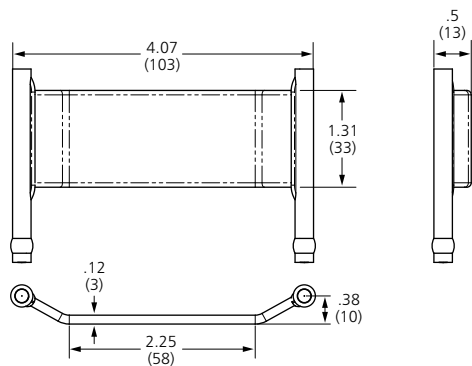


**CP20**

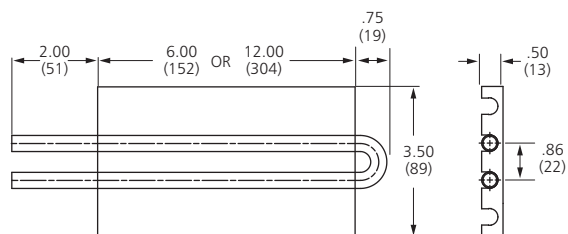


Actual mounting surface 2" x 2" (50 mm x 50 mm)

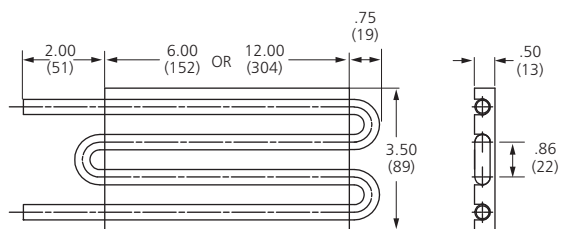
**CP25**



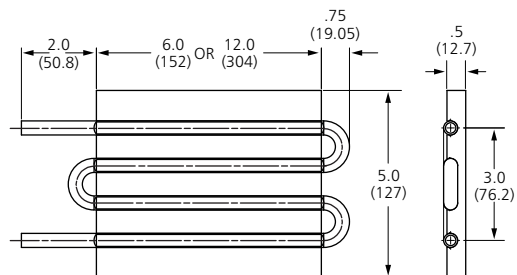
**CP10 2-pass**



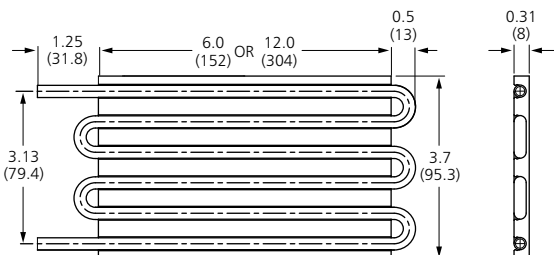
**CP10 4-pass**



**CP12**



**CP15**



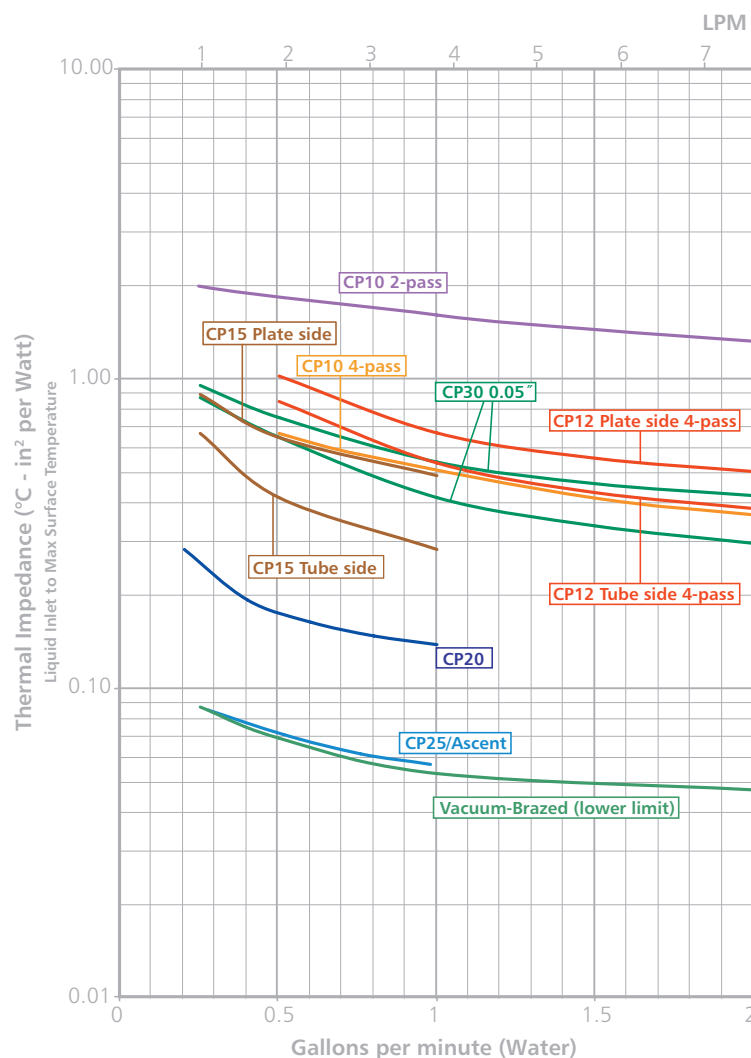
PDFs, IGS files, and eDrawings of standard cold plates are available at [www.Lytron.com](http://www.Lytron.com). Main dimensional label is inches. Dimension in parentheses is mm.

Thermal resistance is normally expressed as °C per Watt. Thermal resistance describes how much hotter the surface of a cold plate is relative to the temperature of the fluid flowing through the cold plate, under a given thermal load. Our performance curves show the local thermal resistance—the surface temperature versus the local liquid temperature. Full details on thermal resistance calculations and how to select a cold plate technology are on page 40.

### Normalized performance graphs

This graph shows the **normalized** thermal resistance for our standard cold plate products (i.e. thermal impedance per square inch). It enables cold plate technologies to be compared independently of individual part geometries. The lower the thermal impedance, the better the performance of the cold plate.

1. Thermal resistance is inversely proportional to area. To find the thermal resistance of a 25 inch<sup>2</sup> (161 cm<sup>2</sup>) cold plate, divide the normalized performance by 25.
2. Our CP30 standard cold plate is designed for prototyping purposes, so it has a thick surface plate for machining. We show two traces—before (0.5"/13 mm) and after (0.05"/1.3 mm) machining. The performance of a custom vacuum-brazed cold plate is usually significantly better than the standard part.
3. For comparison purposes, the performance of all cold plates is shown using water as the coolant. Treated water is recommended with aluminum (CP20 & CP30) cold plates.
4. Please visit [www.Lytron.com](http://www.Lytron.com) for individual cold plates' thermal performance, pressure drop graphs, weight, and fluid volume.



### Cold Plate Specifications & Fittings\*

Model	Tubed Material	Tube Diameter	Configuration	Fitting	Mounting Surface
CP30G01	Aluminum	NA	Square	9/16-18 UNF-3B	7.8" x 11" (19.81 cm x 27.94 cm)
CP20G01/G02	Aluminum	3/8" (9.5 mm)	U	Straight or Beaded*	2" x 2" (5.08 cm x 5.08 cm)
CP20G03/G04	Aluminum	3/8" (9.5 mm)	Z	Straight or Beaded*	2" x 2" (5.08 cm x 5.08 cm)
CP25G01/G02	Copper	1/4" (6.4 mm)	U	Straight or Beaded*	2.25" x 1.3" (5.72 cm x 3.30 cm)
CP10G01/G02	Copper	3/8" (9.5 mm)	2-Pass	Straight or Beaded*	6" x 3.5" (15.24 cm x 8.89 cm)
CP10G03/G04	Stainless Steel	3/8" (9.5 mm)	2-Pass	Straight or Beaded*	6" x 3.5" (15.24 cm x 8.89 cm)
CP10G05/G06	Copper	3/8" (9.5 mm)	2-Pass	Straight or Beaded*	12" x 3.5" (30.48 cm x 8.89 cm)
CP10G07/G08	Stainless Steel	3/8" (9.5 mm)	2-Pass	Straight or Beaded*	12" x 3.5" (30.48 cm x 8.89 cm)
CP10G14/G15	Copper	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	6" x 3.5" (15.24 cm x 8.89 cm)
CP10G16/G17	Stainless Steel	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	6" x 3.5" (15.24 cm x 8.89 cm)
CP10G18/G19	Copper	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	12" x 3.5" (30.48 cm x 8.89 cm)
CP10G20/G21	Stainless Steel	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	12" x 3.5" (30.48 cm x 8.89 cm)
CP12G01/G02	Copper	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	6" x 5" (15.24 cm x 12.70 cm)
CP12G05/G06	Copper	3/8" (9.5 mm)	4-Pass	Straight or Beaded*	12" x 5" (30.48 cm x 12.70 cm)
CP15G01/G02	Copper	1/4" (6.4 mm)	6-pass	Straight or Beaded*	6" x 3.75" (15.24 cm x 9.53 cm)
CP15G05/G06	Copper	1/4" (6.4 mm)	6-pass	Straight or Beaded*	12" x 3.75" (30.48 cm x 9.53 cm)

\* Letter G followed by an odd number indicates straight fittings and letter G followed by an even number indicates beaded fittings. For example, part number CP20G01 has a straight fitting and CP20G02 has a beaded fitting.



## Selecting a Cold Plate Technology

To select the best cold plate for your application, you need to know the cooling fluid flow rate, the fluid inlet temperature, the heat load of the devices attached to the cold plate, and the maximum desired cold plate surface temperature,  $T_{\max}$ . From these you can determine the maximum allowable thermal resistance of the cold plate.

First, calculate the maximum temperature of the fluid when it leaves the cold plate,  $T_{\text{out}}$ . This is important because if  $T_{\text{out}}$  is greater than  $T_{\max}$ , there is no solution to the problem.

$T_{\text{out}}$  can be calculated by solving the heat capacity equation:

$$T_{\text{out}} = T_{\text{in}} + \frac{Q}{\rho \cdot \dot{V} \cdot C_p}$$

$T_{\text{out}}$  = temperature of fluid leaving cold plate  
 $T_{\text{in}}$  = inlet temperature of fluid  
 $Q$  = heat load of devices  
 $\rho$  = density of the fluid  
 $\dot{V}$  = cooling fluid flow rate  
 $C_p$  = specific heat of the fluid

Alternatively, you can use the heat capacity graphs found on [www.Lytron.com](http://www.Lytron.com). These graphs describe the change in temperature,  $\Delta T$ , that occurs along the fluid path. To find  $T_{\text{out}}$ , add  $\Delta T$  to the inlet temperature,  $T_{\text{in}}$ .

Assuming  $T_{\text{out}}$  is less than  $T_{\max}$ , the next step is to determine the required normalized thermal resistance ( $\theta$ ) for the cold plate using this equation:

$$\theta = (T_{\max} - T_{\text{out}}) \cdot (A/Q)$$

$\theta$  = thermal impedance  
 $T_{\max}$  = maximum desired cold plate surface temperature  
 $T_{\text{out}}$  = temperature of fluid leaving cold plate  
 $A$  = area being cooled  
 $Q$  = heat load of devices

Any cold plate technology that provides a normalized thermal impedance less than or equal to the calculated value will be a suitable solution.

### Example:

A cold plate is used to cool a 2" x 4" (5.08 cm x 10.16 cm) IGBT that generates 500 W of heat. It is cooled with 20°C water at a 0.5 gpm flow rate. The surface of the cold plate must not exceed 55°C.

### We know:

$T_{\text{in}}$ : 20°C       $T_{\max}$ : 55°C       $Q$ : 500 Watts       $A$ : 8 in<sup>2</sup>

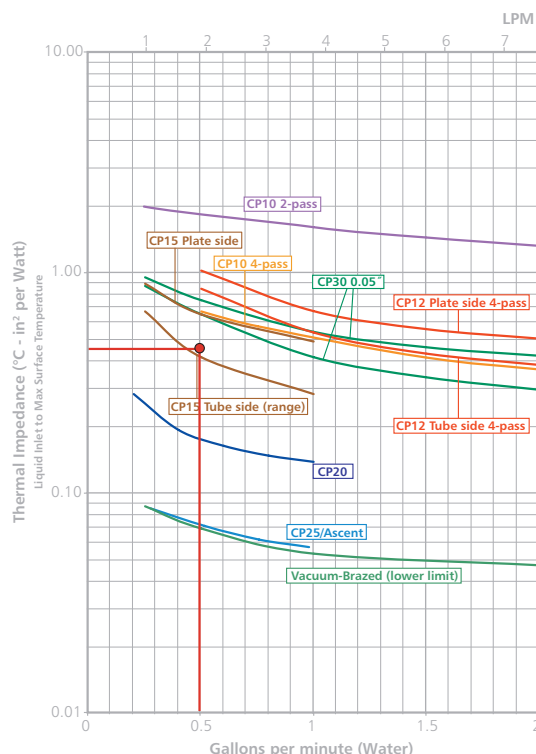
### We need to calculate $T_{\text{out}}$ and $\theta$ .

First calculate  $T_{\text{out}}$ . Using the heat capacity graphs on [www.Lytron.com](http://www.Lytron.com), we find that the temperature change for 500 W at a 0.5 gpm flow rate is 4°C. Therefore  $T_{\text{out}} = 20^\circ\text{C} + 4^\circ\text{C} = 24^\circ\text{C}$ .

$T_{\text{out}}$  is less than  $T_{\max}$  so we can proceed to the second part of the problem. The required thermal impedance is given by this equation:

$$\theta = (T_{\max} - T_{\text{out}}) \cdot (A/Q) \quad \begin{aligned} \theta &= (55^\circ\text{C} - 24^\circ\text{C}) \cdot (8 \text{ in}^2 / 500 \text{ W}) \\ \theta &= 0.5^\circ\text{C-in}^2/\text{W at } 0.5 \text{ gpm} \end{aligned}$$

We then plot this point on the normalized thermal impedance graph. Any technology below this point will meet the thermal requirement. The CP15, CP20, CP25, and CP30 provide the necessary thermal impedance. However, because the cooling fluid is water, you should only consider the CP15 and CP25 cold plates.







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*With more than five decades of experience in heat exchanger design and manufacture, Lytron's expertise is second-to-none. Our heat exchangers are used in many industries including military and aerospace, medical and industrial lasers, medical imaging, analytical instrumentation, power electronics, semiconductor equipment, machine tools, and telecommunications.*

*Any of our heat exchanger technologies can be customized to your exact requirements. We also supply heat exchanger subassemblies, adding fittings, hoses, fans, sensors, and other instrumentation to your specification. And our 15 standard product lines ensure that when you need an off-the-shelf part we are likely to have something that meets your requirements.*

## Custom Heat Exchangers for High Performance Applications

Lytron supplies custom heat exchangers for applications that require high performance and reliability. We design and build lightweight plate-fin, flat-tube, and tube-fin heat exchangers for the aerospace, military, medical, laser, traction, and power generation markets as well as others.

Lytron's engineering team provides expert design, analysis, and verification for custom solutions. Our engineers perform advanced thermal analysis using cutting-edge, proprietary simulation software based on more than 50 years of empirical data. This results in the most accurate thermal performance predictions available today. We can also validate and verify your heat exchanger's design using Lytron's extensive in-house engineering laboratory. Our testing capabilities include thermal testing, maturity testing, flight certification testing, and verification testing.

Throughout the prototype process, Lytron's production engineers work closely with design engineers to ensure that your heat exchanger is Designed-for-Manufacturability (DFM). Since Lytron's engineers and manufacturing are located in the same facility, products transition smoothly from design, through prototyping, to production. We also carry out all performance-critical manufacturing processes in-house, from fin stamping and tube bending to vacuum brazing and heat treating. This gives us control over the finished product, as well as increased flexibility and shorter lead times.

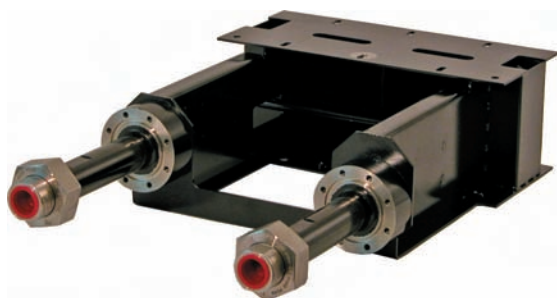
In addition to providing best-in-industry design and manufacturing, Lytron also offers more heat exchanger technologies than any other thermal solutions company. Lytron has the technology you need and the experience to customize it for your application.



*A vacuum-brazed, air-cooled condenser for aircraft features two continuous, serpentine, flat tube extrusions welded together, an integrated hail guard, a cast inlet plenum duct, and a manifolded inlet and outlet*



*Hydraulic oil cooler designed for a helicopter application has a custom manifold with bypass valves, an air duct, and mounting brackets*



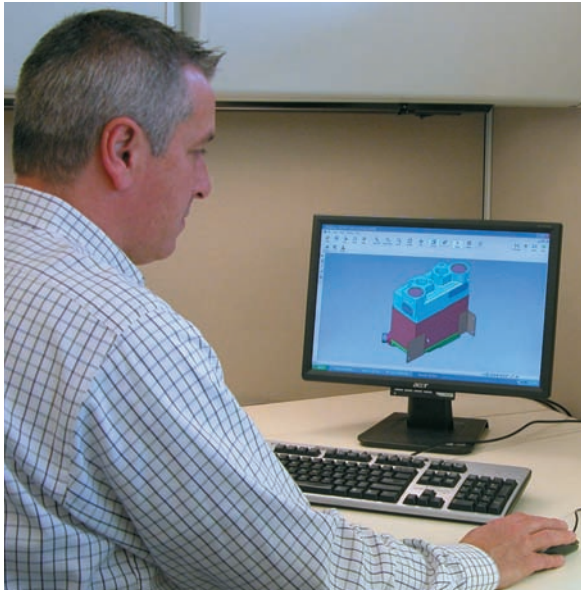
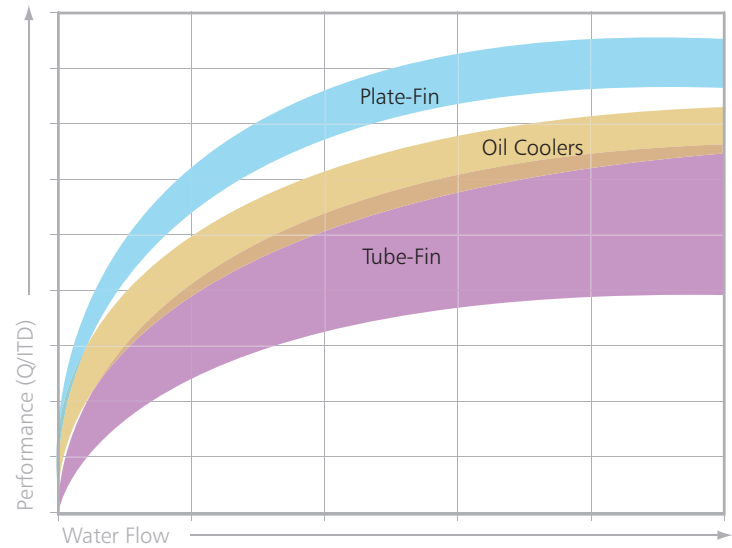
*Water-to-air tube-fin heat exchanger coated for corrosion resistance designed and manufactured to meet military specifications and AWS standards for naval applications*



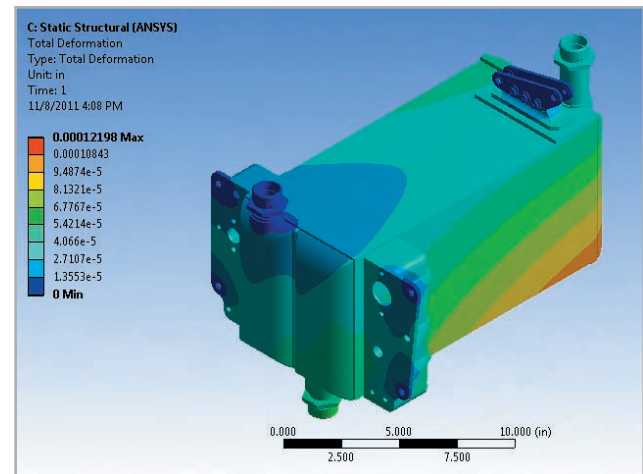
*Liquid-to-liquid oil cooler for commercial aircraft designed to withstand 400,000 pressure cycles from 0 to 600 psi and a burst of pressure of over 1,600 psi*

## Heat Exchanger Technologies Performance Comparison Chart

This chart compares the performance of different heat exchanger technologies, including plate-fin heat exchangers, flat tube oil coolers, and tube-fin heat exchangers. Performance is shown as  $Q/ITD$ , the heat load divided by the difference in incoming temperature of the liquid and air. Units are not shown so that heat exchanger technologies can be compared regardless of size. Please visit [www.Lytron.com](http://www.Lytron.com) to see additional custom heat exchangers.



*Our experienced engineering team has the knowledge and tools necessary to provide you with a custom thermal solution that meets all of your requirements.*



*Our engineers perform structural analysis as needed to ensure your heat exchangers will meet your demanding specifications.*

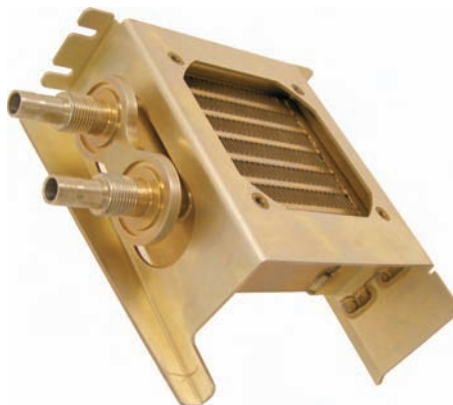
## Vacuum-Brazed Heat Exchangers

Lytron's aluminum heat exchangers offer superior heat transfer. They are vacuum-brazed in an environmentally controlled room for maximum cleanliness, quality, and reliability. With our numerically controlled vacuum brazing process and robust fixture designs, we can ensure complete metallurgical bonding between the fins and the separator plates or flat tubes. This guarantees ruggedness and leak-free operation. Lytron operates several vacuum brazing ovens, including one that can braze parts up to 10 feet (3.05 m) long and 3 feet 2 inches (0.97 m) wide.

### Plate-Fin Heat Exchangers

All our aluminum, vacuum-brazed, plate-fin heat exchangers are custom-designed, as every requirement is unique. Plate-fin heat exchangers are widely used in aerospace, military, and other high performance applications because they offer excellent thermal transfer capacity combined with small size and weight. Plate-fin heat exchangers can be designed for use with any combination of gas, liquid, and two-phase fluids.

We carefully select the number of plate and fin layers, the size of the plates and fin, and the type of fin for optimum performance. Manifold ducting and mounting brackets are welded in place as specified, and any required paint or coating (including MilSpec) can be added.



*Plate-fin heat exchanger with manifold, mounting brackets, fan plate, and corrosion protection coating for use in a military ground vehicle*



*Custom plate-fin heat exchanger with manifold and chemical conversion coating*



*Titanium plate-fin heat exchangers*

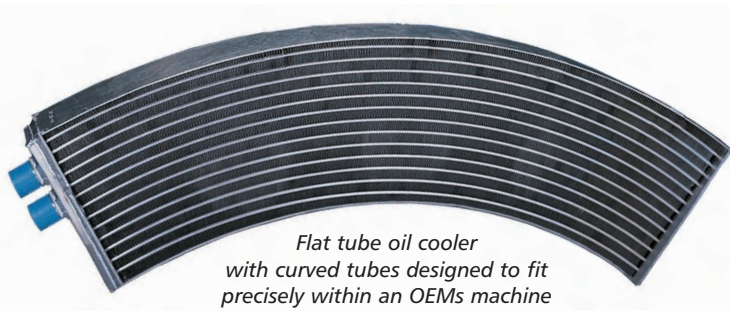


*Plate-fin evaporator with dual core designed and manufactured for use in a military ground vehicle*



### Flat Tube Heat Exchangers

Lytron's vacuum-brazed, extruded flat tube technology is used in oil coolers, condensers, and more. Flat tube technology allows for many customization possibilities. Four different flat tube widths are available, and the length and the number of tubes can be varied. The flat tube can also be bent into a 1/4" (6.35 mm) inside radius without buckling, so heat exchangers can be manufactured in a curved shape if needed. Custom fittings and manifolds can be added, and flat tube heat exchangers can be painted or anodized for extra protection.



*Flat tube oil cooler  
with curved tubes designed to fit  
precisely within an OEM's machine*



*Hydraulic oil cooler for business jet with custom  
"picture frame" mounting brackets*

### Tube-Fin Heat Exchangers

The building blocks of a tube-fin heat exchanger are tubes, fin, and frame. We have a variety of fin patterns to choose from, and can customize the tube configuration and frame. Lytron also works with specialty metals, such as nickel and cupronickel. To meet the stringent shock and vibration requirements of some applications, we can also provide ruggedized frames and fluid connections and insert additional tube sheets as supporting elements within the core. Paints and coatings, including MilSpec paints, are available. Fluid inlets and outlets can be customized with bends, fittings, hoses, and more.



*Large tube-fin heat exchanger for server cooling  
is 6' (1.8 m) long and 3' (0.9 m) wide*



*Large 4' (1.2 m) heat exchanger with  
nickel tubes and copper fin*

## Value-Added Assemblies

Lytron also designs and manufactures custom heat exchanger assemblies, providing Original Equipment Manufacturers (OEMs) with an innovative design that meets system interface challenges. Heat exchanger assemblies include plate-fin heat exchangers, flat tube heat exchangers, evaporators, condensers, oil coolers, or tube-fin heat exchangers, as well as any number of other components that make integration of your heat exchanger faster and easier. The simplest heat exchanger assemblies are heat exchangers with fans, while the most complicated are major sub-assemblies or entire cooling systems ready to drop into your system or equipment. Value-added components include, but are not limited to:

- Fans and finger guards
- Controls, including fan speed controls
- Pumps and pump systems
- Fittings/connectors and hoses/tubing
- Shrouds and ducting
- Mounting brackets
- Reservoirs
- Electrically actuated thermal control valves
- Pressure bypass and solenoid valves
- Check valves
- Thermostats for temperature control
- Temperature/pressure sensors
- Relays for on/off functions
- Air heaters
- Bladders/pressure compensators
- Cold plates
- Wiring harnesses
- Drain ports
- Shock isolators
- Hail/FOD guards

There are many benefits to working with Lytron for the design and build of your heat exchanger assembly or sub-assembly:

- Innovative designs and the highest quality products
- Fewer suppliers
- Fewer part numbers
- Lower total cost of assembly due to Lytron's supply chain management program and efficient manufacturing processes
- Faster time to market
- More time for you to focus on your final product.

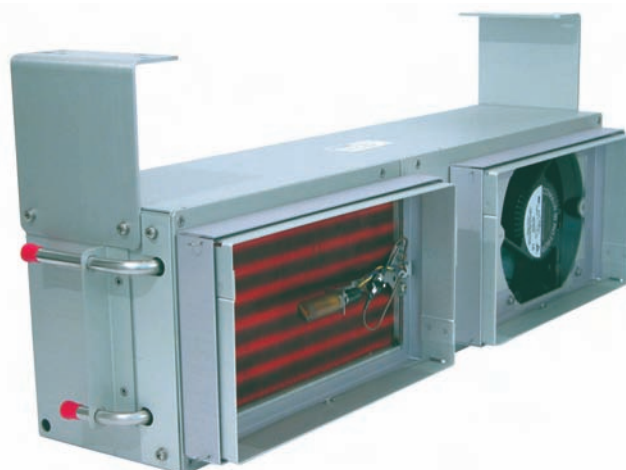
Please contact Lytron today to discuss your requirements.



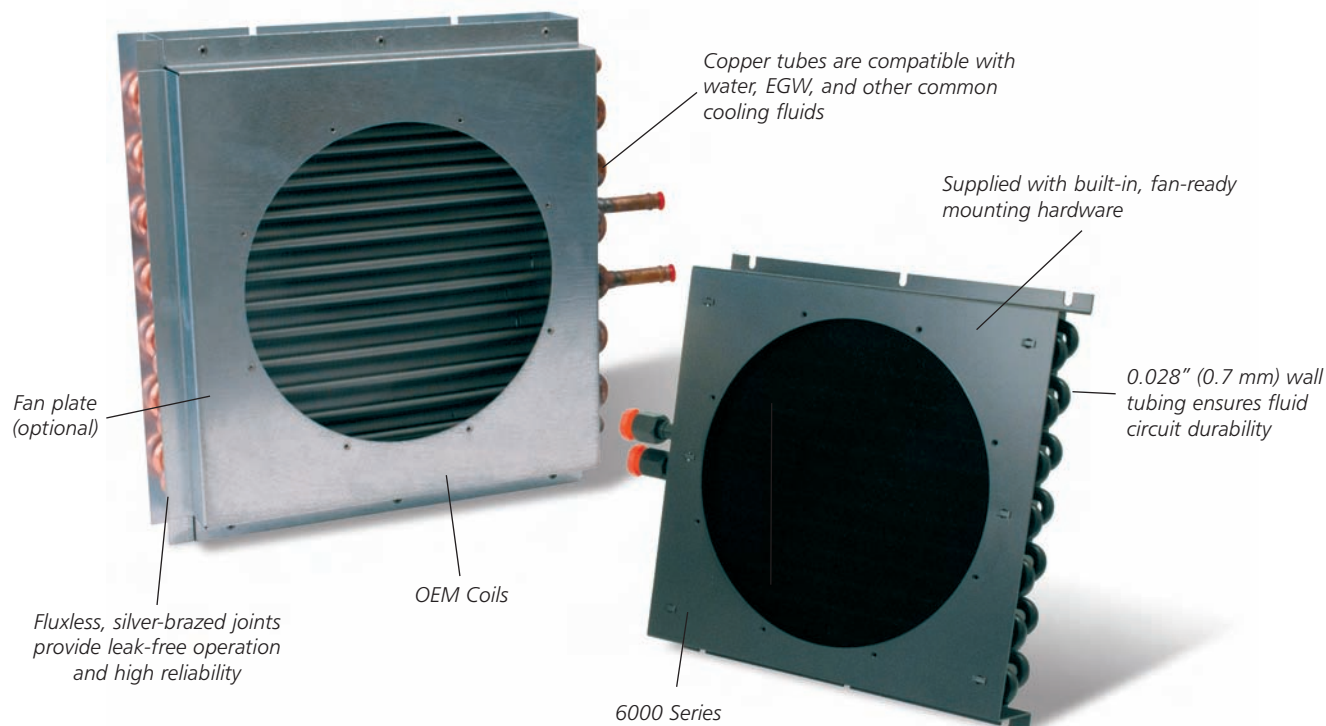
*Liquid-to-liquid plate-fin heat exchanger, designed for oil cooling in a military ground vehicle, has a custom manifold, mounting brackets, and corrosion protection coating*



*Tube-fin heat exchanger assembly with integrated fans and tubes*



*Clear anodized heat exchanger subassembly including fan and temperature sensor*

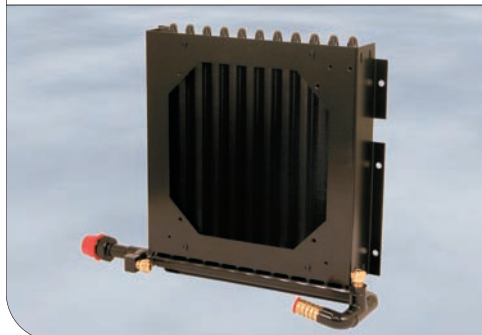


Both the OEM Coils and 6000 Series copper tube-fin heat exchangers offer high performance and reliability. The OEM Coils heat exchanger has aluminum fins and is unpainted with galvanized steel side plates. The 6000 Series heat exchanger has a different tube configuration, uses copper fins, is painted black for corrosion resistance, and includes a fan plate. OEM Coils are best suited for the price-sensitive customer in applications where the appearance of the heat exchanger is not critical, such as when the heat exchanger is hidden inside of the equipment. The 6000 Series is an attractive, high performance heat exchanger that delivers efficient heat transfer and maximum reliability in a compact package.

- **Engineered for performance:** The OEM Coils and 6000 Series are both engineered for performance. The seamless copper tubes are expanded into the fin with an extruded full collar that ensures excellent metal-to-metal contact to optimize thermal performance. However, with the 6000 Series, the higher tube density results in maximum heat transfer.
- **Reliable, leak-free, and robust:** Our thick-walled (0.028"/0.7 mm) seamless copper tubing and fluxless silver-brazed joints ensure the integrity of the fluid path. All OEM Coils and 6000 Series heat exchangers are also pressure tested to 150 psi (10.3 bar) to guarantee reliability. The 6000 Series units are electro-static dip painted for long life even in corrosive or harsh environments.
- **Compatible with a range of coolants:** The OEM Coils and 6000 Series are compatible with water, Ethylene Glycol/Water (EGW) solutions, and other common coolants.

Please see our specifications table on page 59 to review the heat exchanger options, including sizes, configurations, fittings, fans, and more.

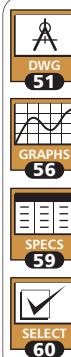
6000 Series heat exchanger with custom circuitry, sensor ports, and inlet/outlet fittings



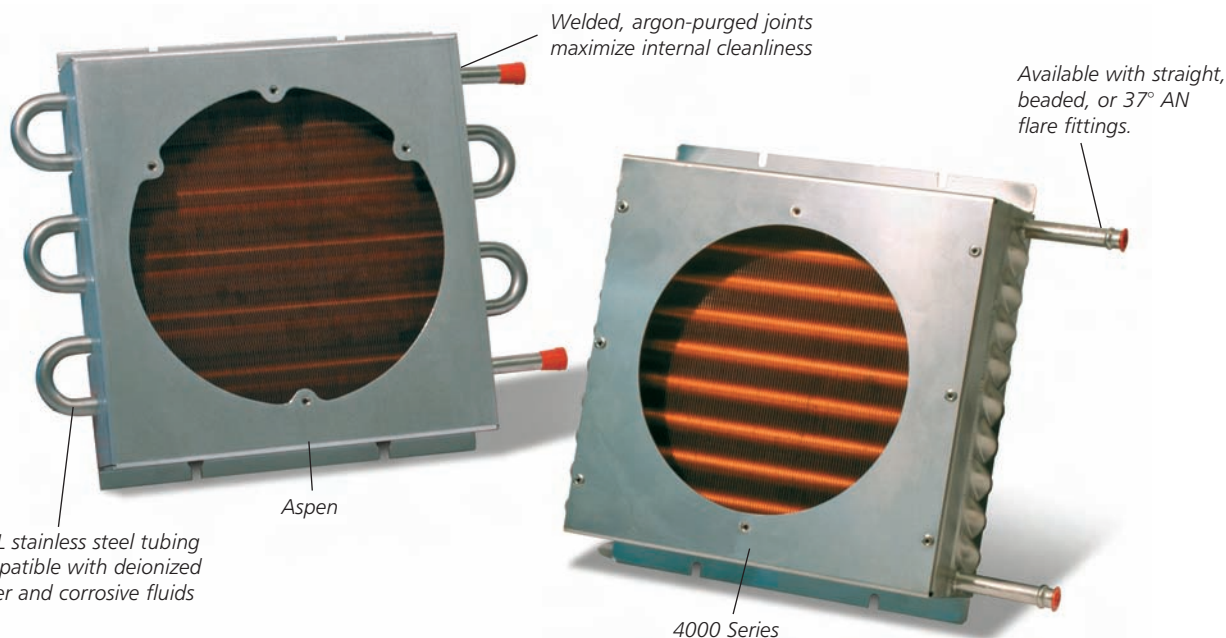
#### Customization Options

For high volumes of the OEM Coils or 6000 Series, we can customize dimensions, tube configurations, inlet/outlet positions, fittings, or paints/coatings to meet your requirements. Assemblies including fans and other components can also be supplied.

See page 42 for more custom heat exchangers.







The Aspen and 4000 Series tube-fin heat exchangers are ideal for applications where deionized water or corrosive fluids are used and a high performing heat exchanger is required. When a slightly lower performance/size ratio is acceptable, the Aspen offers better value - 80% of the performance of the 4000 Series at approximately 50% of the cost. The Aspen also has lower air and liquid side pressure drops than the 4000 Series. However, when high performance in a small envelope is required, the 4000 Series is the best option.

- **Engineered for performance:** The Aspen and 4000 Series are both engineered for performance. Heavy-walled, seamless stainless steel tubes are expanded into copper fin with an extruded full collar. The copper fin and the excellent metal-to-metal contact between the tube and the fin collar ensure optimum thermal performance.
- **Compatible with deionized water and corrosive liquids:** All the wetted surfaces in the Aspen and 4000 Series are 316L stainless steel, so they are ideal for use with high purity and/or corrosive coolants such as deionized water.
- **Rugged and reliable:** The welded stainless steel frame and fan plate offer durability and strength. The Aspen and 4000 Series heat exchangers are 100% leak tested to 150 psi (10.3 bar). The Aspen has 0.020" (0.5 mm) wall tubing and the 4000 Series has 0.028" (0.7 mm) wall tubing.
- **Integrated fan plate for improved performance and convenience:** The integrated fan plate acts as a plenum to ensure uniform air-flow distribution through the core, thus maximizing performance. It also enables easy fan installation.
- **Extremely clean (Aspen):** With our Aspen Series, our proprietary manufacturing process expands the tubes into the copper fin without the use of oils and our liquid return design eliminates potential particle trapping sites, which can contaminate cooling fluid. Argon-purged welded joints further ensure cleanliness.

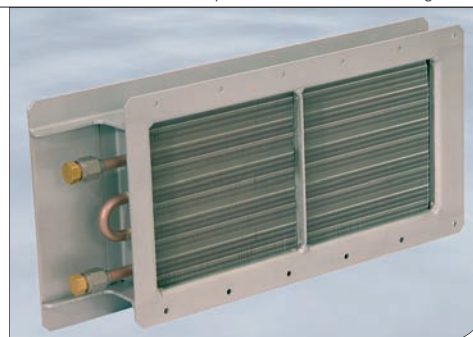
Please see our specifications table on page 59 to review the heat exchanger options, including sizes, configurations, fittings, fans, and more.

Custom cupronickel tube-fin heat exchanger

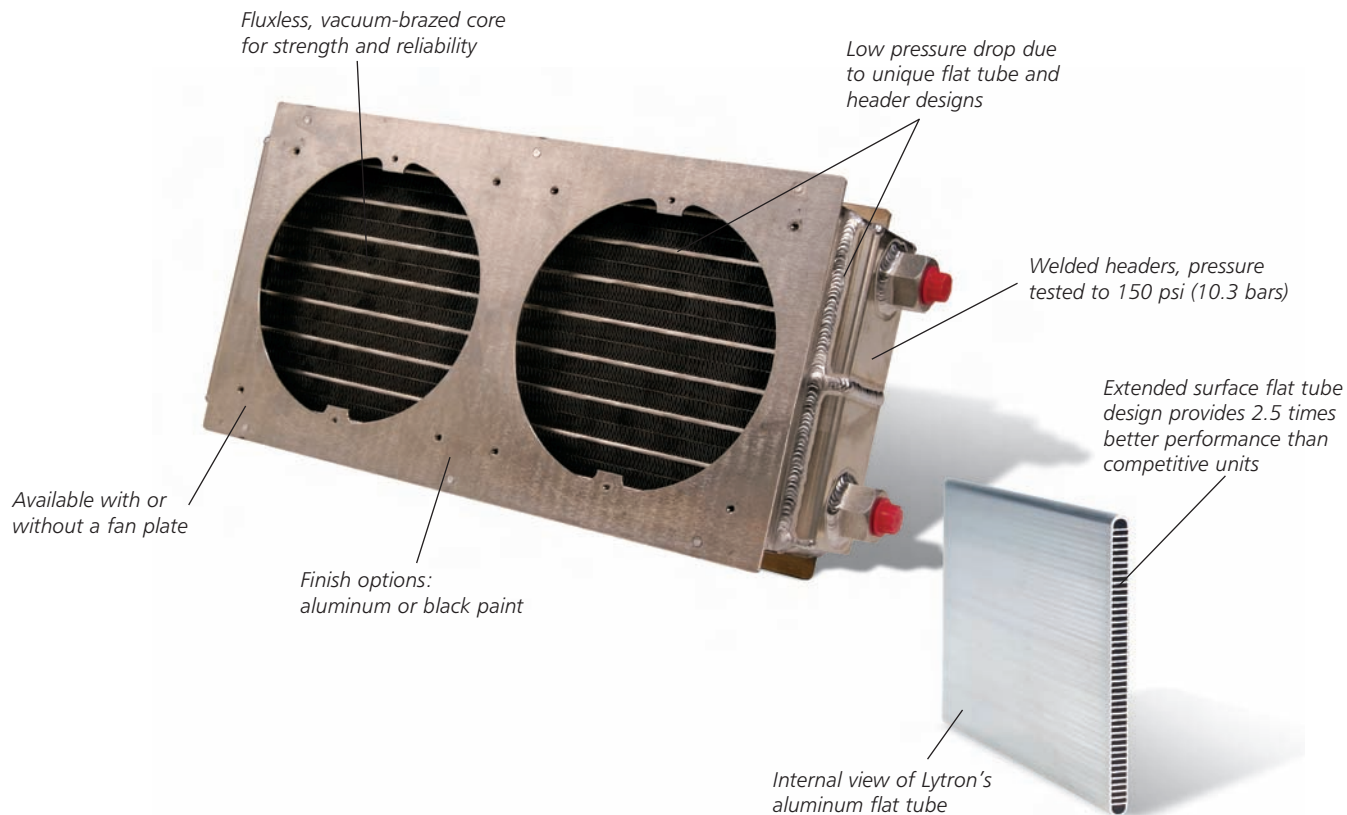
## Customization Options

Aspen and 4000 Series style heat exchangers can be manufactured in custom sizes and tube configurations to meet your thermal and mechanical specifications. Inlet/outlet positions, fittings, paints, and other coatings are available. Assemblies including fans and other components can also be supplied.

See page 42 for more custom heat exchangers.







ES Series oil coolers are engineered for high performance with poor heat transfer fluids such as oils and EGW. They provide up to 2.5 times greater thermal performance per unit volume than competitive models.

- **High performance:** The ES Series uses Lytron's unique aluminum flat tube technology, which has multiple extended surface channels in each tube. These tubes provide maximum cooling by having a large surface area in contact with the fluid (approximately 12 in<sup>2</sup> (77 cm<sup>2</sup>)/linear inch of tube). Lytron's air-side fin geometry efficiently channels air across the fin surface to further boost heat transfer capability.
- **Clean and reliable:** The fluxless vacuum-brazed construction results in a clean, rugged, and highly reliable part with excellent thermal contact and mechanical strength.
- **Low pressure drop:** Our flat tube fluid channels and efficient header manifold result in a very low pressure drop so smaller, less expensive pumps can be used.
- **Lightweight:** The all-aluminum, vacuum-brazed construction is lightweight.

Please see our specifications table on page 59 to review the heat exchanger options, including sizes, configurations, fittings, fans, and more.

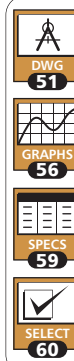
Commercial condenser with single-piece aluminum flat tube



## Customization Options

Oil coolers can be manufactured in different sizes and tube widths, and with custom inlet/outlet configurations. Curved heat exchangers can be manufactured as the flat tube can be bent without buckling or damaging the internal channels. Assemblies including fans and other components can also be supplied.

See page 42 for more custom heat exchangers.



## Liquid-to-Liquid Heat Exchangers

*Much smaller and lighter than conventional shell-and-tube designs*

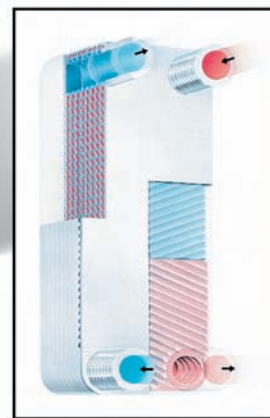
*Copper-brazed for water, EGW, and other common coolants, or nickel-brazed for high purity and corrosive coolants*



*Extremely efficient herringbone construction for maximum heat transfer*



*Stainless steel sheets are brazed together at the edges and at a matrix of contact points for a reliable and rugged part*



*Internal view of liquid-to-liquid brazed plate heat exchanger*

Lytron's brazed-plate heat exchangers are unsurpassed for liquid-to-liquid heat transfer. Their innovative design packs maximum performance into a compact and reliable package.

- **High performance in a small package:** Lytron's liquid-to-liquid heat exchangers are up to 80-90% smaller in volume and weight than conventional shell-and-tube designs. The counterflow design utilizes stainless steel sheets stamped with a herringbone pattern of grooves, stacked in alternating directions to form separate flow channels for the two liquid streams. This allows 90% of the material to be used for heat transfer, making it extremely efficient.
- **High reliability:** The plates are brazed together at the edges and at a matrix of contact points between sheets, ensuring that the heat exchangers are highly reliable and rugged.
- **Copper- and nickel-brazed versions for compatibility with a wide range of fluids:** We offer copper-brazed units for use with water, EGW, and other common coolants. Our nickel-brazed units are appropriate for use with deionized water, high purity, and corrosive fluids.
- **High operating temperatures and pressures:** Copper-brazed units can be operated at temperatures of up to 383°F (195°C) and pressures up to 450 psig (31 bar). Nickel-brazed units can be operated at temperatures of up to 662°F (350°C) and pressures up to 232 psig (16 bar).

*Liquid-to-liquid heat exchanger subassembly with custom hoses and fittings*

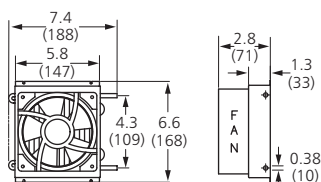
### Customization Options

Liquid-to-liquid heat exchangers can be supplied as subassemblies with fittings, hoses, and other accessories.

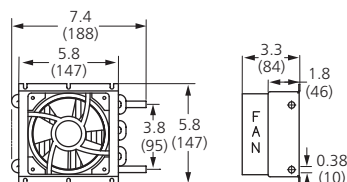
See page 42 for more custom heat exchangers.



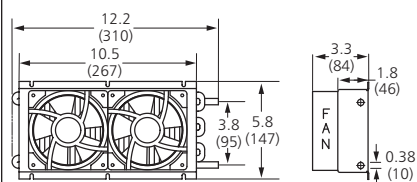
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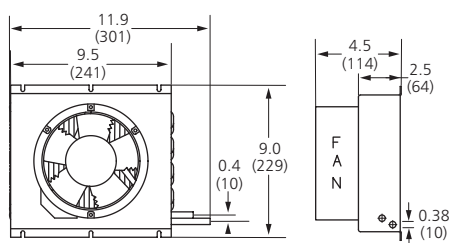
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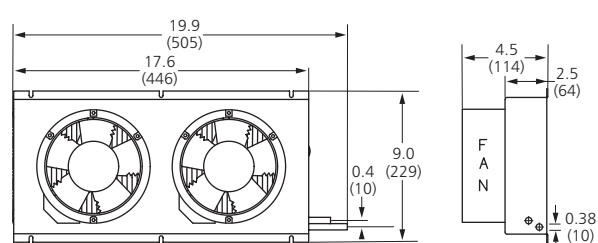
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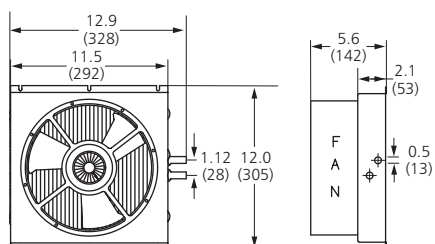
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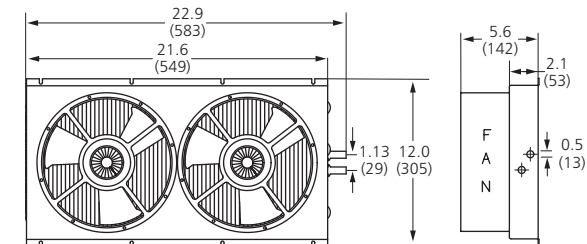
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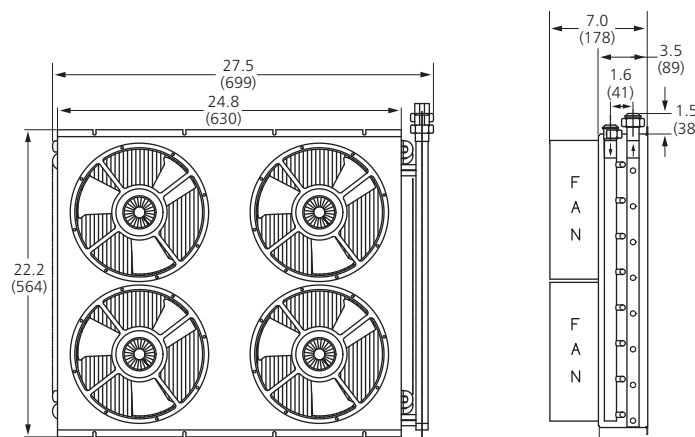
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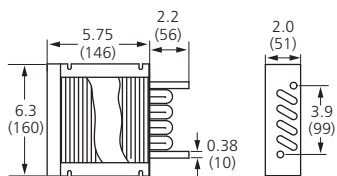


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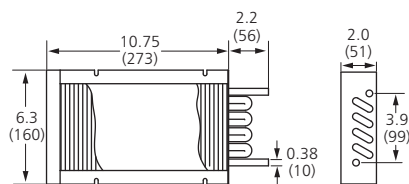


PDFs, IGS files, and eDrawings of standard heat exchangers are available at [www.Lytron.com](http://www.Lytron.com).  
Main dimensional label is inches. Dimension in parentheses is mm.

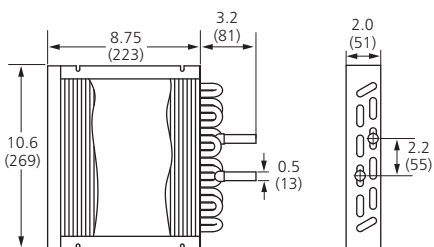
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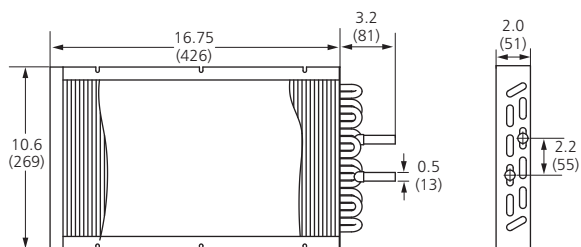
**M05-100**



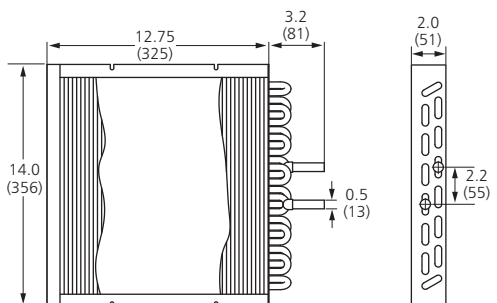
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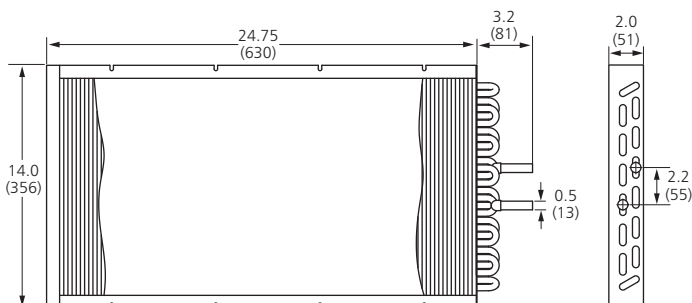
**M10-160**



**M14-120**

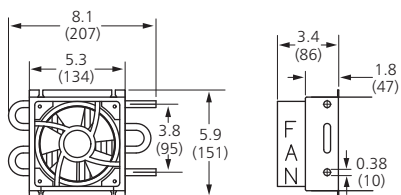


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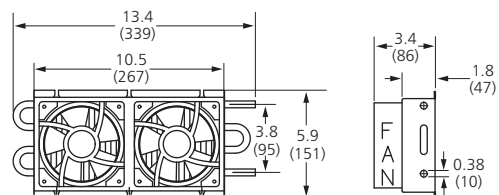




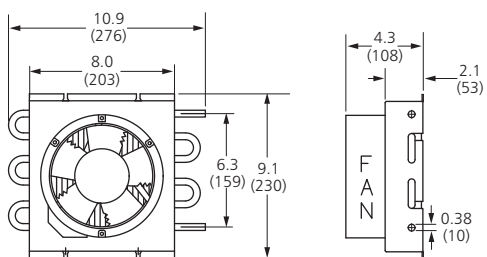
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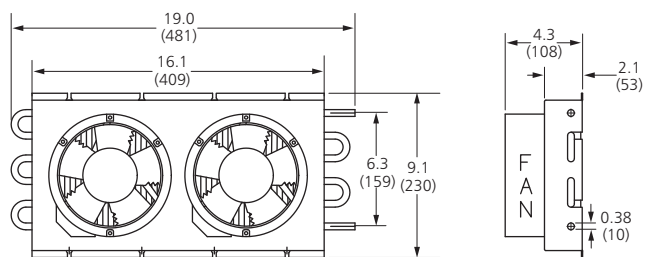
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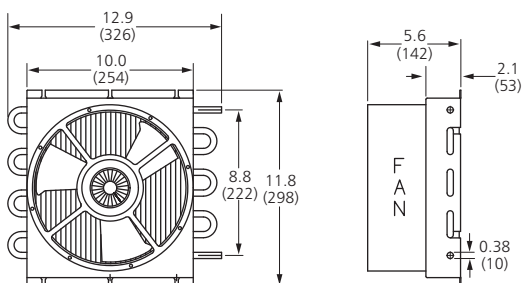
**AS06-08**



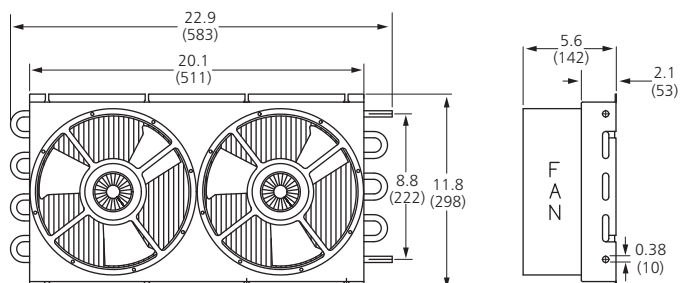
**AS06-16**



**AS08-10**

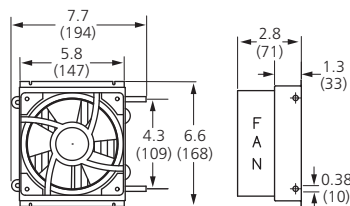


**AS08-20**

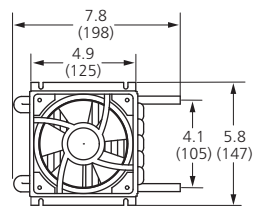


PDFs, IGS files, and eDrawings of standard heat exchangers are available at [www.Lytron.com](http://www.Lytron.com).  
Main dimensional label is inches. Dimension in parentheses is mm.

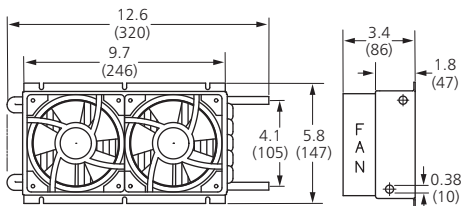
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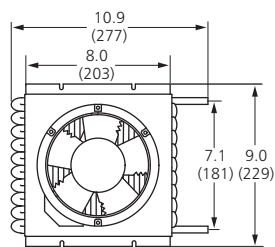
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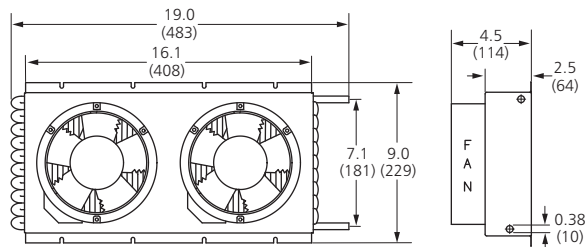
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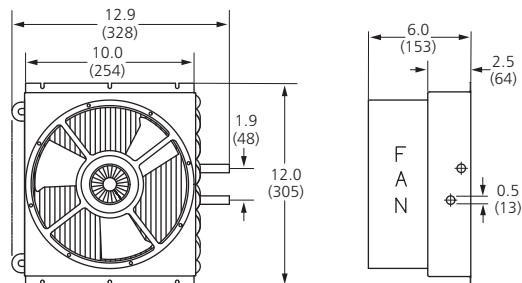
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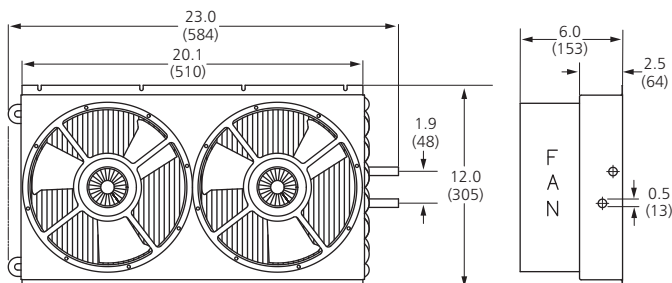
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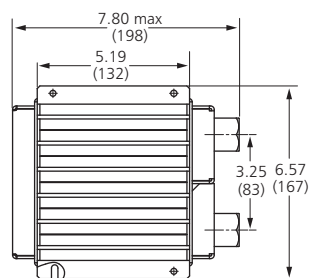
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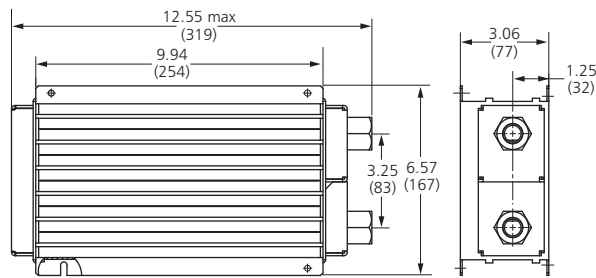
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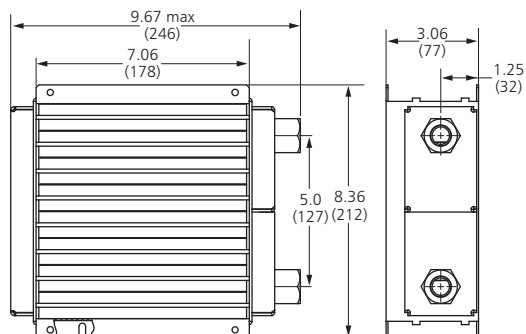


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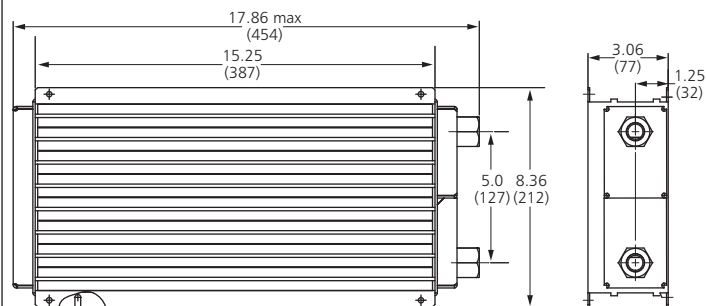


PDFs, IGS files, and eDrawings of standard heat exchangers are available at [www.Lytron.com](http://www.Lytron.com).  
Main dimensional label is inches. Dimension in parentheses is mm.

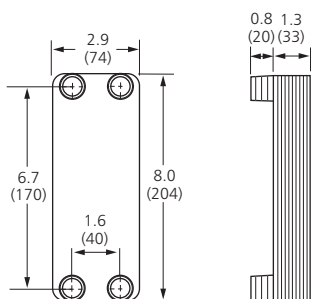
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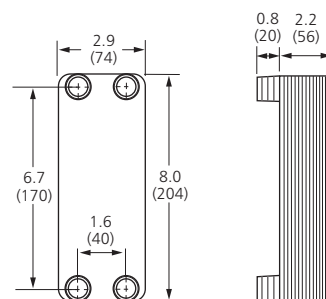
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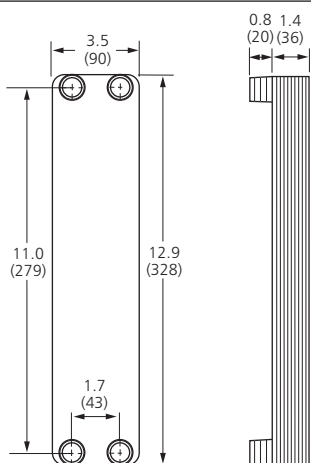
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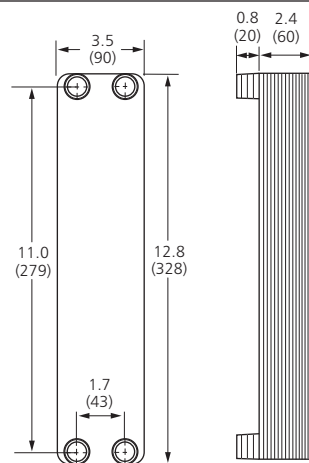
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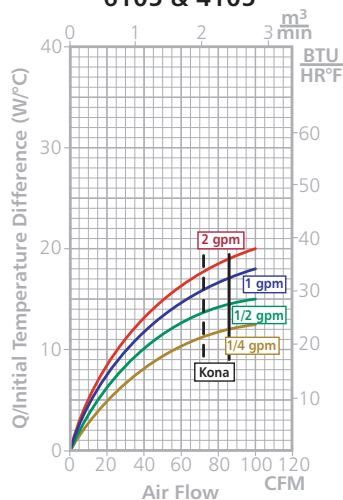
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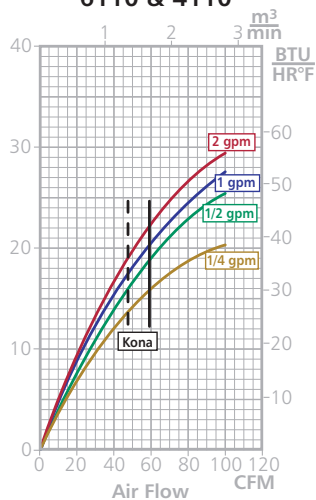
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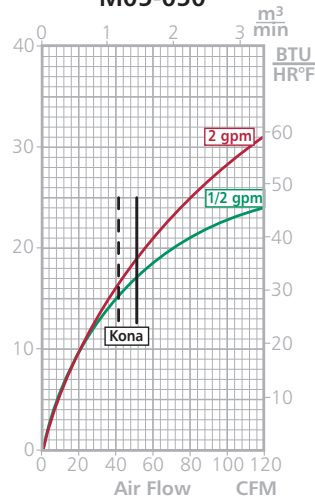
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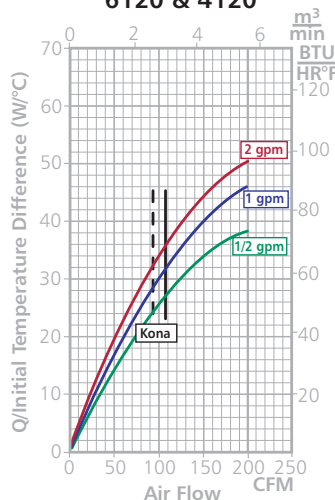
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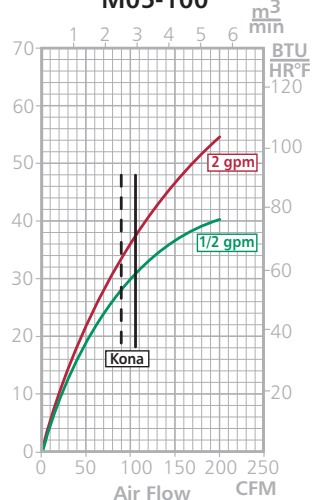
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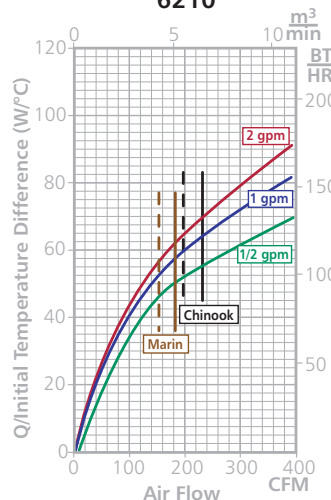
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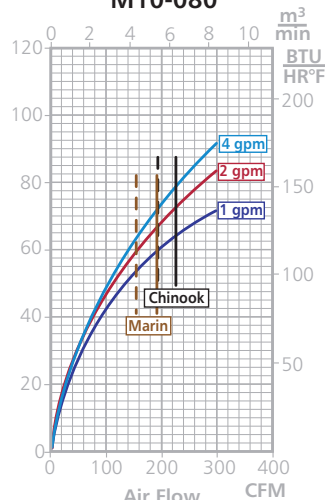
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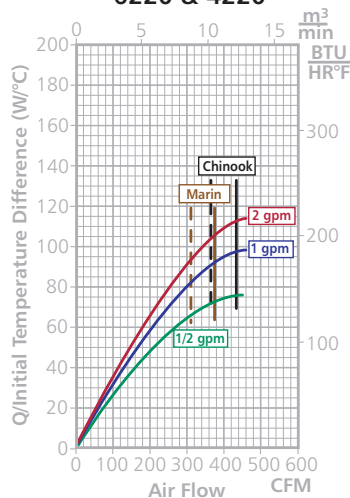
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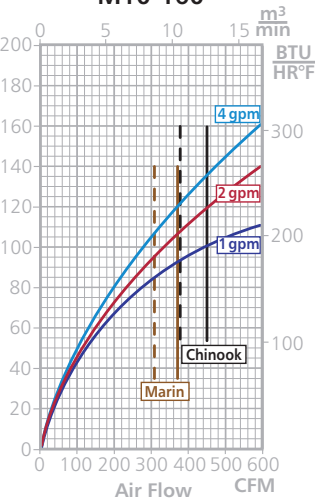
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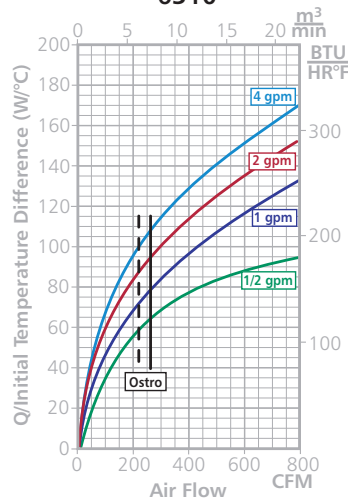
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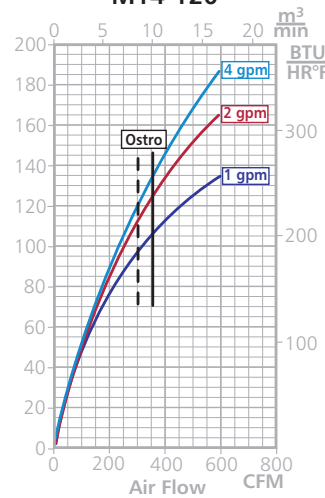
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6310



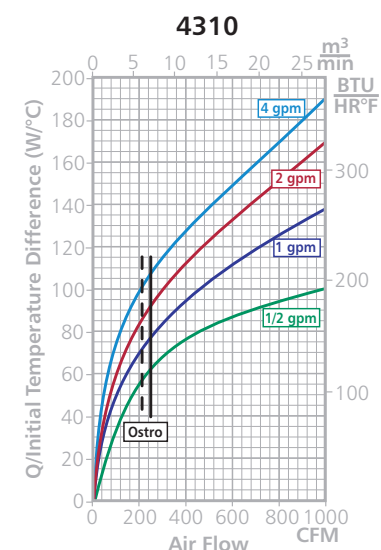
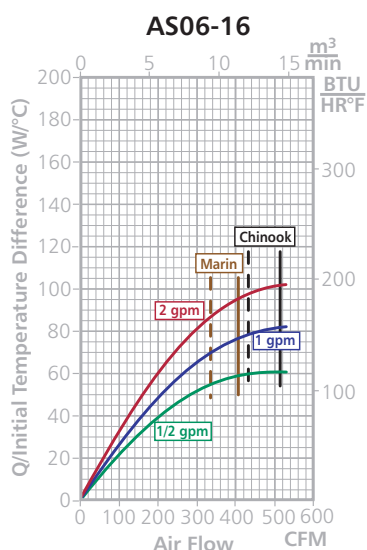
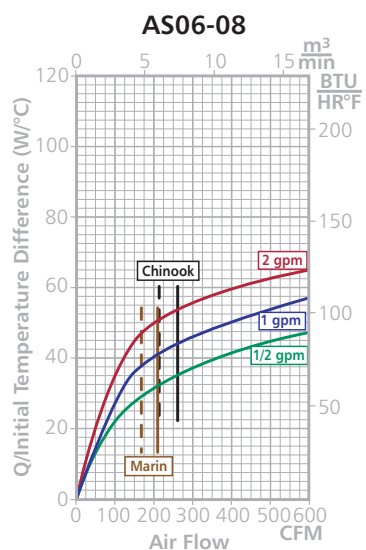
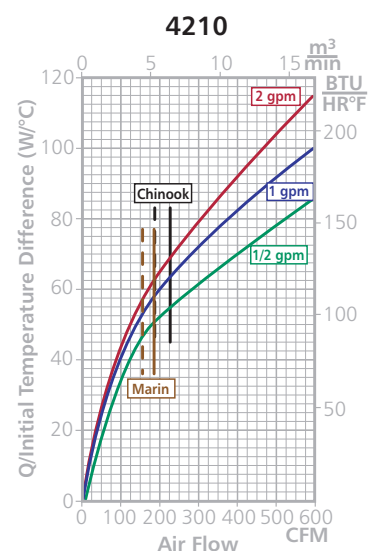
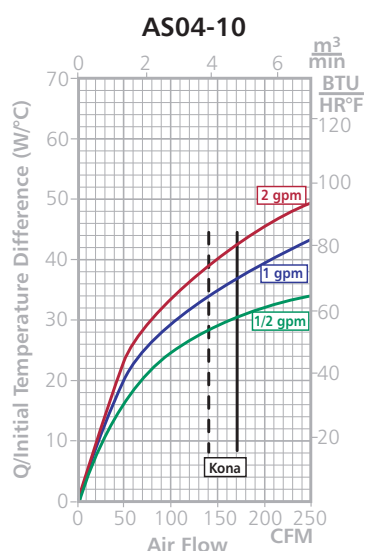
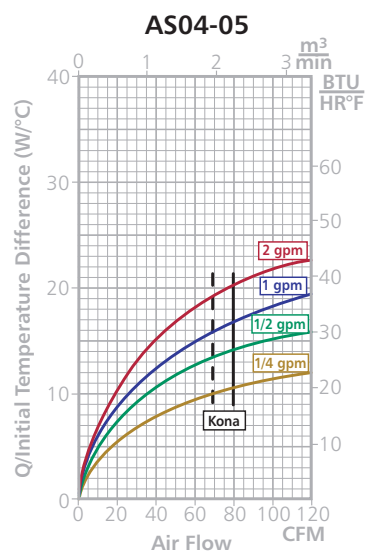
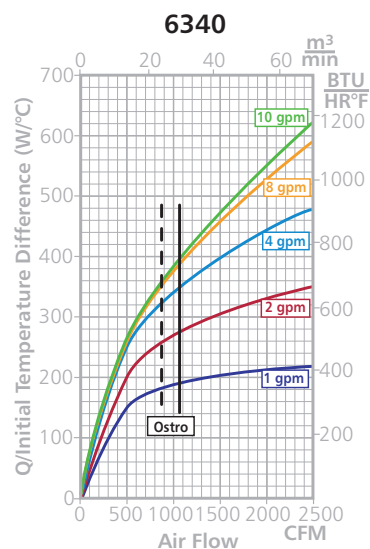
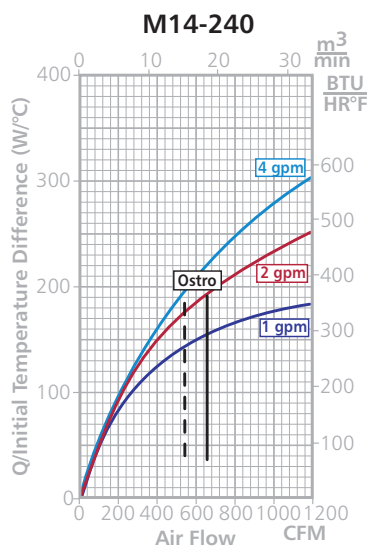
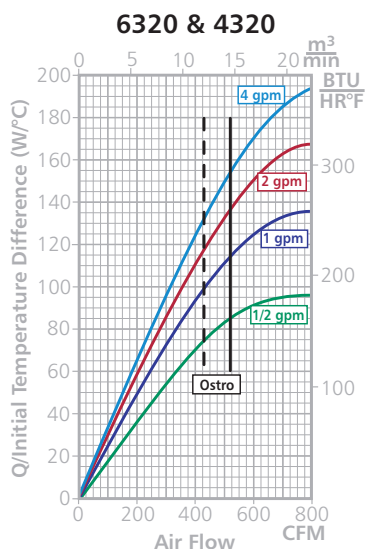
M14-120



<sup>1</sup> The solid vertical lines indicate the performance provided by our standard fans at 60 Hz and 20°C. Dashed fan lines represent fan performance at 50 Hz and 20°C.

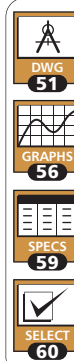
For pressure drop curves, please visit [www.Lytron.com](http://www.Lytron.com).



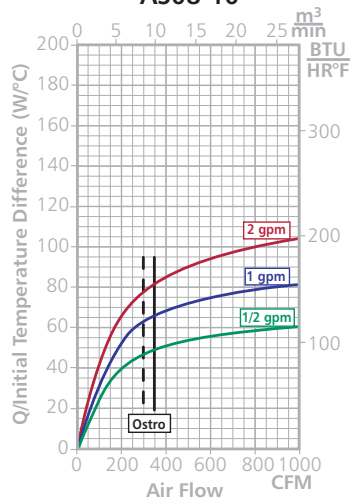


<sup>1</sup> The solid vertical lines indicate the performance provided by our standard fans at 60 Hz and 20°C. Dashed fan lines represent fan performance at 50 Hz and 20°C.

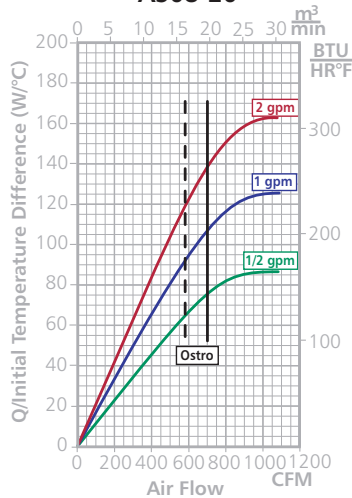
For pressure drop curves, please visit [www.Lytron.com](http://www.Lytron.com).



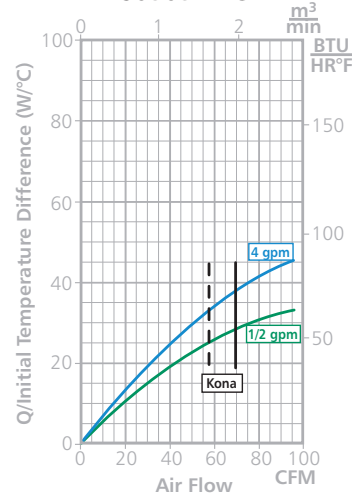
AS08-10



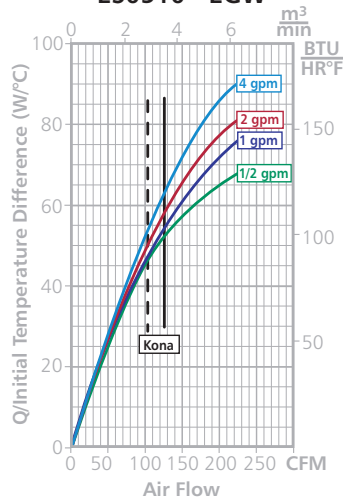
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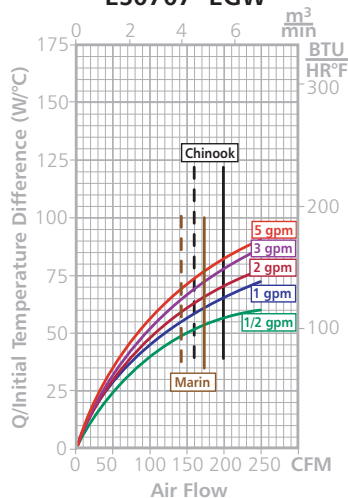
ES0505 - EGW<sup>3</sup>



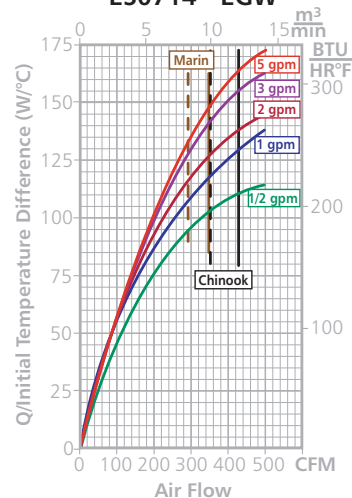
ES0510 - EGW<sup>3</sup>



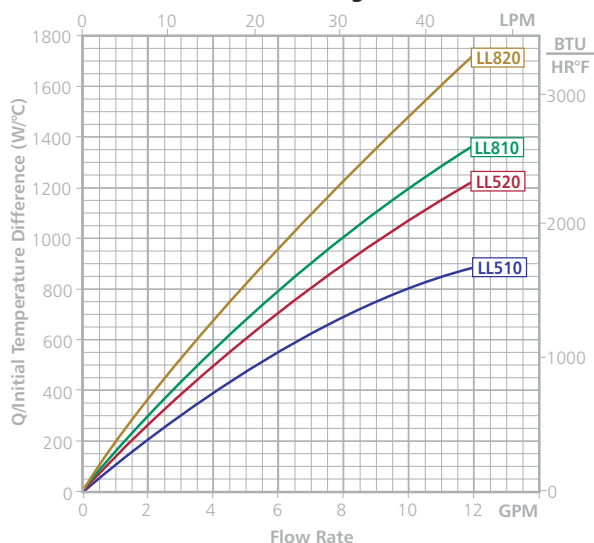
ES0707 - EGW<sup>3</sup>



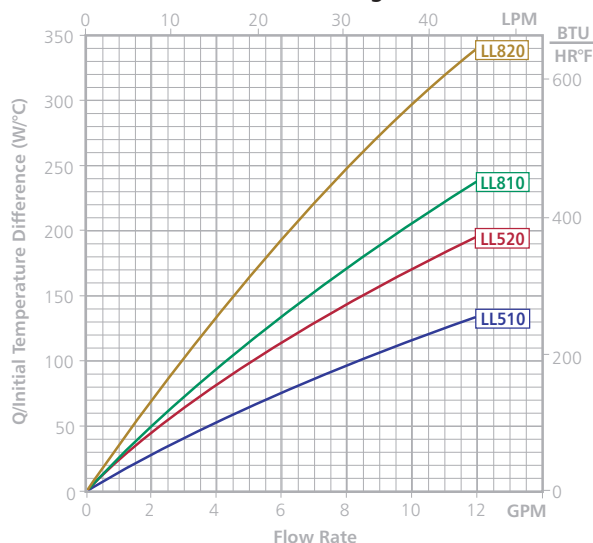
ES0714 - EGW<sup>3</sup>



Liquid-to-Liquid  
Thermal Performance Using Water and Water



Liquid-to-Liquid  
Thermal Performance Using Water and Oil



<sup>1</sup> The solid vertical lines indicate the performance provided by our standard fans at 60 Hz and 20°C. Dashed fan lines represent fan performance at 50 Hz and 20°C.

<sup>2</sup> See [www.Lytron.com](http://www.Lytron.com) for ES Series performance graphs for oil. <sup>3</sup> 50/50 EGW at 160°F (71°F).

For pressure drop curves, please visit [www.Lytron.com](http://www.Lytron.com).

First select a  
core number

Next, select a  
fitting option

Add a fan plate  
if desired

Arrive at a base  
part number  
e.g. 6120G1 BD

Add any  
additional  
options

CORE NUMBER	FITTINGS <sup>1</sup>			FAN PLATE	FANS <sup>2</sup>				
	SB	BD	AN		Kona	Marin	Chinook	Ostro	# of fans
<b>6105G1</b>	•	•	•	included	•				1
<b>6110G1</b>	•	•	•	included	•				1
<b>6120G1</b>	•	•	•	included	•				2
<b>6210G1</b>	•	•	•	included		•	•		1
<b>6220G1</b>	•	•	•	included		•	•		2
<b>6310G3</b>	•	•	•	included				•	1
<b>6320G3</b>	•	•	•	included				•	2
<b>6340G1<sup>1</sup></b>				no fan plate					
<b>6340G2<sup>1</sup></b>				included				•	4
<b>M05-050</b>	•	•	•	0=no fan plate; 1=fan plate	•				1
<b>M05-100</b>	•	•	•		•				2
<b>M10-080</b>	•	•	•			•	•		1
<b>M10-160</b>	•	•	•			•	•		2
<b>M14-120</b>	•	•	•					•	1
<b>M14-240</b>	•	•	•					•	2
<b>AS04-05G01</b>	•	•		included	•				1
<b>AS04-10G01</b>	•	•		included	•				2
<b>AS06-08G01</b>	•	•		included		•	•		1
<b>AS06-16G01</b>	•	•		included		•	•		2
<b>AS08-10G01</b>	•	•		included				•	1
<b>AS08-20G01</b>	•	•		included				•	2
<b>4105G1</b>	•	•	•	included	•				1
<b>4110G10</b>	•	•	•	included	•				1
<b>4120G10</b>	•	•	•	included	•				2
<b>4210G10</b>	•	•	•	included		•	•		1
<b>4220G10</b>	•	•	•	included		•	•		2
<b>4310G10</b>	•	•	•	included				•	1
<b>4320G10</b>	•	•	•	included				•	2
<b>ES0505G<sup>1</sup></b>				21=no paint, no fan plate; 22=black paint, no fan plate; 23=no paint, fan plate attached; 24=black paint, fan plate attached	•				1
<b>ES0510G<sup>1</sup></b>					•				2
<b>ES0707G<sup>1</sup></b>						•	•		1
<b>ES0714G<sup>1</sup></b>						•	•		2

### Liquid-to-Liquid Part Numbers

Core Number	LL510G12	LL520G12	LL810G12	LL820G12	LL510G14	LL520G14	LL810G14	LL820G14
Plate material	AISI 316L stainless steel							
Braze material	copper 99.9%				nickel 99.7%			
Number of plates	10	20	10	20	10	20	10	20
Dry Weight	lbs	2.6	3.7	4.9	6.7	2.6	3.7	4.9
	kg	1.2	1.7	2.1	2.9	1.2	1.7	2.1
Fittings	¾" MNPT							

<sup>1</sup> SB=Stub End; BD=Beaded Fitting; AN=37° AN Flare; 6340G1 AND 6340G2 - Leave blank: 0.875" O.D. union fitting; ES Series—leave blank: ¾-18 NPT fitting (e.g. – ES0707G24 has an NPT fitting, black paint, and fan plate)

<sup>2</sup> Fans, fan plugs, and fingerguards must be ordered separately. Assembly available on orders of 10+ pieces—ask for details.

Please visit [www.Lytron.com](http://www.Lytron.com) for heat exchanger dry weight and fluid volume, fan, fan plugs, and fingerguard specifications and complete part numbers, ordering information, and distributors.

## 1. Cooling Liquid

In order to select the correct Lytron heat exchanger or oil cooler, you must first determine the required thermal performance for your application. Use the example shown below:

### Step 1: Application Data

Liquid type:	Water
Required heat load (Q):	3,300 W (11,263 BTU/Hr)
Temp. of incoming liquid ( $T_{\text{liquid in}}$ ):	80°C (176°F)
Temp. of incoming air ( $T_{\text{air in}}$ ):	21°C (70°F)
Rate of liquid flow:	2 gpm (7.6 lpm)

### Step 2: Select the heat exchanger product series

Choose an aluminum, copper, or stainless steel heat exchanger based on the fluid compatibility. Aluminum tubing is usually used with light oils, or Ethylene Glycol and Water (EGW) solutions, copper is normally used with water, stainless steel is used with deionized water or corrosive fluids.

### Step 3: Calculate the Initial Temperature Difference (ITD)

Subtract the temperature of the incoming air from the temperature of the incoming liquid as it enters the heat exchanger.

$$\begin{aligned} \text{ITD} &= T_{\text{liquid in}} - T_{\text{air in}} \\ &= 80^{\circ}\text{C} - 21^{\circ}\text{C} = 59^{\circ}\text{C} \text{ (or } 176^{\circ}\text{F} - 70^{\circ}\text{F} = 106^{\circ}\text{F)} \end{aligned}$$

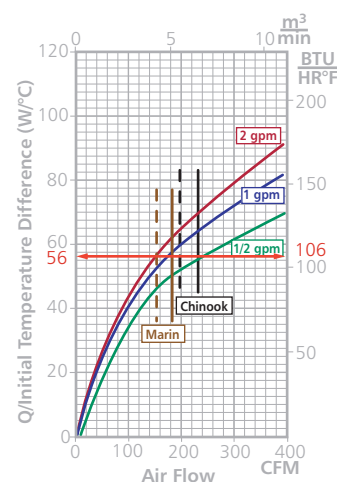
### Step 4: Calculate the required performance capability (Q/ITD)

Divide the required heat load (Q) by the ITD found above in step 3.

$$\text{Performance capability} = \frac{Q}{\text{ITD}} = \frac{3,300 \text{ W}}{59^{\circ}\text{C}} = 56 \text{ W/}^{\circ}\text{C} \text{ or } \frac{11,263 \text{ BTU/HR}}{106^{\circ}\text{F}} = 106 \text{ BTU/HR}^{\circ}\text{F}$$

### Step 5: Select the appropriate heat exchanger model

Refer to the thermal performance graphs for the heat exchangers selected. (Performance graphs for copper heat exchangers, stainless steel heat exchangers, and oil coolers can be found on pages 56, 57, and 58 respectively.) Any heat exchanger that exceeds 56 W/°C at 2 gpm (using a standard fan) would be acceptable. As shown in the following graph, Lytron's 6210 exceeds the required performance.

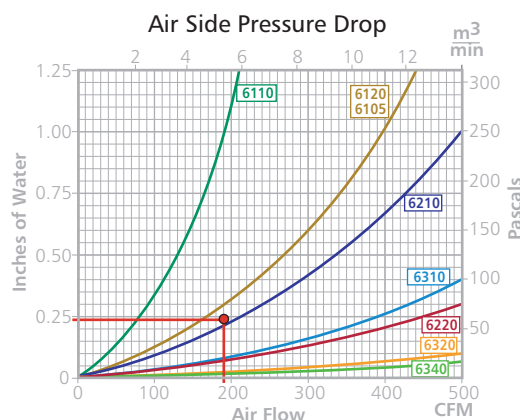
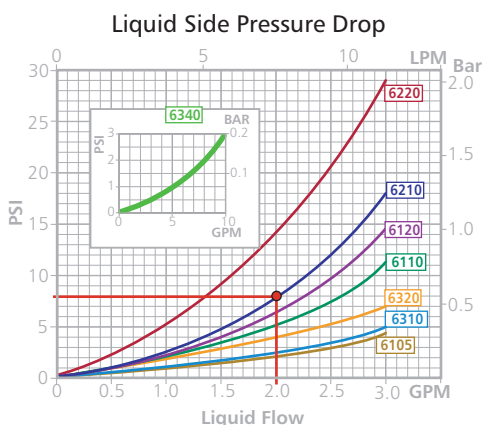


### Step 6: Determine the liquid pressure drop

From the data given, we know our pump needs to supply water at 2 gpm. Using the liquid side pressure drop chart for the 6210 curve on [www.Lytron.com](http://www.Lytron.com), the point where a vertical line at the 2 gpm point on the x-axis intersects with the 6210 curve reveals that the liquid pressure drop through the 6210 is 8 psi (0.55 bars). The pump selected must overcome this pressure drop to ensure a 2 gpm flow.

### Step 7: Determine the air pressure drop

The vertical line on the thermal performance chart indicates the air flow rate (180 CFM for the Marin fan) as provided by our standard fans at 60 Hz. The intersection point of this air flow rate and the 6210 graph on the air side pressure drop reveals that the air side pressure drop through the 6210 is 0.24 inches of water (55 pascals).





## 2. Cooling Air

In cabinet cooling applications, the air is hotter than the liquid. In this case, the ITD is the difference between the hot air entering the heat exchanger and the cold liquid entering the heat exchanger. You may need to calculate the temperature rise using the heat load and the temperature of the cool air entering the cabinet.

### Example: Cabinet Cooling application

You are cooling a cabinet containing electronic components that generate 2400 W of heat. The air in the cabinet must not exceed 55°C. What heat exchanger should be selected, and what is the temperature of the cool air entering the electronics cabinet?

#### Step 1: Application Data

Liquid type:	Water
Required heat load (Q):	2,400 W (8,189 BTU/Hr)
Temp. of incoming liquid (T <sub>liquid in</sub> ):	20°C
Max. temp of air in cabinet (T <sub>air in</sub> ):	55°C (131°F) — This is the temperature of the hot air entering the heat exchanger
Rate of liquid flow:	2 gpm (7.6 lpm)

#### Step 2: Calculate the ITD

Subtract the temperature of the incoming liquid from the temperature of the incoming air as it enters the heat exchanger.

$$ITD = T_{air\ in} - T_{liquid\ in} = 55^{\circ}C - 20^{\circ}C = 35^{\circ}C \text{ (or } 131^{\circ}F - 68^{\circ}F = 63^{\circ}F)$$

#### Step 3: Calculate the required performance capability (Q/ITD)

Divide the required heat load (Q) by the ITD found above in step 2.

$$\text{Performance capability} = \frac{Q}{ITD} = \frac{2,400\ W}{35^{\circ}C} = 68.6\ W/^{\circ}C \text{ or } \frac{8,189\ BTU/HR}{63^{\circ}F} = 130\ BTU/HR^{\circ}F$$

#### Step 4: Select the appropriate heat exchanger model

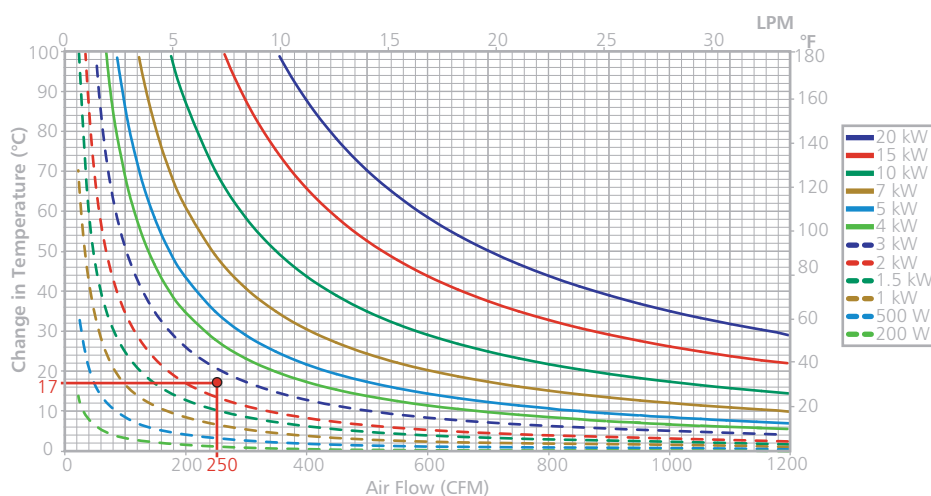
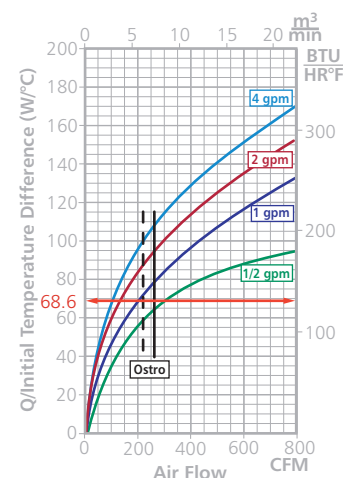
Refer to the thermal performance graphs for the heat exchangers selected. (Performance graphs for copper heat exchangers, stainless steel heat exchangers and oil coolers can be found on pages 56, 57, and 58 respectively.) Any heat exchanger that exceeds 68.6 W/°C at 2 gpm (using a standard fan) would be acceptable. Using water as the coolant, a copper heat exchanger is recommended. As shown in the following graph, Lytron's 6310 exceeds the required performance, offering a Q/ITD of approximately 96 W/°C using our Ostro fan.

Liquid and air pressure drop can be determined the same way as in the previous example.

#### Step 5: Calculating the temperature of the cool air entering the cabinet

Now, to calculate the temperature of the cool air entering the cabinet, use the temperature change graph for air found on [www.Lytron.com](http://www.Lytron.com). With a heat load of 2,400 W, and a flow rate of 250 CFM (the flow rate of the standard Ostro fan recommended for use with the 6310) we can see that the temperature change is 17°C. This means that the cool air entering the cabinet will be: 55°C – 17°C = 38°C

<sup>1</sup> These graphs offer a simple graphical way of estimating fluid temperature change if you know your heat load and flow, without having to do calculations. The graphs for water, air, 50/50 Ethylene Glycol/Water (EGW) and oil allow you to calculate temperature changes for air and liquid for all types of heat exchangers.

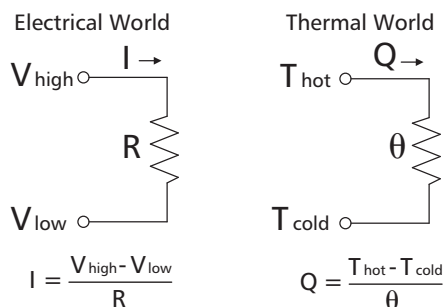


This section is an engineering introduction to thermal systems. It covers the basic principles of thermal transfer and explains the terminology and performance graphs used in this catalog.

## What is heat?

At the atomic level, heat is nothing more than the vibration of the atoms that make up the matter around us. Molecules that are vibrating excite other molecules through the emission of photons. This transfer of energy has the effect of increasing the vibration of the receiving molecule, and decreasing the vibration of the emitting molecule. These interactions are very complex at the atomic level, but at the bulk level, which averages the effects of many molecules working simultaneously, the heat transfer situation becomes much simpler. At the bulk level, there are just three primary forms of heat transfer: conduction, convection, and radiation. Lytron's products are simpler still, relying primarily on just conduction and convection.

When considering the bulk heat transfer properties of materials, it is important to understand an interesting feature of heat transfer: Heat always moves from the higher temperature body to the lower temperature body. The following diagram compares the similarity between the electrical world and the thermal world in this regard:



Just as electrical current flows from a higher voltage source to a lower voltage sink, heat flows from a higher temperature source to a lower temperature sink. The ability of this heat, "Q", to flow is directly proportional to the temperature difference between the source and the sink, and inversely proportional to the thermal resistance, "θ", between them. This is analogous to the electrical world where current flow, "I", is impeded by electrical resistance, "R".

Every object in the universe is subject to these effects. Higher temperature bodies are constantly sending heat to lower temperature bodies to raise their temperature. Consequently, it is very difficult to make accurate heat transfer measurements because unwanted thermal effects are attempting to participate in every experiment. While these effects can be mitigated through careful planning, they can never be eliminated. Heat transfer measurement is an exacting science.

## What is conduction?

If the two ends of a solid bar are maintained at different temperatures, heat will flow from the higher temperature end of the bar to the lower temperature end. The rate at which the heat flows is directly proportional to the temperature difference between the ends of the bar, the cross-sectional area of the bar, and a property of the bar called the "thermal conductivity". If the temperature difference is increased, or the cross-sectional area of the bar is increased, or if a material with greater thermal conductivity is selected, the heat flow rate will increase. On the other hand, heat flow is inversely proportional to the length of the rod. If the rod is twice as long, the heat flow will be cut in half. Sometimes engineers speak of the 'temperature gradient' in a conducting material. This is the temperature difference divided by the length. For example, if the temperature difference is doubled, but the length is doubled as well, the temperature gradient would stay the same, and the heat flow will remain unchanged. Heat flow is directly proportional to the temperature gradient.

Below is the thermal conductivity equation, where Q is the rate of heat flow, "k" is the thermal conductivity of the material, "ℓ" is the length of the rod, "A" is the cross-sectional area, and "ΔT" is the temperature difference between the hot and the cold ends of the rod.

$$Q_{\text{conduction}} = \frac{k \cdot A \cdot \Delta T}{\ell}$$

The diagram shows a horizontal rod of length ℓ and cross-sectional area A. The left end is at temperature T<sub>hot</sub> and the right end is at temperature T<sub>cold</sub>. Heat flow Q is shown moving from the hot end to the cold end. The thermal conductivity k is indicated above the rod.

This equation makes clear several principles that are used in Lytron's cold plates and heat exchangers. If we define the thermal resistance " $\theta$ " as ( $\ell/kA$ ), this equation looks like the thermal resistance equation defined earlier:

$$Q = \frac{\Delta T}{\theta_{\text{conduction}}} \quad \text{where} \quad \theta_{\text{conduction}} \equiv \frac{\ell}{k \cdot A}$$

In this example, anything we can do to increase " $k$ " or " $A$ ", while decreasing the length " $\ell$ " that the heat has to travel will reduce the thermal resistance. The common thread in Lytron's product offerings is that they have been designed for reduced thermal resistance.

### What is convection?

A typical cold plate or heat exchanger application is more complicated than the solid bar example described previously. In addition to the transfer of heat by thermal conductivity through the solid materials of a cold plate or heat exchanger, there may be one or more fluids that bring the heat to the hot side, and/or which take the heat away from the cold side through the process of convection.

Convection is a very efficient means of heat transfer. Unlike conduction, where the molecules are stationary, in convection, the molecules are moving. Because the molecules are moving, the rate of heat transfer can be considerably higher than in conduction. The equation for heat transfer by convection is:

$$Q_{\text{convection}} = A \cdot h \cdot (T_{\text{solid}} - T_{\text{fluid}})$$

where " $A$ " is the area where the solid surface and the fluid interact,  $T_{\text{solid}}$  and  $T_{\text{fluid}}$  are the temperatures of the solid surface and the fluid respectively, and " $h$ " is the film coefficient. The film coefficient varies widely depending on the properties of the fluid and how fast it is moving. The table below shows typical values of the film coefficient<sup>1</sup>:

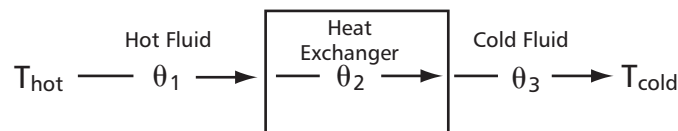
Situation	$h$ (W/m <sup>2</sup> ·°C)
Free convection in air	5 to 25
Free convection in water	500 to 1,000
Forced convection in air	10 to 500
Forced convection in water	100 to 15,000
Boiling water	2,500 to 25,000
Condensing steam	5,000 to 100,000

Like the conduction equation, the convection equation can be rewritten in terms of thermal resistance:

$$Q_{\text{convection}} = \frac{(T_{\text{surface}} - T_{\text{fluid}})}{\theta} = \frac{\Delta T_{\text{sf}}}{\theta} \quad \text{where} \quad \theta_{\text{convection}} = \frac{1}{h \cdot A}$$

### Heat exchanger performance

The heat transfer performance of a heat exchanger can now be characterized by including the convective thermal resistance terms in addition to the conductive thermal resistance term described earlier. In summary there are three components to the overall thermal resistance of a heat exchanger:



- 1) A convection component, " $\theta_1$ ", which describes the transfer of heat from a heated fluid into the surface of the heat exchanger;
- 2) A conduction component, " $\theta_2$ ", which describes the transfer of heat through the solid materials of the heat exchanger;
- 3) And, a second convection component, " $\theta_3$ ", which describes the flow of heat out of the heat exchanger into a cooling fluid.

<sup>1</sup> Chapman, Alan J., *Fundamentals of Heat Transfer*, Macmillan Publishing Company, 1987, p. 14.

Each of these separate thermal resistance components can be summed together to generate a global thermal resistance for the heat exchanger and the two fluids, as shown:

$$\theta_{\text{Global}} = \theta_1 + \theta_2 + \theta_3$$

By comparison, a cold plate typically has a single fluid (for cooling). Therefore a cold plate would have just two components: a thermal conductivity component and a single convective component.

If we generically reduce any cold plate or heat exchanger application to a black box that transmits heat from a hot side to a cold side, then anything we can do to decrease the global thermal resistance<sup>2</sup> will allow one of two things to happen:

- 1) If the temperature difference is fixed, more heat will flow, or,
- 2) If the heat flow is fixed, the temperature difference will reduce.

For example, if active heat-producing components are mounted onto a cold plate with a low thermal resistance, the temperature of the components will be much closer to the temperature of the cooling fluid, than had they been mounted onto a cold plate with a large thermal resistance. The lower the global thermal resistance, the better the performance.

## Air-side versus liquid-side limits

The graph below depicts the thermal capacity performance of our 6340 copper heat exchanger. The 4 gpm trace depicts a steep rise in performance as the air flow increases from zero, and then a plateau at larger air velocities. This behavior is typical of heat exchangers.

To understand what is causing this behavior, it is useful to revisit the global thermal resistance equation which we derived earlier:

$$\theta_{\text{Global}} = \theta_1 + \theta_2 + \theta_3$$

We can rewrite this as:

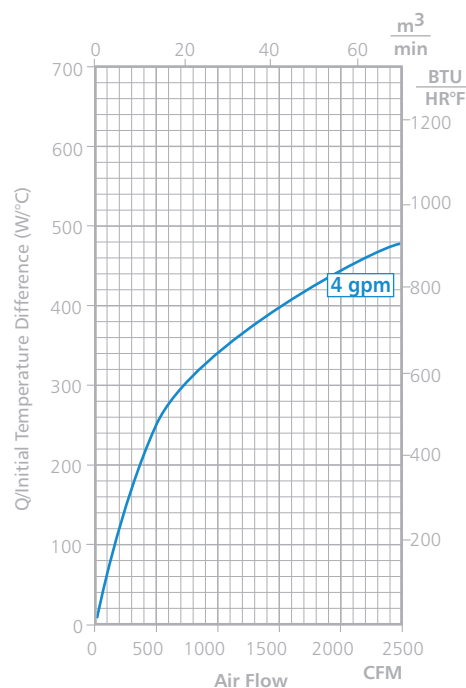
$$\theta_{\text{Global}} = \theta_{\text{liquid-hx}} + \theta_{\text{hx}} + \theta_{\text{hx-air}}$$

where the first term is the thermal resistance from the heated liquid, the second term is the thermal resistance due to thermal conductivity through the heat exchanger, and the third term is the thermal resistance to move the heat out of the heat exchanger into the air.

In practice, the second term tends to be much smaller than the other two terms, so we can simplify this equation as:

$$\theta_{\text{Global}} \cong \theta_{\text{liquid-hx}} + \theta_{\text{hx-air}}$$

At very low air flow rates, the slope of the trace is very steep. In this regime, the second term is much larger than the first term. When this happens we say that the heat exchanger is "air-side limited". In this regime, different levels of liquid flow make little difference to performance. When this happens, the only way to improve the performance of the heat exchanger is to increase the air flow.



<sup>2</sup>A heat exchanger or cold plate with zero thermal resistance, while physically impossible, would be the ideal heat transfer product. Such a product would provide a thermal short-circuit: heat would flow without the requirement of a temperature gradient.



At very high air flow rates, the second term approaches zero. When this happens, we say that the performance of the heat exchanger is “liquid-side limited”. In other words, further increases in the airflow make no significant improvement because the second term is already so small. When a heat exchanger is liquid-side limited, the only way to increase the performance is to increase the liquid flow.

The trade off between these two terms is what causes the characteristic shape of our heat exchanger curves. When the two terms are roughly equal in magnitude, this is when the heat exchanger is balanced. A balanced heat exchanger makes optimum use of its materials.

### Boundary layers

As a fluid moves past a stationary surface, there will be a velocity gradient of fluid molecules in the fluid stream. The slowest moving molecules will be the ones that are in direct contact with the surface, and which are being slowed down by friction with the surface, while the fastest moving molecules will be the ones that are farther away.

A useful engineering approximation is to assume that there is a thin layer of fluid which is completely stationary along the surface. This thin layer is called a boundary layer. Because the boundary layer is stationary, the heat transfer through this layer is determined using thermal conductivity equations instead of convection equations.

Thermal performance is affected by the thickness of the boundary layers in a heat exchanger. When the fluid velocity increases, the boundary layers become smaller. This has the effect of increasing the film coefficient and thereby reducing the thermal resistance.

### The graphs in this catalog

The performance graphs that describe our cold plates in this catalog are based on thermal resistance or thermal impedance. The lower the trace on the graph, the better the performance. In contrast, the performance graphs for the heat exchangers in this catalog are based on thermal conductance. In these graphs, the higher the trace, the better the performance. Thermal conductance is the reciprocal of thermal resistance:

$$\text{Thermal Conductance} = \frac{1}{\text{Thermal Resistance}}$$

The reason for this difference in approach in our cold plates and heat exchangers is due to industry conventions. To avoid confusion, look at the units of the Y-axis. If the units are °C/W, then this is thermal resistance and a small number is the better result. If the units are W/°C, then this is thermal capacity and a large number is the better result.

### Another thing to know about the graphs in this catalog

The performance data for heat exchangers provided in this catalog are based on the temperature of the fluid when it *enters* the product. The example on page 60, which describes how to size a heat exchanger, is based on the assumption that we already know the desired entrance temperatures of the heated fluid and the cooled fluid. To convert between the entrance and exit temperatures, we can use the heat capacity equation shown below:

$$\Delta T = \frac{Q}{\rho \cdot \dot{V} \cdot C_p}$$

This equation describes the change in temperature of a fluid that occurs based on the heat being transferred “Q”, the density “ρ” of the fluid, the volumetric flow rate of the fluid “ $\dot{V}$ ”, and the specific heat of the fluid “ $C_p$ ”. These calculations can be cumbersome to do manually. The four temperature change graphs on [www.Lytron.com](http://www.Lytron.com) provide a quick way of calculating the results of this equation for four common heat transfer fluids: air, water, oil, and 50% Ethylene Glycol/Water (EGW).

### Working with Lytron

Fortunately, you do not have to be a heat transfer expert to work with Lytron. Our website provides convenient sizing programs that will select a Lytron standard product based upon your thermal requirements. We also have applications engineers who are available to work with you if you have special requirements. In addition to the standard products in this catalog, we also build custom products for qualified Original Equipment Manufacturers (OEMs). Please contact your Lytron sales representative and we will put you in touch with the appropriate Lytron resource.

## Material Properties<sup>1</sup>

Material	C <sub>p</sub> : Specific Heat		ρ: Density		K: Thermal Conductivity	
	BTU/lb°F	J/kg°C	lbs/ft <sup>3</sup>	kg/m <sup>3</sup>	BTU/hr ft °F	W/m°C
AIR (STP)	0.24	1,006	0.07	1.2	0.01	0.017
ALUMINUM, 6061	0.23	896	169	2700	104	180
COPPER, 110	0.09	377	558	8940	226	391
COOLANOL 25	0.44	1,838	56.4	903	0.07	0.12
DIALA-X®	0.44	1,840	54.3	870	0.08	0.14
20/80 EGW SOLUTION	0.93	3,817	63.9	1023	0.33	0.57
40/60 EGW SOLUTION	0.84	3,470	65.7	1052	0.26	0.45
50/50 EGW SOLUTION	0.78	3,283	66.4	1064	0.23	0.39
FLUORINERT™, FC-77	0.25	1,047	110.9	1776	0.037	0.064
HYDRAULIC OIL <sup>2</sup>	0.44	1,842	54.2	868	0.07	0.12
MIL-H-5606	0.46	1,924	52.5	842	0.08	0.14
MIL-L-23699	0.44	1,830	61.1	980	0.08	0.14
POLYALPHAOLEFIN (PAO)	0.52	2,180	49.6	794	0.08	0.14
SAE 10W OIL	0.45	1,901	54.6	875	0.07	0.12
SAE 30W OIL	0.45	1,901	54.6	875	0.07	0.12
STAINLESS STEEL, 316	0.12	500	501	8025	9.40	16.20
WATER	1.00	4,184	62.3	998	0.34	0.59

<sup>1</sup> At 20°C    <sup>2</sup> Typical

## Conversion Factors

MULTIPLY	BY	TO OBTAIN
Watts	3.412	BTU/hr
Watts/°C	1.896	BTU/hr°F
Horsepower	745	Watts
CFM (Cubic Feet per Minute)	0.028	m <sup>3</sup> /min
PSI (Pounds per Square Inch)	0.069	Bars
PSI (Pounds per Square Inch)	27.68	Inches of Water
GPM (Gallons per Minute)	3.785	LPM (Liters per Minute)
Ft <sup>3</sup> (Cubic Feet)	7.48	Gallons
Pressure Head (Feet of Water)	0.434	PSIG
Inches of Water	249	Pascals
In. (Inches)	25.4	mm (millimeters)
lbs (Pounds)	0.454	kg (kilograms)
Tons of Refrigeration	12,000	BTU/Hr
°F (Fahrenheit)	5/9 (°F-32)	°C
°C (Celsius)	(1.8 x °C)+32	°F
C <sub>p</sub> (BTU/lb°F)	4.18	J/kg°C
Density (lb/ft <sup>3</sup> )	16.018	kg/m <sup>3</sup>
ΔT (°C)	1.8	ΔT (°F)
Mass Flow (lb/hr)	0.000126	kg/sec

## Temperature Conversion

°C	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
°F	-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230	248	266	284	302	320	338	356

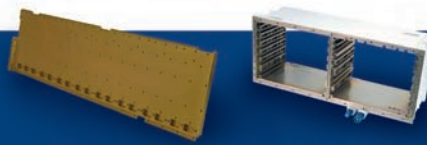
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## **Corporate Headquarters**

Lytron Inc.  
55 Dragon Court  
Woburn, MA 01801, USA  
+1-781-933-7300  
[www.Lytron.com](http://www.Lytron.com)



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Ossipee, NH  
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[www.Lytron.com](http://www.Lytron.com)

### **Germany**

Castrop-Rauxel  
+49(0)23059 208774  
[www.Lytron.de](http://www.Lytron.de)

### **China**

Shanghai  
+86 (21) 6247-3561  
[www.Lytron-inc.cn](http://www.Lytron-inc.cn)

### **Singapore**

Hola Centre  
+65 6841-6283  
[www.Lytron.com](http://www.Lytron.com)

## **Distributors**

### **USA**

MSC Industrial Supply Co.  
+1-800-645-7270  
[www.MSCDirect.com](http://www.MSCDirect.com)

### **Europe**

AMS Technologies AG  
+49(0)89895 770  
[www.ams.de](http://www.ams.de)

### **Japan**

Alpha Electronics Corp.  
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[www.alphacorpjp.com](http://www.alphacorpjp.com)

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