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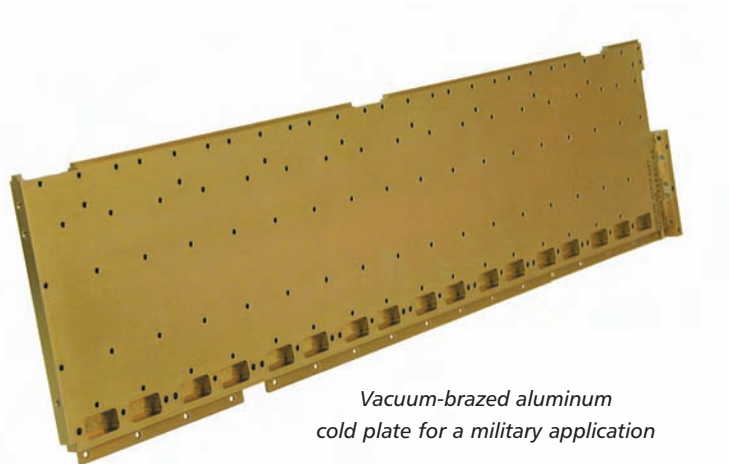
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In a world of compact designs with increasing power densities, cold plates are satisfying demanding contact cooling requirements in applications as diverse as high-powered electronics, power generation, medical equipment, military and aerospace, and 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.

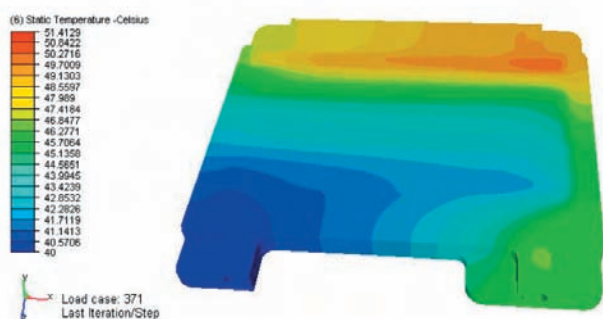


Vacuum-brazed aluminum cold plate for a military application

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.



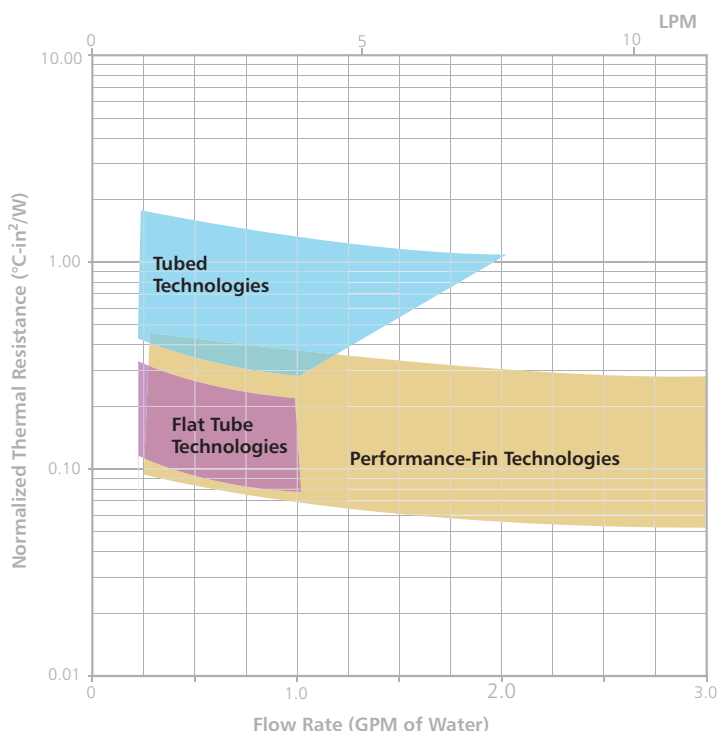
We're experts at build-to-specification cold plate design and manufacturing. We perform thermal analysis using advanced simulation software as well as use CFD and structural analysis software.



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



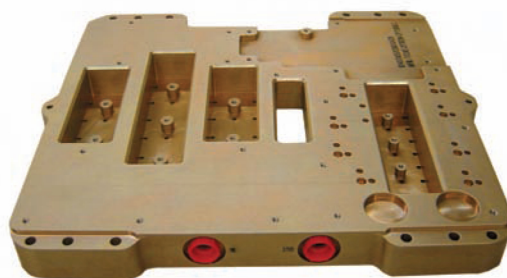
Ruggedized, aluminum, liquid-cooled chassis for electronics cooling in a military application



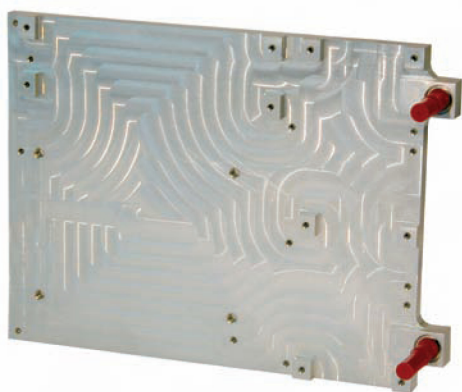
Copper cold plate designed and manufactured by Lytron for electronics cooling is about the same size as a cell phone

Cold Plates

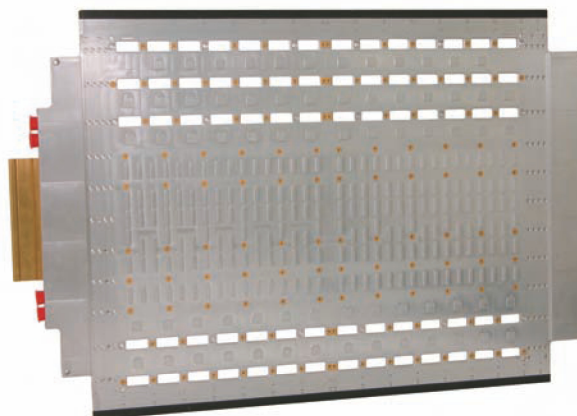
Performance-fin aluminum and copper cold plates offer nearly unlimited customization opportunities. They can be precisely engineered to match your performance, pressure drop, and dimensional requirements. Since Lytron manufactures its own fin, we can customize the internal fin as well as the cold plate's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



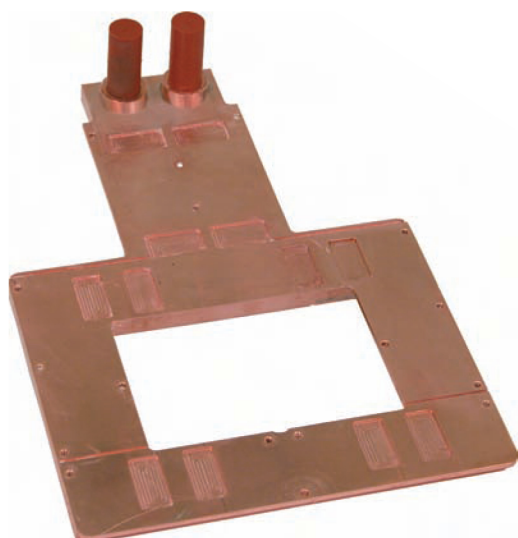
Vacuum-brazed aluminum cold plate for power electronics cooling in a military application



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

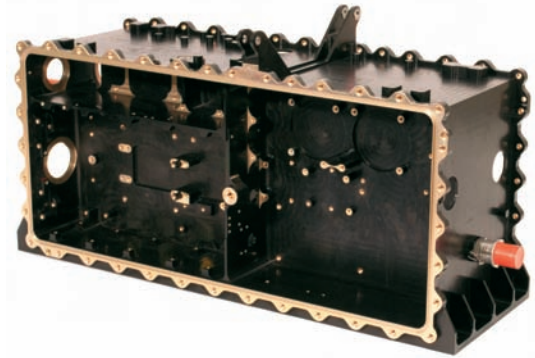


Copper cold plate for cooling diodes in the telecommunications industry

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

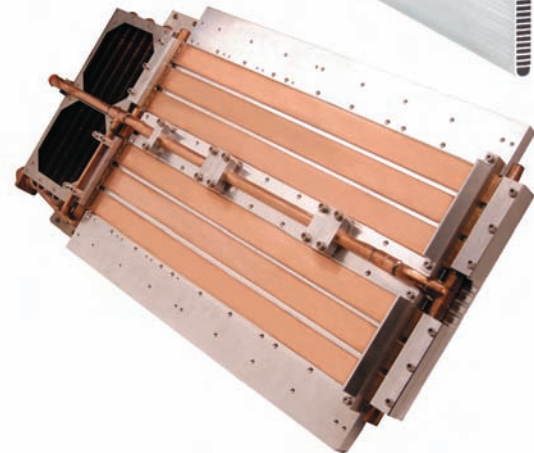
Flat Tube Cold Plates

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.

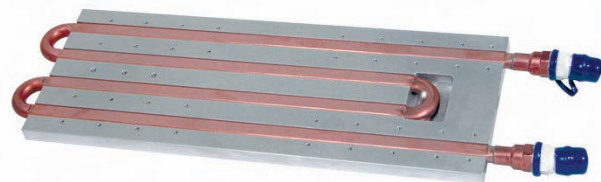
Aluminum flat tube



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

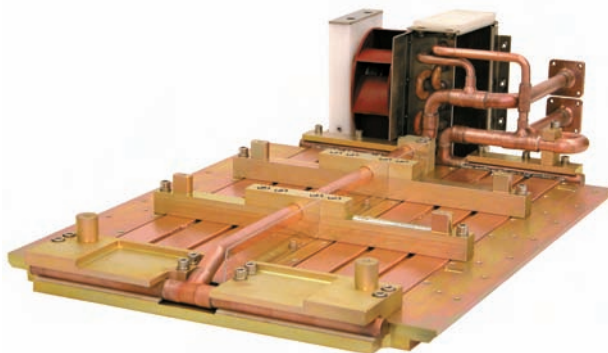
Our expertise goes well beyond components. We understand what is needed for seamless integration of your component into your system. An assembly can be as simple as a cold plate with hoses, or as complex as a cold plate with a heat exchanger, fans, and more. Value-added components may include:

- 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

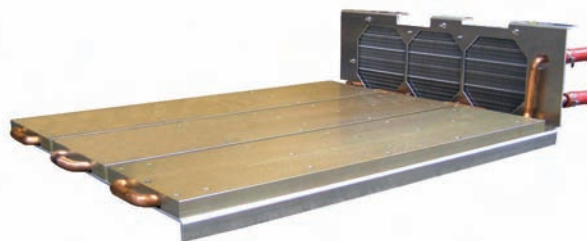
We source the components for value-added assemblies through our robust supply chain management program or work with customer supplied components so that your cold plate integration goes as smoothly as possible. By working with Lytron on the design and manufacture of your assembly, you can achieve:

- 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

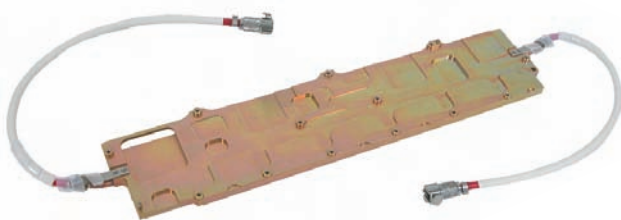
Please contact Lytron today to discuss your requirements.



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



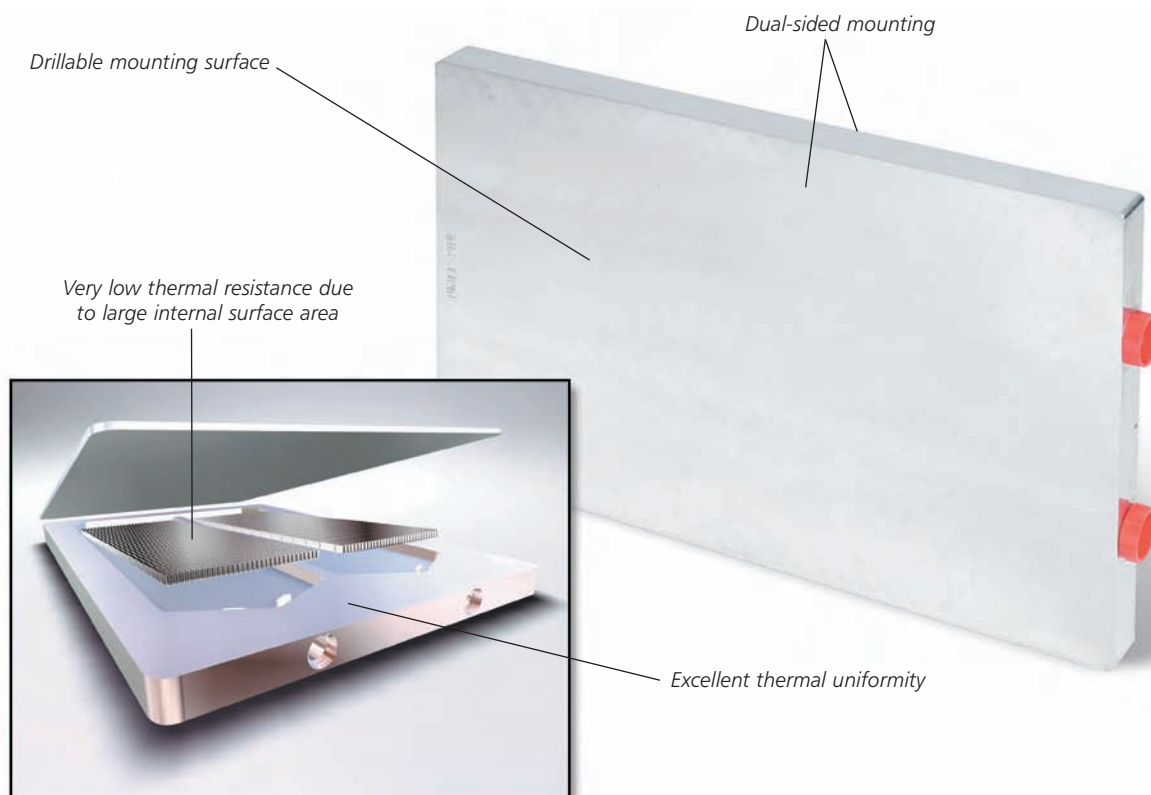
Power supply cold plate consisting of three custom tubed cold plates and one heat exchanger with fan plates



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.

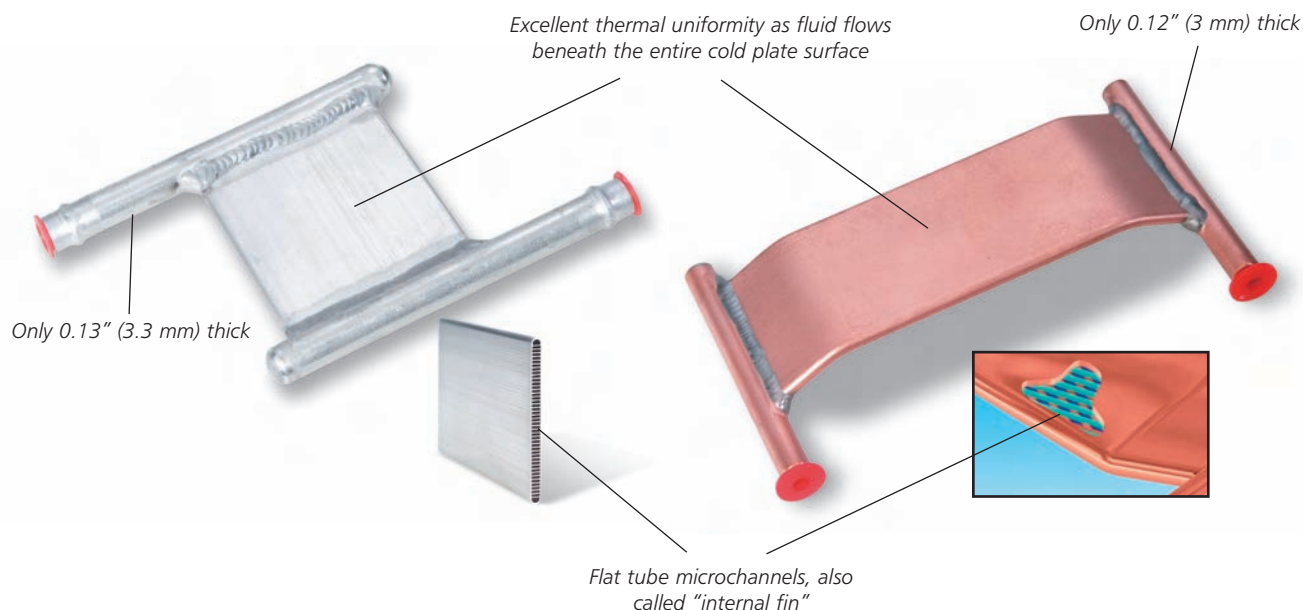
Custom vacuum-brazed cold plate with extensive surface machining.



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 $0.05^{\circ}\text{C}\cdot\text{in}^2/\text{W}$ ($0.33^{\circ}\text{C}\cdot\text{cm}^2/\text{W}$), 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 $0.13^{\circ}\text{C}\cdot\text{in}^2/\text{W}$ ($0.84^{\circ}\text{C}\cdot\text{cm}^2/\text{W}$) 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



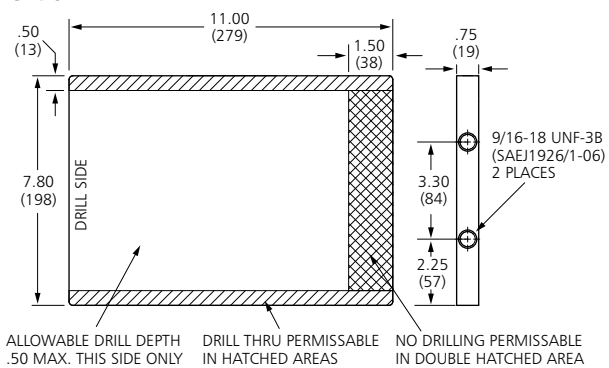
Customization Options

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.

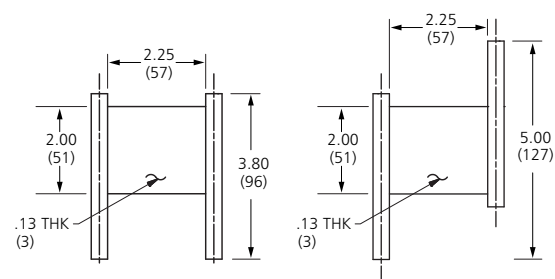
See page 30 for more custom cold plates.



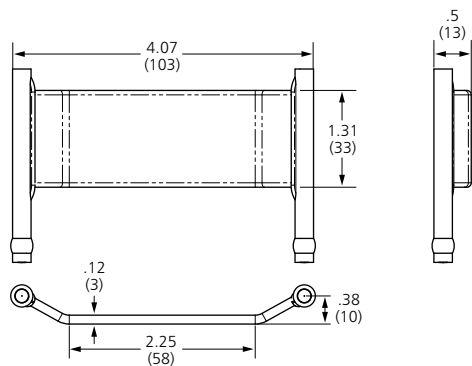
CP30



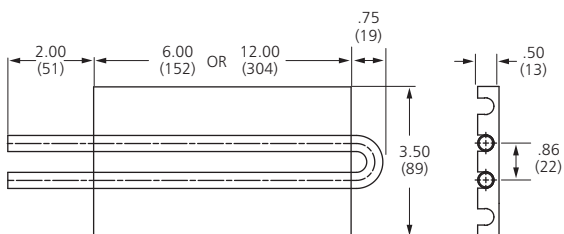
CP20



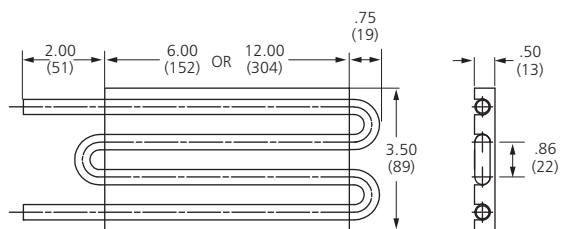
CP25



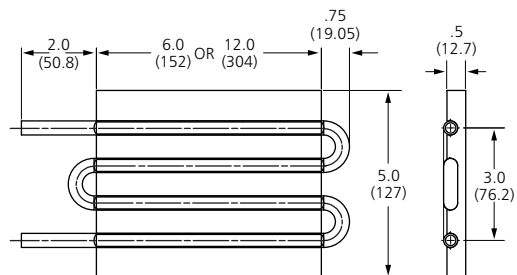
CP10 2-pass



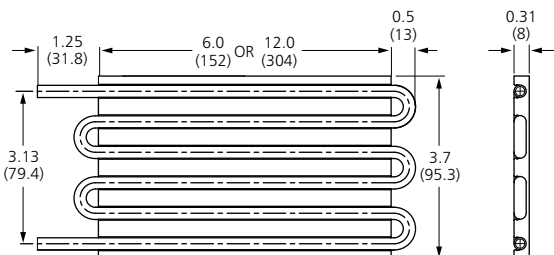
CP10 4-pass



CP12



CP15



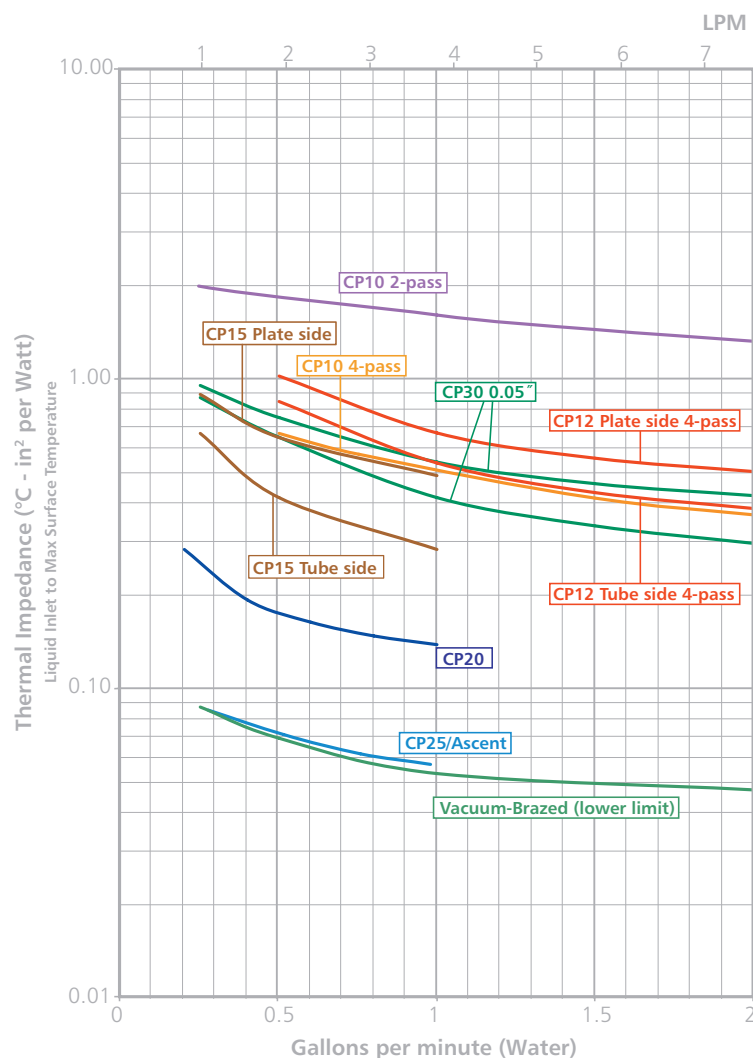
PDFs, IGS files, and eDrawings of standard cold plates are available at www.Lytron.com. Main dimensional label is inches. Dimension in parentheses is mm.

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 inch² (161 cm²) 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 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_{out} . This is important because if T_{out} is greater than T_{\max} , there is no solution to the problem.

T_{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_{out} = temperature of fluid leaving cold plate
 T_{in} = inlet temperature of fluid
 Q = heat load of devices
 ρ = 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. These graphs describe the change in temperature, ΔT , that occurs along the fluid path. To find T_{out} , add ΔT to the inlet temperature, T_{in} .

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

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

θ = thermal impedance
 T_{\max} = maximum desired cold plate surface temperature
 T_{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_{in} : 20°C T_{\max} : 55°C Q : 500 Watts A : 8 in²

We need to calculate T_{out} and θ .

First calculate T_{out} . Using the heat capacity graphs on 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_{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.

