FERRAZ

COOLING DEVICES

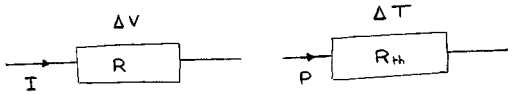
WATER COOLING DEVICES
FERRAZ EDGE & TECHNOLOGY

- DESIGNED FOR HIGH POWER SEMICONDUCTOR COOLING (PRESS-PACK & MODULE)
- OFFERING :
  - FULL SAFETY
  - HIGHER RELIABILITY
  - SPACE GAIN
- COST-SAVING WITH THE LOWEST PRICE PER KVA
- ACCELERATE YOUR DESIGN WITH THE MASTERING OF THERMAL CONCEPTION

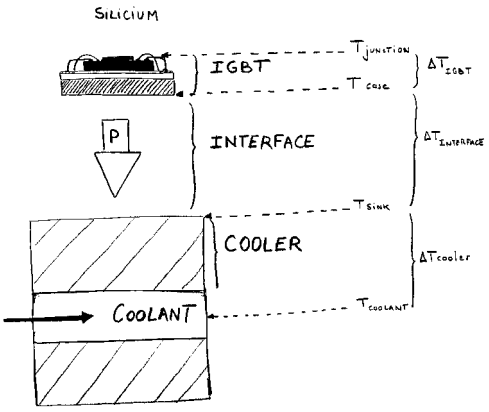
BASIC REMINDERS

LOWERING THERMAL RESISTANCE

Electrical analogy to understand basic thermal resistance concept.



For a given dissipated power P (Current I), the lower the thermal resistance to power dissipation (the lower the resistance to current conduction), the lower the temperature rise above ambiant (the lower the voltage drop): $\Delta T = RthxP$. ($\Delta V = RI$)
FERRAZ cooling technologies are dedicated to lower the temperature rise above ambiant. These technologies show thermal resistances lower than conventional devices. Each °c saved by FERRAZ coolers is gained to reach higher current rating for the silicium or to increase MTBF (Mean Time Before Failure).



SILICIUM AND TEMPERATURE

An optimal thermal management prevents the silicium melting and avoids a component derating. The maximum junction temperature must most often stay below 125°c.

$T_{junction} = \Delta T_{IGBT} + \Delta T_{interface} + \Delta T_{cooler} + T_{coolant\ inlet}$

$T_{junction} = (Rth_{IGBT} + Rth_{interface} + Rth_{cooler}) \times P + T_{coolant\ inlet}$

To keep $T_{junction}$ below 125°c at P maximum, ($Rth_{SCR} + Rth_{interface} + Rth_{cooler}$) should be minimum.

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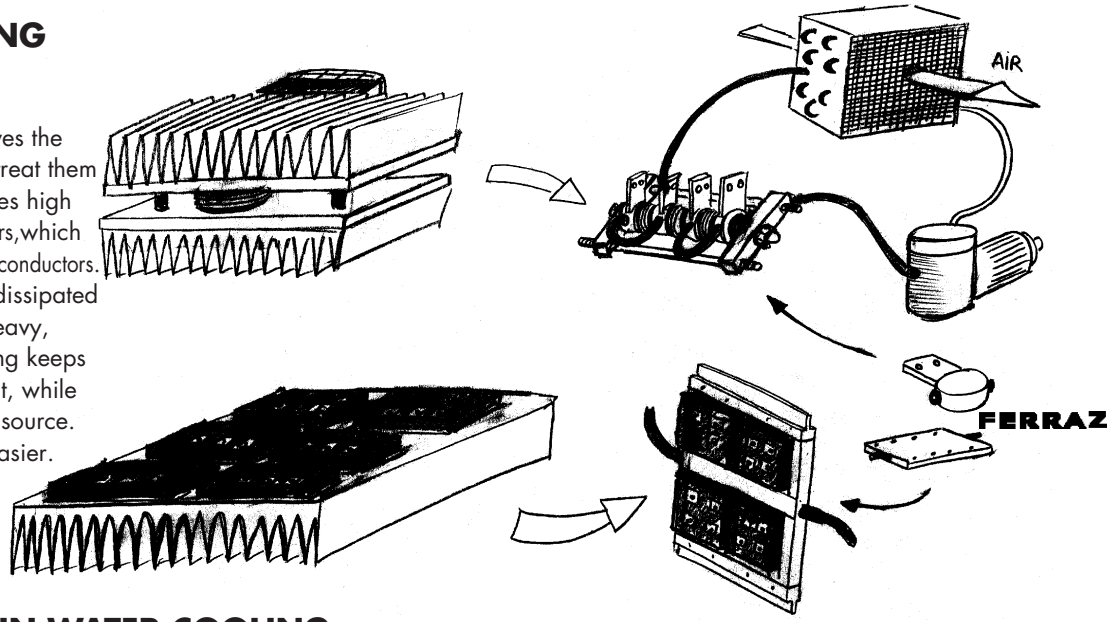
GROUPE CARBONE LORRAINE

Magnitude order of Rth	Rth $_{SC}$	Rth $_{interface}$	Rth $_{SCR}$ + Rth $_{interface}$	Rth of a conventional cooler (assumption)	Dissipated power increase if Rth $_{cooler}$ reduced by 50%
SCR (diameter 85 mm)	about 10°c/kW	2 to 4°c/kW	about 12°c/kW	20°c/kW	45%
High power IGBT (130 x 140) mm^2	about 15°c/kW	5 to 8°c/kW	about 20°c/kW	20°c/kW	33%
Low power IGBT (100 x 60) mm^2	about 50°c/kW	20 to 30°c/kW	about 70°c/kW	20°c/kW	12%

MODUCAL® and CALISTOR® water coolers improve performance of high power devices with high power dissipation and low thermal resistance junction-to-case.

WATER COOLING

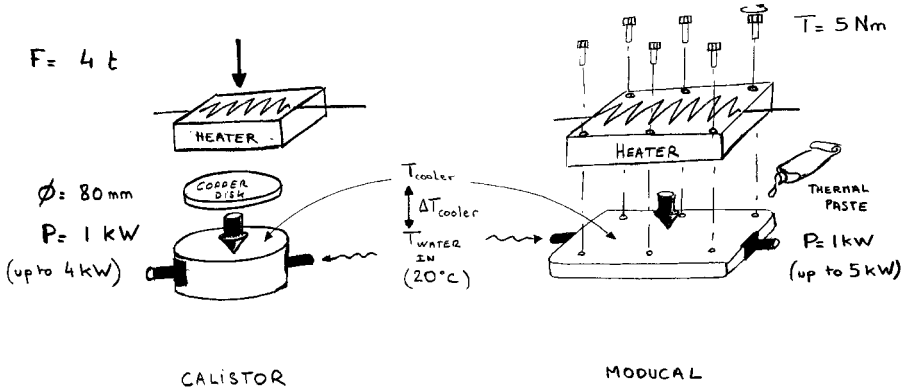
The water cooling loop removes the calories from their source to treat them properly. FERRAZ manufactures high performing water heat exchangers,which are a part of the loop to cool semiconductors. When high power has to be dissipated air cooling becomes bulky, heavy, dusty and noisy. Water cooling keeps electronics clean and compact, while separating cold sink from hot source. The thermal management is easier.



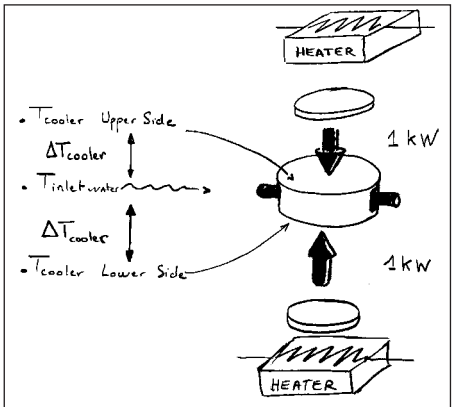
FERRAZ EDGE IN WATER COOLING

A VERY LOW THERMAL RESISTANCE

Most of conventional water coolers available on the market are made of holes drilled in a block of copper or aluminium. The following table shows features to compare the thermal resistances values between conventional technology and FERRAZ CALISTOR® or MODUCAL® technology in either one-side heating and two-side heating for a 80mm capsule device.



Test conditions : Single side heating

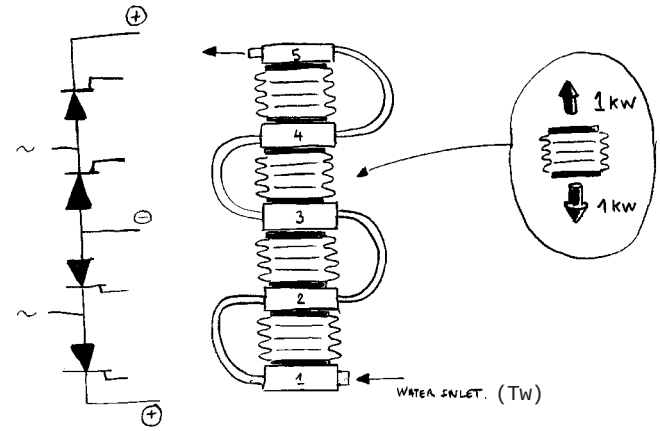


Double side heating

	Single side heating Dissipated power 1 kW		**Double side heating** Dissipated power 2 kW	
Cooler	Drilled copper block	Calistor 90	Drilled copper block	Calistor 90
ΔT_{cooler} at a 6 l/mn (1.58 US gal./mn*) water flow rate	17.5°c	12°c	51°c	12°c
Thermal resistance (T_{cooler} - $T_{coolant\ inlet}$)/ P	17.5°c/kW	12°c/kW	25.5°c/kW	6°c/kW
Pressure drop mbar (psi*) at a 6 l/mn (1.58 US gal./mn*) water flow rate	140 (2)	120 (1.75)	140 (2)	120 (1.75)

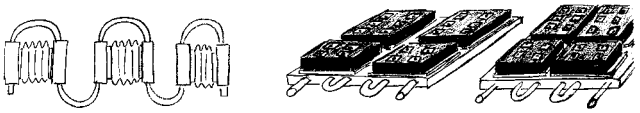
* Pure water at 20°c - US gal. = 3.785L - 1 psi = 68.9 mbar

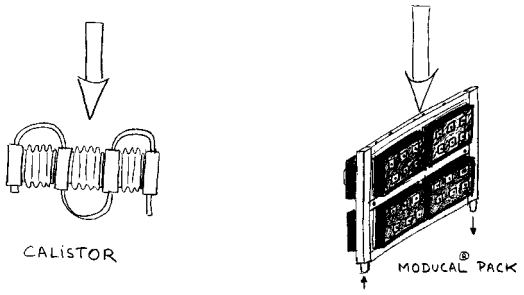
An application example : cost savings, weight and volume reduction



Cooler #	1	2	3	4	5
Dissipated power in cooler (kW)	1	2	2	2	1
Water temperature increase in cooler(°c)	2.5	5	5	5	2.5
T water inlet # - Tw (°c)	0	2.5	7.5	12.5	17.5
T cooler # - Tw (°c) for CALISTOR®	12	14.5	19.5	24.5	29.5
T cooler # - Tw (°c) for drilled copper block	17.5	53.5	58.5	63.5	35

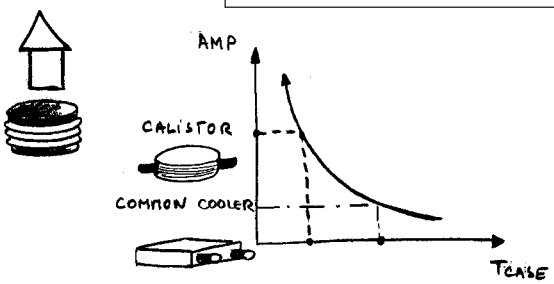
Values at 6 l/mnn water flow rate
Reminder : 1 kW increases pure water temperature of 2.5°c at 6 l/mnn water flow rate (physic of water).

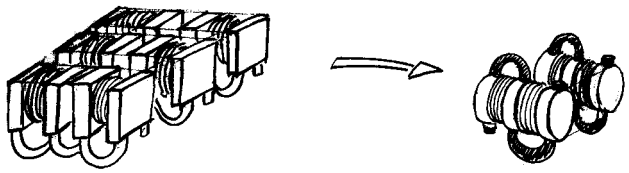




If inlet water is at 40°c, then the hottest CALISTOR® is 69.5°c (40+29.5) compared to the hottest drilled copper block at 103.5°c (40+63.5) (same applies to MODUCAL® for IGBT modules cooling).
Due to the above limitation, designers have then to cool each semiconductor with a pair of coolers. For n semiconductors they need 2n coolers, whereas with CALISTOR® they only need n+1, using the two sides of the device for SCRs in series.

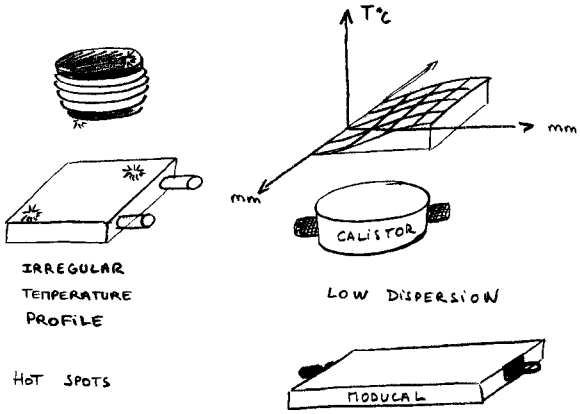
MORE AMPS OUT OF THE SAME SCR OR IGBT MODULE





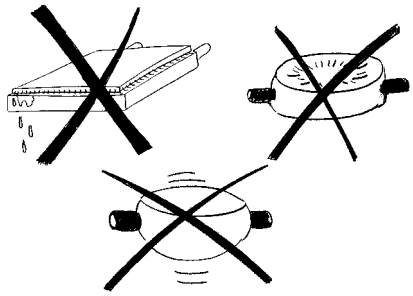
Less components needed, less parallel arms reducing cost, volume and weight.
A better thermal resistance gained with CALISTOR® or MODUCAL® technology leads to a higher current rating and a lower cost of Amp.

GREATER RELIABILITY FOR THE SEMICONDUCTOR



Consequence : lowering of the maintenance cost.
A better thermal resistance as well as even surface temperature gained with CALISTOR® or MODUCAL® technology leads to a lower SCR junction temperature and an increased reliability of the component.

MECHANICAL PLUSes

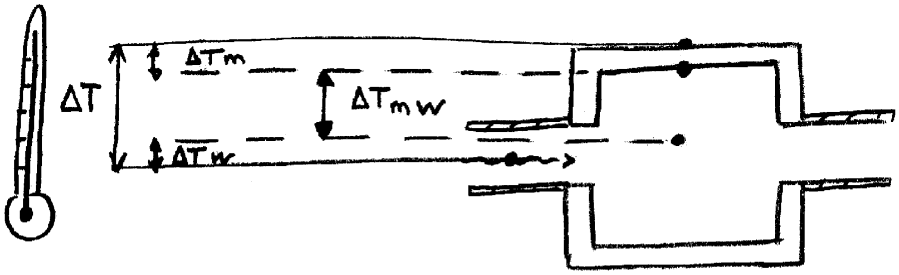


No welding means a leaktight structure with no risk of cracks.
Withstand high clamping force (up to 10-ton on a 80mm CALISTOR® dia.) and high internal pressure (up to 50-bar) both without deformation.

SAVING ON RUNNING COST

A high efficient heat transfer is gained at a low flow rate and low pressure drop, and consequently the power comsumption of the pump is reduced.

PHYSICS OF CALISTOR® AND MODUCAL®

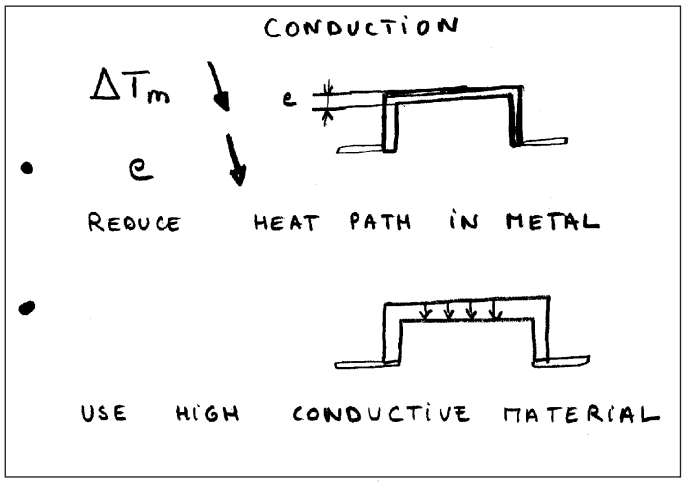


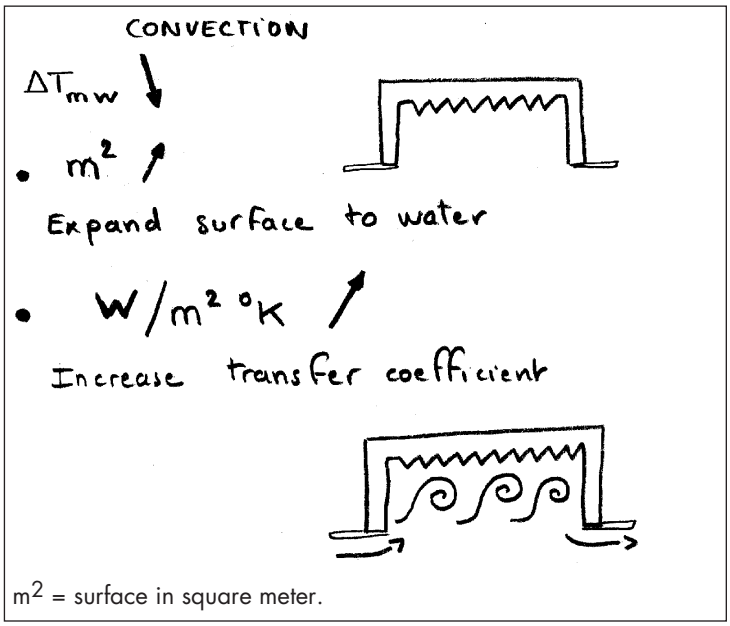
The temperature rise above inlet water temperature of the cooler surface is made of :

– the temperature rise due to the conduction of heat through the metal ΔTm,

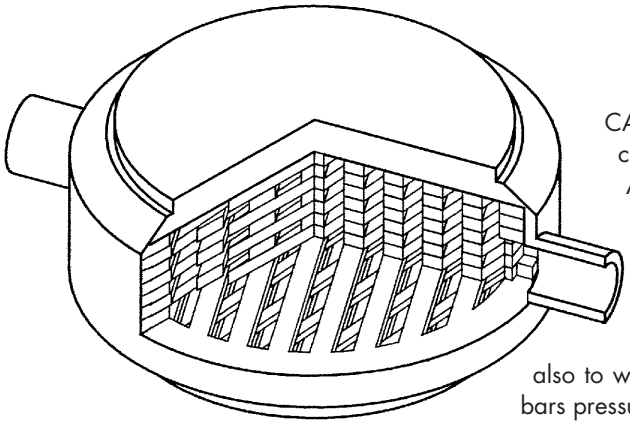
– the temperature rise due to the convection of heat from metal to water ΔTmw,

– the temperature rise of water ΔTw.





m^2 = surface in square meter.



CALISTOR® and MODUCAL® are the ideal arrangement to lower both conduction and convection temperature rises.

A patented brazed inner and aluminium-made structure lowers the heat path through metal, optimizes the heat transfer coefficient with turbulent flows obtained at low flow rates and a large surface in contact with water.

The patented brazed inner structure enables to withstand high clamping pressure with inner pillars from one side to the other and also to withstand very high internal pressure while being helium leaktight at 50 bars pressure.

ADVICES FOR COOLING WITH CALISTOR® AND MODUCAL®

Their use in a closed loop system where water quality remains under control is highly recommended, besause connecting the cooling circuit to the water mains might result in corrosion of aluminium.

In most applications in high power drives or large rectifiers, filtered and deionized water is used in order to increase the water resistivity. When cooling capsule devices, the aluminium cooler is under voltage. Stainless steel nozzle as sacrificial anode onto CALISTOR® or MODUCAL® will prevent aluminium electroerosion. The pipes are often made of stainless steel or plastic.
Copper parts such as water-cooled busbar, or copper inductance coils ... should be avoided.
When cooling insulated product like IGBT module; the aluminium will not be under potential, therefore corrosion inhibitors, though electrically conductive, can be used if different materials are used in the water circuitry depending on customer use and experience.

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