# DLC - DIRECT LIQUID COOLING FOR HTS SWITCHES

For the operation at higher frequencies and/or higher load currents, Behlke solid-state switches are offered with different cooling options to meet individual power and design requirements.Those cooling options are Increased Thermal Conductivity (ITC), Ceramic Cooling Surface (CCS), Cooling Fins (CF), Grounded Cooling Flange (GCF), Indirect Liquid Cooling (ILC) and Direct Liquid Cooling (DLC). The direct liquid cooling is the most efficient cooling solution at all and provides the lowest thermal resistance in connection with a very compact switch design. It is also the cooling method of choice, if stray capacitances and corona losses shall be minimized. The DLC cooling uses a non-conductive heat transfer fluid, which directly circulates arround the power semiconductors and the driver circuitry of the DLC switch. In essence, a simple DLC cooling system consists of an ESD protected pump with reservoir for de-aeration and radiators or heat exchangers for re-cooling. The hermetically sealed cooling circuit will be under light pressure at operating temperature. The normal temperature range is 0 - 55°C. The preferred cooling media is a perfluorinated polyether (PFPE) for dielectrical purposes, e.g. GALDEN® HT-135. GALDEN® PFPE has excellent physical properties, it is non-toxic, non-flammable and vaporizes absolute residue-free. Fig.1-4 show some examples of possible basic configurations. If required, individual cooling systems can additionally be equipped by safety & control electronics, flow indicators, electronic thermometers and fillports. Please consult factory for technical details and free design support.

**Fig. 1**

## Pump & reservoir

**Example:**
PU-1, pump unit with reservoir, tacho signal, thermo sensor, ESD protection and decoupled base plate. 7-12V, 4-20 Watts, max. 3 l / min.

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**Example:**
HTS 800-100-SCR, thyristor switch, with options DLC, FH, PT-C, PT-HV. Max. voltage 80 kV, max. current 1 kA.

## HTS switch with DLC

Switch dimensions are depending on power requirements!

## Active radiator

**Example:**
AR-800W, single active radiator for max. 800W power dissipation, complete with highly reliable PAPST fan of 120x120 mm², 12 VDC / 3,6 W inclusive tacho signal.

**Fig. 2**

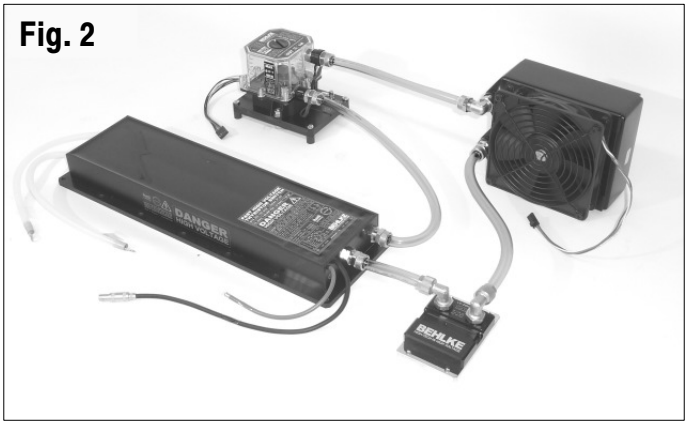

**Fig. 4**

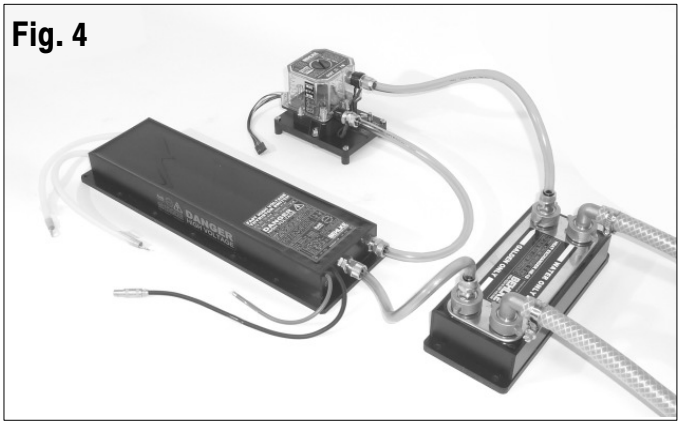

**Fig. 3**

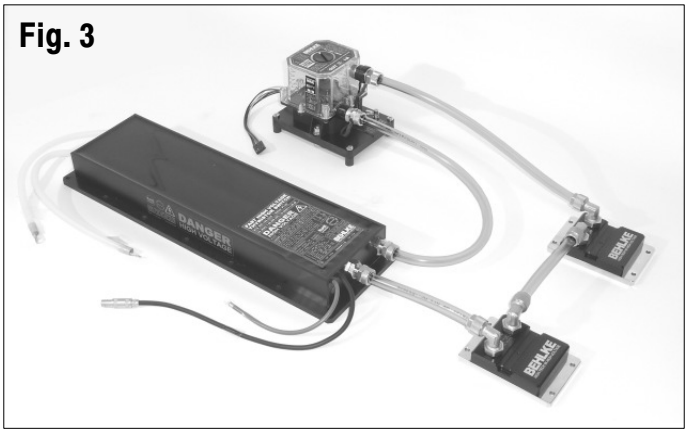

**Fig. 1** Simple cooling system using a small active radiator for a maximum power dissipation of 800 Watts. Active radiators with 120x120mm² fans are available in different sizes for a maximum power dissipation from 0.5 to 9 kW.

**Fig. 2** Active radiator AR-800W combined with passive liquid cooler LC-200W for increased system safety and reliability.

**Fig. 3** Two passive liquid coolers LC-200W in series to utilize standard heatsinks or massive metal housings as heatsink (e.g. aluminium front and rear panel of a 19" housing).

**Fig. 4** Plate heat exchanger for secondary cooling with water. Ideal for extreme power requirements. Heat exchangers are available in various sizes up to 100 kW power dissipation.

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## PUMP UNIT PU-1

GALDEN® COMPATIBLE


- Self adjusting ceramic bearing with liquid lubrication
- Life expectancy > 50.000h @ 60°C / full power
- Speed / power adjustable by voltage (7-12 V / 4-20 W)
- Max. flow rate 3 l/min with GALDEN HT135 @ 25°C
- With tacho signal output for pump function monitoring
- Complete with ESD protected reservoir, decoupled base plate and temperature sensor for speed control purposes
- Dimensions (LxWxH) 120 x 88 x 94 mm³, weight 530 g

## GALDEN® PFPE HT 135


**5kg ≈ 2.9 l** **1.7kg ≈ 1 l**

- Perfluorinated Polyether for insulation and heat transfer
- Biologically inert, non-toxic and non-flammable
- Excellent thermal stability, very low kinematic viscosity
- Clean handling, liquid vaporizes absolute residue-free
- Max. power density on surfaces to be cooled: 4 W / cm²
- Dielectric strength = 40 kV/mm, dielectric constant = 1.92

## ACTIVE RADIATOR AR-500W


VERY LOW NOISE

- $R_{th}$<0.06 K/W (useful power ≈ 500 Watt @△T= 30K)
- Complete with 12V/1.2 W PAPST fan + tacho generator
- Dimensions (LxWxH) 155 x 120 x 60 mm³, weight 600g

## ACTIVE RADIATOR AR-800W


- $R_{th}$<0.037 K/W (useful power ≈ 800 Watt @△T= 30K)
- Complete with 12V/3.6 W PAPST fan + tacho generator
- Dimensions (LxWxH) 155 x 120 x 87 mm³, weight 800g

## ACTIVE RADIATOR AR-2000W

GALDEN® COMPATIBLE

- $R_{th}$<0.015 K/W (useful power ≈ 2000 Watt @△T= 30K)
- Complete with 2x 12V/3.6 W PAPST fans + tacho generator
- Dimensions (LxWxH) 275 x 120 x 87 mm³, weight 1.45 kg

## ACTIVE RADIATOR AR-3000W

GALDEN® COMPATIBLE

- $R_{th}$<0.01 K/W (useful power ≈ 3000 Watt @△T= 30K)
- Complete with 3x 12V/3.6 W PAPST fans + tacho generator
- Dimensions (LxWxH) 395 x 120 x 87 mm³, weight 2,02 kg

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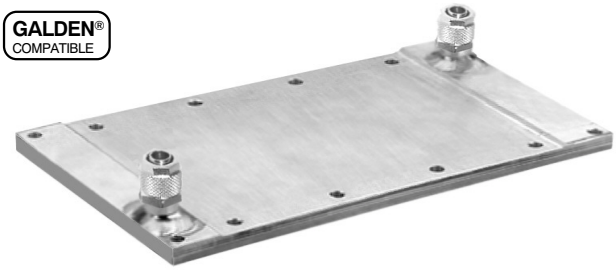
## LIQUID COOLER LC-200W

GALDEN® COMPATIBLE


For attachment on existing heat sinks or large metal housings. Ideal if 19" front & rear panels shall be utilized as passive radiators. Several coolers can be connected in series. $R_{th}$<0.15 K/W, max. useful power 200 Watts @$\Delta$T= 30K. Cooling flange off massive copper. Dimensions 90x60x42 mm³, 470g.

## LIQUID COOLER LC-1500W

GALDEN® COMPATIBLE



- Attachment on existing heat sinks or large metal housings
- $R_{th}$ <0.02 K/W, max. power 1500 Watt @$T_{flange}$= 25 °C
- Dimensions (LxWxH) 250 x 144 x 50 mm³, weight 2,5 kg

## PASSIVE RADIATOR PR-1-1

GALDEN® COMPATIBLE

High efficiency cooling profile complete with two 90° fittings. Dimensions (LxWxH) 420 x 50 x 50 mm³, weight 770 g

## PASSIVE RADIATOR PR-1-4

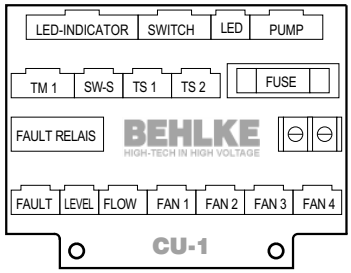
Set of four PR-1-1 cooling profiles incl. connecting pieces. Dimensions (LxWxH) 420 x 200 x 50 mm3, weight 3.2 kg

## HEAT EXCHANGER HE-10


GALDEN® COMPATIBLE

- Complete with fittings for primary and secondary circuit
- $R_{th}$ <0.003 K/W, max. power 10 kW @ $T_{water}$= 25 °C
- Dimensions (LxWxH) 224 x 89 x 55 mm³, weight 1,6 kg

## CONTROL UNIT CU-1




- Temperature depending speed control of pump and fans
- Monitoring of tacho signals from pump, flow turbine & fans
- Four channels for fans with tacho signal, 12V/10 W each
- Potential free relay contact for interlock purposes (NO+NC)
- Connection for one thermometer TM-1 and two sensors
- Function switch and indicators are connected externally for easy system integration. Supply voltage 12 VDC.

## THERMOMETER+SENSORS

GALDEN® COMPATIBLE

TM-1


TS-1 TS-2 TS-3

- LCD display with blue background illumination, snap-in assembly, measuring range 0 - 90°C, resolution 0.1 °C, supply voltage 5 VDC / 20 mA, 4 pin AMPMODU plug
- Sensor for G1/4 threads or for tubing 11/8 mm, with ESD protection, 3 pin AMPMODU plug

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## FLOW INDICATOR FI-1

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## FLOW SENSOR FS-1

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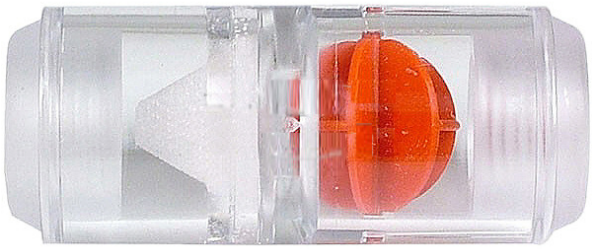
Flow turbine,
digital tacho signal
and background light

## FLOW INDICATOR FI-2

GALDEN® COMPATIBLE



Flow indicator with particle filter. 2x G1/4" fittings required

## FLOW SENSOR FS-2

GALDEN® COMPATIBLE

Flow turbine with diamond
bearing, digital tacho signal

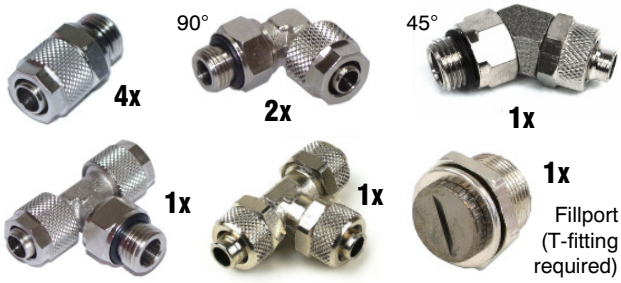
## FITTING KIT FK-8x1.0

GALDEN® COMPATIBLE


Metal fittings for tubing 8 x 1.0 mm, threads G1/4 with O-ring, 90° and 45° fittings are freely rotatable by 360°.

## FITTING KIT FK-8x1.5

GALDEN® COMPATIBLE




Metal fittings for tubing 8 x 1.5 mm, threads G1/4 with O-ring, 90° and 45° fittings are freely rotatable by 360°.

## TUBING

GALDEN® COMPATIBLE

**PVC 8 x 1.5**

**PUR 8 x 1.0**

**PE 8 x 1.0**

**PTFE 8 x 1.0**


5m ring. PVC is ideal for laboratory use, PUR, PE & PTFE is recommended for professional purposes & higher temperature.

**Further components for individual cooling solutions are available on request.**