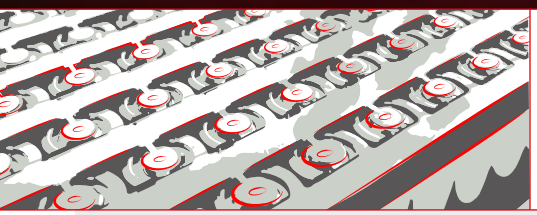
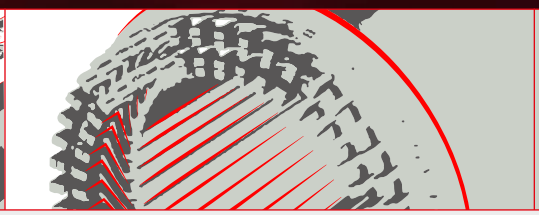
HIGH POWER WELDING MODULE

RAYLASE

LASER WELDING – LASER CUTTING





FLEXIBLY CONFIGURED, EASILY INTEGRATED

Whether hairpins, cell connectors, structural components, or battery housings, production in e-mobility places the highest demands on precision, reproducibility, and monitoring. Different component heights, tight tolerances, and short cycle times require a welding system that can be seamlessly integrated into complex production lines without compromising on quality and control.

For this purpose, the HIGH POWER WELDING MODULE offers the optimum solution. As a modular platform, it can be flexibly adapted to a wide range of requirements—mechanically, visually, and in terms of software—and thus offers a solution that is precisely tailored to the application. Nevertheless, integration remains simple: the fully matched, complete solution with integrated collimation, preconfigured interfaces, and a suitable control system eliminates the typical additional work involved in assembly and coordination.

The optional camera system enables visual process monitoring, while the integrable OCT system provides real-time monitoring of the welding process. With the RAYLASE software platform, including SP-ICE 3 control card and RAYGUIDE MATCH software, all components can be efficiently controlled and conveniently integrated into the higher-level production process.

As a result, the HIGH POWER WELDING MODULE offers a robust platform that allows the implementation of applications with the highest requirements in a reliable, reproducible, and process-safe manner.

www.raylase.com

Configurable turnkey solution

Easy integration & maintenance

Optimized for industrial production

PLATFORM SOLUTION WITH INTEGRATED PROCESS CONTROL

The HIGH POWER WELDING MODULE is a fully integrable welding solution for demanding industrial applications with laser powers of up to 8 kW. Thanks to its modular architecture, the system can be precisely adapted to application-specific requirements, both mechanically and optically, as well as in terms of software. The preconfigured collimation, options for camera and OCT connections, and integration into the RAYLASE software platform enable fast installation and stable processes, even at high cycle rates.

This makes the HIGH POWER WELDING MODULE the ideal solution for your welding processes. See for yourself:

Mechanically and software-integrated OCT sensor

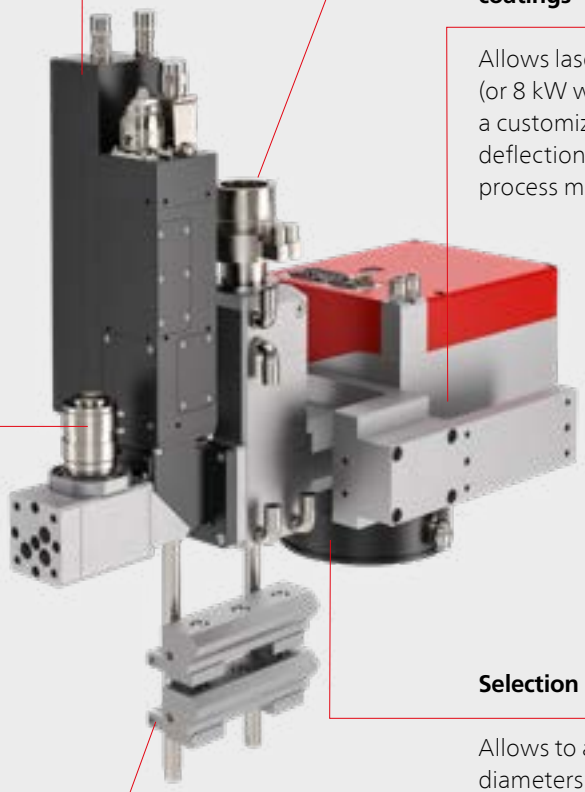
Enables measurement of the keyhole depth during the welding process for quality assurance

Water-cooled collimator for QBH and QD fiber connectors

Ensures optimum beam configuration and simplifies integration into a production system

Selectable mirror substrates and coatings

Allows laser powers of up to 6 kW (or 8 kW with 75 % duty cycle) and a customized configuration of the deflection unit to meet dynamic and process monitoring



Camera solution with matching camera adapter and camera lens

For automatic position detection of components, as well as for visual process monitoring and quality control

Selection of suitable F-Theta lenses

Allows to adapt the field sizes and spot diameters to the individual application

Two-piece Airknife

Protects the deflection unit and optics from splashes and smoke using compressed air

OPTICAL COHERENCE TOMOGRAPHY

MONITORING OF THE KEYHOLE DEPTH DURING LASER WELDING

Especially in processes involving deep, dynamic welding, precise control of the welding depth is crucial to the quality of the joint. Such measurements become possible using optical coherence tomography (OCT), which enables real-time monitoring of the dynamics of the melt pool.

An OCT can be used to determine the welding depth directly during the welding process. (Source: Lessmüller Lasertechnik GmbH)

For this purpose, the HIGH POWER WELDING MODULE can be optionally equipped with a fully integrated OCT system. It uses the OCT250 from Lessmüller Lasertechnik - a coaxial, interferometric inline measuring system for high-precision measurement of the keyhole depth during the welding process. The measurement takes place directly in the beam path and in real time - without any additional calibration effort.

The integration is fully implemented on the mechanical, optical, and software levels. In combination with the digital scanner control (SL2-100), the positions of the OCT measuring laser and the processing laser can be coordinated to match the respective application. The continuous measurement data is then available for evaluation in the Lessmüller software, while the RAYGUIDE software provides the user with IO/NIO information.

Typical areas of application include structurally critical welding processes, such as controlled deep penetration welding for battery housings, copper connectors, or aluminum components, wherever a constant welding depth is crucial for quality.

ON-AXIS CAMERA MONITORING

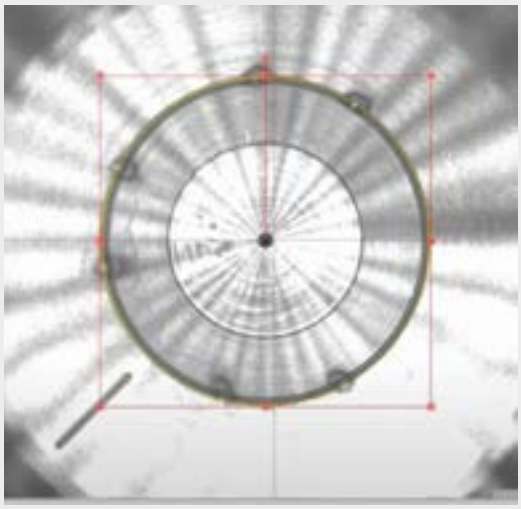
CAMERA-BASED PRODUCTION PREPARATION AND MONITORING

Whether during setup, teach-in, or visual inspection during production, an integrated camera provides valuable insights into the processing area. The on-axis camera solution in the HIGH POWER WELDING MODULE provides a centered, undistorted image directly along the beam path - ideal for precise adjustment and process-related documentation.

Thanks to the F-Theta objective, the camera focus remains permanently in the working plane, eliminating the need for tracking the z-position. This facilitates setup and enables stable visual observation across the entire working field. The camera observation can be easily combined with the RAYGUIDE software to detect workpiece positions, adjust processing paths, or minimize manual interventions.

When welding cell connectors in battery modules, the on-axis camera enables precise visual positioning of the laser spots on the contact surfaces, even with varying component geometries or imprecise clamping positions. In combination with RAYGUIDE MATCH, the system can also automatically recognize reference features on the component and adapt the laser processing dynamically without manual adjustment.

This significantly reduces the alignment time, enabling fully automated production. Furthermore, camera monitoring is suitable for visual inspection before the process begins, for support during setup procedures, and for documentation and traceability after welding.



The work piece can be detected using an on-axis camera. Subsequently, the laser processing can be adapted accordingly.

MODULAR DESIGN – INDIVIDUALLY CONFIGURABLE

Whether it's a camera, OCT, F-theta, or collimation, all components of the HIGH POWER WELDING MODULE can be precisely tailored to the respective process, providing maximum flexibility with minimal integration effort.

Optical Coherence Tomography Sensor
from Lessmüller Lasertechnik (OCT250)

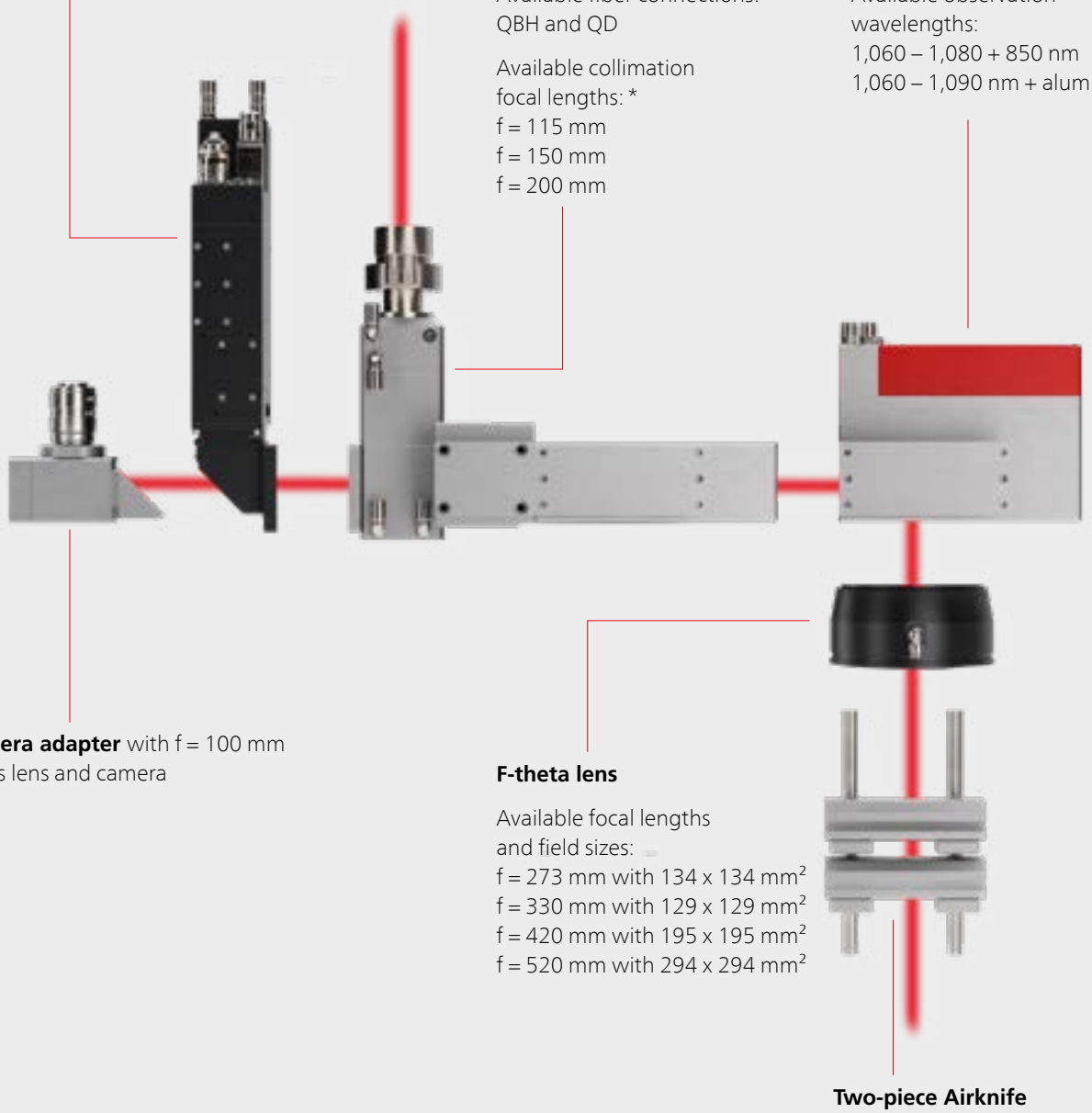
Water-cooled collimator
for 1,060 – 1,080 nm
including mounting bracket

Available fiber connections:
QBH and QD

Available collimation
focal lengths: *
f = 115 mm
f = 150 mm
f = 200 mm

SUPERSCAN IV 30
Available mirror substrates:
Quarz and Silicon carbide

Available observation
wavelengths:
1,060 – 1,080 + 850 nm
1,060 – 1,090 nm + aluminum



Camera adapter with f = 100 mm
focus lens and camera

F-theta lens

Available focal lengths
and field sizes:
f = 273 mm with 134 x 134 mm²
f = 330 mm with 129 x 129 mm²
f = 420 mm with 195 x 195 mm²
f = 520 mm with 294 x 294 mm²

Two-piece Airknife

* Additional focal lengths available on request

RELIABLE WELDING FOR SENSITIVE MATERIAL COMBINATIONS

Welding aluminum and copper is an indispensable but technically challenging process in battery module manufacturing. The different melting points, thermal conductivities, and absorption behaviors of this material combination make it difficult, especially with thin layer thicknesses. Even slight fluctuations in laser power or focus position lead to instabilities in the melt pool, unwanted pores, or incomplete joints.

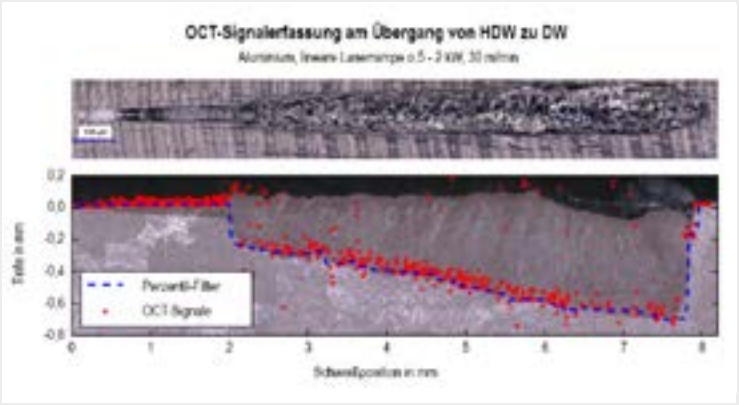
At the same time, the e-mobility industry demands fast, scalable processes with minimal scrap rates. A single battery pack can contain up to 20,000 welded joints, each of which is relevant to safety and functionality. Additionally, component geometry often varies due to series changes or batch influences. Intelligent process monitoring must therefore react in real time, be easy to integrate into existing lines, and be able to handle different materials flexibly.

Integrated monitoring with OCT and camera – coaxial, precise, and reliable

The HIGH POWER WELDING MODULE can be equipped with two fully integrated monitoring technologies: the OCT250 from Lessmüller Lasertechnik for interferometric depth measurement and an on-axis camera for visual process observation. Both solutions are arranged coaxially in the beam path, mechanically integrated, and controllable via the RAYLASE control platform. Additionally, a welding monitoring system based on photosensitive diodes from any manufacturer on the market can be connected coaxially via a sensor adapter.

The OCT system measures the weld depth directly during the process, providing high-resolution data on the stability of the keyhole, even in the presence of complex seam patterns or changing material conditions. The measurement data is recorded with high data rate (250 kHz) and can be used for documentation, process monitoring, or control. This allows the early detection, evaluation, and targeted adjustment of any fluctuations in depth.

The integrated camera additionally provides a focused live image. It supports both setup and the process itself, for example, through visual inspection of the processing zone, identification of reference points, or camera-assisted positioning via RAYGUIDE MATCH.



Comparison of the OCT measurement of the weld penetration depth and the actual longitudinal micrograph of the same seam area. (Source: Lessmüller Lasertechnik GmbH)

High throughput meets zero-defect target

The combination of OCT depth measurement and on-axis camera makes the HIGH POWER WELDING MODULE a stable and reliable welding solution for demanding material combinations such as aluminum-copper. The user can immediately detect critical process deviations during processing and actively intervene or take automatic countermeasures.
This reduces rejects, stabilizes series production, and meets the highest requirements for traceability and process documentation. The fully coordinated integration—mechanical, optical, and software-related—minimizes the effort required for initial setup, making the solution ideal for production lines with changing requirements, high throughput, and zero-defect targets.

The perfect companion:

RAYGUIDE

SIMPLE PROCESS SOFTWARE

Guarantees fast and easy interactions for customised programming. User-friendly set-up and calibration of the deflection unit and effortless automation.

SP-ICE

SP-ICE 3 CONTROL CARD WITH FEEDBACK

Can be used universally as well as specifically for individual requirements. The laser system can thus be optimally controlled, optimised during development and monitored during operation.

GENERAL SPECIFICATIONS

Power supply	**Voltage [V]**	+ 48 or + 30
	Current (RMS) [A]	2
	Current (max.) [A]	5
	Ripple / noise @ 20 MHz bandwith [mV pp]	Max. 300
Ambient temperature [°C]		+15 to +35
Storage temperature [°C]		-10 to +60
Humidity non condensing [%]		≤ 80
Interface signals	**Digital**	XY2-100 Enhanced Protocol SL2-100 Protocol
Typical deflection (optical) [rad]		± 0.393
Resolution XY2-100-E 16-Bit [µrad]		12
Resolution SL2-100 20-Bit [µrad]		0.76
Repeatability (RMS) [µrad]		< 2.0
Position noise (RMS) [µrad]		< 3.2
Temperature drift	**Max. Gaindrift [ppm/K]**	15
	Max. Offsetdrift [µrad/K] [1]	10
Long-term drift 8 h without water temperature control [µrad] [1]		< 60
Long-term drift 8 h with water temperature control [µrad] [1, 2]		< 40

[1] Angles optical. Drift per Axis, after 30 min. warm-up, at constant ambient temperature.
[2] After 30 min. warm-up, under varying process loads, with water temperature control set for ≥ 2 l/min and 22°C water temperature.

APERTURE DEPENDING SPECIFICATIONS – MECHANICAL DATA

Deflection Unit	**HIGH POWER WELDING MODULE with SUPERSCAN IV-30**	
Input aperture [mm]	30	
Beam displacement [mm]	35.4 (QU), 36.0 (SC)	
	without OCT	**with OCT**
Weight [kg] [1]	approx. 15	approx. 20
Dimensions (incl. water connections) (L x W x H) [mm] [1]	approx. 435 x 241 x 305	approx. 522 x 241 x 439

[1] Weight and dimensions for example: incl. collimator (f = 115 mm), F-theta lens (f = 420 mm), camera adapter, if applicable OCT sensor, without air knife

TYPE DEPENDENT SPECIFICATIONS – TUNINGS

Tuning	**Description**
Vector-Tuning (VC)	Optimized tuning with a wide range of applications with emphasis on processing speed.

TYPE DEPENDENT SPECIFICATIONS – DYNAMIC DATA

Deflection Unit	**SUPERSCAN IV-30 QU**		**SUPERSCAN IV-30 SC**	
Tuning	VC			
Supply Voltage [V]	30	48	30	48
Processing speed [rad/s] [1]	30	50	40	65
Positioning speed [rad/s] [1]	30	50	40	65
Tracking error [ms]	0.48		0.3	
Step response time at 1% of full scale [ms] [2]	1.2		0.8	

[1] See "Calculation of speed".
[2] Setting to 1/5,000 of full scale.

Calculation of speed:
Speed in processing field = Focal length F-Theta Lens x processing speed
Example 1: SUPERSCAN IV-30 QU with F-Theta Lens f = 273 mm, processing speed 50 rad/s (48V),
v = 0.273 m x 50 rad/s = 13.65 m/s

Example 2: SUPERSCAN IV-30 SC with F-Theta Lens f = 420 mm, processing speed 65 rad/s (48V),
v = 0.420 m x 65 rad/s = 27.3 m/s

OPTICS SPECIFICATIONS

Laser	Fiber laser 1,060 – 1,080 nm	Fiber laser 1,060 – 1,090 nm
Mirror substrate / wavelength [nm]	QU 1,060 – 1,080 + 850	SC 1,060 – 1,090 + AL
Max. laser power, cw [W]	6,000	6,000

QU = quartz, air cooling > 4 kW mandatory
SC = silicon carbide, air cooling > 2,000 W laser power mandatory
Air cooling recommended for optimum beam quality

AVAILABLE FIBER COLLIMATORS

Collimation focal length [1, 2]	Wavelength [nm]	Max. laser power [W]	Fiber connector
f = 115 mm	1,060 – 1,080	≤ 8,000	QBH / QD
f = 150 mm	1,060 – 1,080	≤ 8,000	QBH / QD
f = 200 mm	1,060 – 1,080	≤ 8,000	QBH / QD

[1] Additional focal lengths available on request.
[2] For each combination with a fiber laser, the appropriate collimation focal length must be calculated and specified by RAYLASE.

AVAILABLE F-THETA LENSES

Focal length	Working distance [mm]	Wavelength [nm]	Lens material	Field size [mm]	Typical focus diameter (1/e²) [µm] [1]
f = 273 mm	373	1,060 – 1,080	Fused Silica	134 x 134	22
f = 330 mm	482	1,060 – 1,080	Fused Silica	129 x 129	26
f = 420 mm	586	1,060 – 1,080	Fused Silica	195 x 195	33
f = 520 mm	688	1,060 – 1,080	Fused Silica	294 x 294	41

[1] Spot diameter in the center of the scan field, calculated for an input beam with $M^2 = 1$ and a full-beam input diameter of 30 mm at the entrance to the deflection unit. This input beam diameter may vary depending on the combination of the collimation focal length and the beam divergence of the laser.

Deflection mirrors, F-Theta Lenses and Collimators

Deflection mirrors and F-Theta Lenses with optimized mounts are available for all typical laser types, wavelength, power densities, focal length and processing fields.
Customer specific configurations are also possible. Please contact the RAYLASE support team for specific information and possible combinations on +49 8153 9999-699 or support@raylase.de.

PROZESS-MONITORING

The HIGH POWER WELDING MODULE can be optionally expanded with sensors for process monitoring and process control. It offers the option of on-axis image acquisition via an optical camera adapter. An on-axis OCT sensor can also be integrated. Both sensors can be integrated via the RAYGUIDE software, enabling automated process control.

OCT-System	Light Source (Wavelength [nm] / Optical Power [mW])	Scanning frequency [kHz]	Typical Resolution (lateral / z) [µm]	Applications
Lessmüller OCT250 [1]	SLED 840 ± 15 / max. 30	max. 250	5 / 12	Keyhole depth, Topology scans

[1] The working range can be adapted by max. ± 80 mm axial and typ. 15 mm lateral (radius of area around center point)

AIRKNIFE

To protect the deflection unit and its optics from smoke, spatter, and other contamination, a two-piece air knife is available as an option for the HIGH POWER WELDING MODULE. It can be attached to the underside of the deflection unit using the holes provided.
The air knife is designed for compressed air with 5–7 bar (0.5–0.7 MPa). The incoming air must be passed through an air filter to ensure that it is dry and free of water. We recommend using an automatic air filter with drainage (for particles ≥ 5 micrometers).

OPTIONS FOR COOLING THE DEFLECTION UNIT

The HIGH POWER WELDING MODULE offer the possibility of water tempearture control (W) for the electronic components and galvanometer scanners.
It also offers the possibility of air cooling (A) for the defelection mirrors.
Both ensure constant working conditions as well as excellent long-term stability and guarantee reliable operation of high-performance applications.

WATER TEMPERATURE CONTROL

Specifications	
Cooling water [1]	Clean tap water with additives
Water hardness [ppm]	< 10
ph value	7 – 8.6
Bacterial content [cfu/ml]	< 1,000
Cooling temperature [°C]	22 – 28
Temperature stability [K]	± 1
Max. water pressure at deflection unity [bar]	< 3
Min. water flow [l/min] and pressure drop [bar]	2 / 0.4
Tube outer diameter [mm]	8

[1] **Caution:** When using cooling water including deionised water, suitable additives must be used to prevent the growth of algea and protect the aluminium and copper components against corrosion.

Additive recommendations (Please consult your additive supplier for dosage information):
Standard industrial applications: Products of company NALCO, e.g. CCL 105 (Premix) oder TRAC105A_B (Additive)
Food & beverage, packaging applications: Polypropylene glykol of company Dow Chemicals, e.g. DOWCAL N

AIR FLUSHING

Specification compressed air		
In accordance with ISO 8573-1 [1]		[1:4:0 (0,005)] [2]
• **Solids / Dust [m^{-3}]:**	**Class 1**	0,1 ≤ d ≤ 0,5: 20.000 0,5 ≤ d ≤ 1,0: 400 1,0 ≤ d ≤ 5,0: 10
• **Water [°C]:**	**Class 4**	Pressure dew point ≤ +3
• **Oil [mg/m³]**	**Class 0**	Specified total oil concentration ≤ 0,005
Recommended air flow [l/min] approx.		50–100
Tube outer diameter [mm]		4

[1] Compressed air Part 1: Impurities and purity classes
[2] Reference conditions: 20 °C, 1 bar, 0 % humidity

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