SPI Lasers UK Limited

Product Specification

High Power Fibre Laser Systems

Note: Illustration shows water cooled variant with LLK-Q beam delivery optic

Definition of Symbols and Terms

This symbol alerts the user to the hazard of exposure to hazardous invisible laser radiation

This symbol alerts the user to the hazard arising from dangerous voltages

This symbol alerts the user to the hazard caused by the weight of the Fibre Laser

This general warning symbol emphasizes important information needed during installation and operation

This symbol identifies the protective conductor terminals (ground point)

DANGER: Describes hazards that could directly or indirectly lead to serious personal injury or death.

WARNING: Describes hazards or practices that could directly or indirectly lead to serious personal injury or death.

CAUTION: Describes hazards that could lead to personal injury or product damage.

PRODUCT: The definition of "Product" as used herein means the item that was procured from SPI Lasers UK Limited. The Product is sold ready for use for its intended purpose as a laser Product for Incorporation.

LASER INTEGRATOR: Any person that integrates the Fibre Laser into their equipment, or any person who uses the Fibre Laser in the form as supplied by SPI.

Change History

Revision	Date	Originator	Description of Change	Section
A	6.3.14	Paul Skull	First Issue	-
B	27.3.14	Paul Skull	Added detail regarding additional Beam Delivery Connector options – QCS and QBH	Numerous
			Removed duplicated warranty section	13.0
C	27.04.15	Paul Skull	Changed the Product variant matrix variables from 'bolded' to 'red' to improve clarity.	4.1
			Added extra text boxes to humidity plots showing condensing and non-condensing areas.	5.1
			Updated contact details to add global service centres	12.0
			Corrected Analogue I/O pin 13 to 'Enabled LED' from 'Emission LED'	8.4
			Updated IEC/EN 60825-1 label from 2007 to 2014 to support a re-assessment and new laser safety certificates for same	11.0
			Updated patent label with new patent numbers and to consolidate with address label and WEEE label	11.0
			Updated rear panel connections section to add new programming switch and remove unused USB and RJ45 connectors	8.1
			Updated pin 4 in the RS232 communications section – standard serial cables can now be used	8.6
			Added new section on the Ethernet Communications interface	8.7
			Added new section on the programming switch	8.8
			Removed references to 150W products and 100V AC input (only required for 150W products)	Numerous
			Updated tunability from 10% minimum to 3% (internal setpoint) and 1% (external setpoint). Removed comment that minimum target value is 3%	6.1
			Update singlemode 20µm full angle divergence spec from 81±8mrad to 80±8mrad	6.4.3 & 6.4.4
			Added new section on back reflection tolerance	6.2
			Improved safety interlock performance level from PL'd' to PL'e'	8.2, 10.1.3, 10.2, 10.2.1

Table of Contents

List of Tables

List of Figures

1.0 Scope

This document summarises the Product Specification Requirements for the R4.3 High Power Fibre Laser family. This document is the top level Customer Interface Specification and provides the integrator with the Form, Fit and Function information for the product. It includes key performance specifications, interface requirements and certification requirements.

The laser is a complete Fibre Laser system. By 'complete' it is meant a laser system as sold and ready for use for its intended purpose without modifications to the specification of the product.

2.0 Trade Marks

The *SPI* logo, GTWave, redPOWER and redENERGY are trademarks or service marks (registered or applied for) of SPI Lasers UK Limited in at least one of the United States of America, the United Kingdom, the European Community, and various other territories throughout the world. All other trademarks are the property of their registered owners.

3.0 Warranties

SPI Lasers UK Limited (hereinafter referred to as SPI) reserves the right to change the information and specifications contained in this Product Specification document without prior notice. The information contained in this document is confidential and proprietary to SPI.

SPI expressly warrants the equipment it manufactures as set forth in the standard Terms and Conditions of sale. SPI makes no other warranties, expressed or implied, including and without limitation, warranties as to merchantability of fitness for a particular purpose.

4.0 General Product Description

The range of R4.3 High Power Fibre Lasers are designed as a **PRODUCT FOR INCORPORATION** for integration into industrial and manufacturing equipment.

The Fibre Laser unit comprises semiconductor pump laser diodes, a Fibre Laser module based on SPI's GTWave™ fibre technology, electrical component drivers, thermal management and an optical fibre delivery cable with either a collimated or a divergent output beam.

The system status and output power level can be monitored and controlled by external RS232 and I/O analogue interfaces. An integrated red pilot laser is provided as an aid to process set-up and beam targeting.

The robust, monolithic design, using a fibre-based MOPA architecture, requires no optical or mechanical adjustments. The laser output power is delivered via a flexible, ruggedised fibre optic cable to allow integration with third party optical process units.

The Fibre Laser can be operated as a CW or Modulated high power laser source under computer control or via an external analogue control interface depending on the required process operating conditions and the integrated system configuration.

The unit is powered from 200-240Vac (50-60Hz) mains electricity. Internal cooling is provided by either forced air or interfaces are provided for connection to a chiller unit or factory water supply depending on the product variant.

4.1 Product Variants

The product variants covered by this Product Specification have order codes:

SP – **200 / 250 / 400 / 500** C – **A / W** – RS – **S / B / Q / K / N** – **06 / 10 / 20** – **RIC / QCS / LKQ / QBH**

Where the red letters and numbers represent the following:

- The first set of red numbers represents the rated output power
- The first set of red letters represents the cooling type, where:
  - A: Air Cooled
  - W: Water Cooled
- The second set of red letters represent the optical interface according to Table 4.1.1, and the second set of numbers represents the output cable length
- The 3-letter reference represents the output connector type

LETTER	FIBRE TYPE	M^2 (nominal)	Core Diameter / µm (nominal)	CONNECTOR TYPE
S	SM	1.1	11	–
B	SM	1.1	20	–
Q	MM	3.5	35	–
K	MM	6.5	50	–
N	MM	15	100	–
–	–	–	–	RIC: Collimated Output
–	–	–	–	QCS: Collimated Output
–	–	–	–	LKQ: Divergent Output
–	–	–	–	QBH: Divergent Output

Table 4.1.1: Optical interface options

Not all combinations are available. For information regarding specific variant options contact SPI Customer Support.

5.0 General System Specifications

5.1 Operating Conditions

	Parameter	Units	Specification
5.1.1	Temperature (Operating) (1)	℃	5 – 40
5.1.2	Humidity (Operating) (1)	% RH	5 – 85 (non-condensing)
5.1.3	Warm-up time to CW rated power	min	<5
5.1.4	Warm-up time full operating conditions (Thermal Equilibrium)	min	<15
5.1.5	Altitude	m	Up to 3000
5.1.6	Pollution degree	-	3

1 Refer to Figure 10.1 for a chart showing the relationship between relative humidity, ambient air temperature and cooling water temperature for non-condensing operation

Table 5.1: Operating Conditions

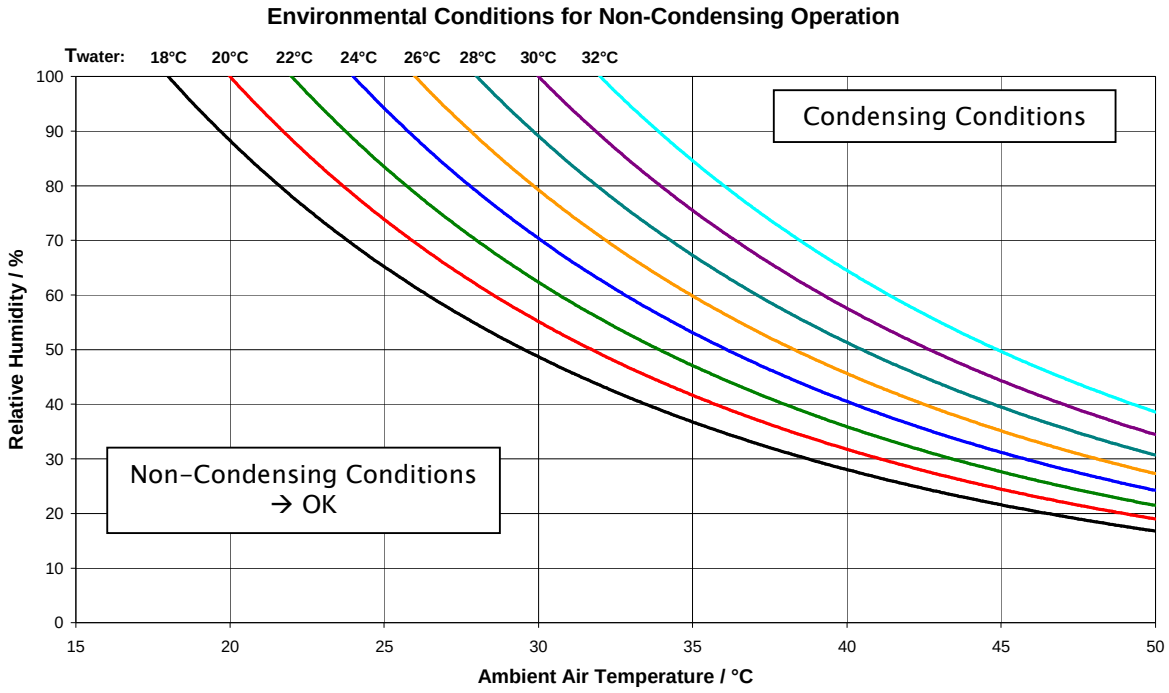


Figure 5.1: Environmental Conditions for Non-Condensing Operation

5.2 Non-Operating Conditions

Parameter		Units	Specification
5.2.1	Temperature (Storage)	℃	0 – 70
5.2.2	Humidity (Storage)	% RH	0 – 95 (non condensing)

Table 5.2: Non-Operating Conditions

5.3 Optical Design Lifetime for Rated Power Performance

Parameter		Units	Specification
5.3.1	Optical System Design Life (1), (2)	hours	20 000

(1) The End of Life (EOL) condition is defined as the time at which the laser output power falls below the rated output power at the maximum EOL diode operating current when used at a cooling water temperature of 25°C

(2) The value for optical system design life is based on the pump diode overhead to deliver rated power in CW operation. If a lower operational duty cycle is used the reliability model assumes the pump diode lifetime to increase proportionally; On this basis an operating duty cycle of 66% will increase the system lifetime at rated power to 30 000 elapsed hours

Table 5.3: Optical Design Lifetime

5.4 Utilities

	Parameter		Units	Specification
5.4.1	Operating Voltage		V AC	200-240 (±10%) Vac (47-63Hz - auto-ranging) Installation Category II
5.4.2	Maximum current (RMS)		A	16
5.4.3	Cooling Laser System	Air cooled laser products(1)	-	Internal forced air
5.4.4		Water cooled laser products(1)		Water cooling supplied by external chiller or house water supply
5.4.5	Cooling Beam Delivery Optic	RIC & QCS	-	Contact cooling
5.4.6		LLK-Q & QBH		Water cooling supplied by external chiller or house water supply

1 Refer to section 4.1 for a description of laser product variants

Table 5.4: Utilities

5.5 External Chiller Unit Requirements: Laser System (water cooled variants only)

CAUTION: To avoid corrosion to the cooling circuit components within the Fibre Laser the use of deionised water is not permitted.

Parameter		Units	200W	250W	400W	500W
5.5.1	Cooling capacity (@20℃ set-point) (1,2)	kW	0.8	1.0	1.6	2.0
5.5.2	Cooling water flow rate (minimum) (1)	l/min	5	5	8	8
5.5.3	Cooling water temperature	℃	20^{+10}_{-0}			
5.5.4	Maximum input (flow) pressure	bar	8			
5.5.5	Pressure drop between flow and return (3)	bar	2			
5.5.6	Connections provided at laser	-	3/8" John Guest Speedfit			
5.5.7	Use of de-ionised water	-	Not permitted			

1 At an ambient temperature of 35℃ at rated power CW operation

2 It is important that the laser is always operated in a non-condensing environment, i.e. above the dew point. Refer to Figure 5.1 for a chart showing the relationship between relative humidity, ambient air temperature and cooling water temperature for non-condensing operation.

3 Refer to Figure 5.5 for a chart showing the nominal relationship between cooling water flow rate and the pressure drop between flow and return.

Table 5.5: External Chiller Unit Requirements – Laser System

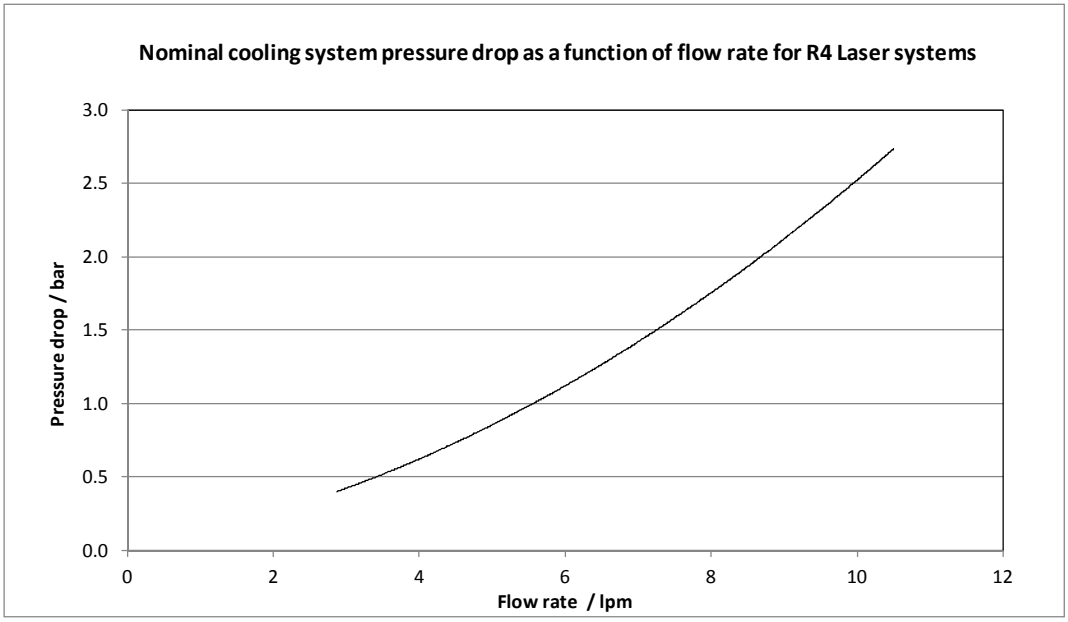


Figure 5.5: Nominal pressure drop as a function of flow rate

5.6 External Chiller Unit Requirements: Beam Delivery Optic

5.6.1 LLK-Q Beam Delivery Optic

Parameter		Units	Specification
5.6.1	Connections at LLK-Q BDO	–	Parker Rectus Type 21 Connector
5.6.2	Connection hose	–	Outer diameter: 6mm Inner diameter: 4mm
5.6.3	Cooling water flow rate	l/min	0.5 – 40
5.6.4	Maximum input (flow) pressure	bar	5
5.6.5	Pressure drop between flow and return (at 1bar input pressure)	bar	0.5
5.6.6	Pressure drop over hose with 4mm ID	bar/m	0.2
5.6.7	Maximum cooling water temperature	℃	35
5.6.8	Minimum cooling water temperature [1]	℃	> 5 above dew point
5.6.9	Chiller cooling capacity	kW	0.5
5.6.10	Cooling water type/quality [2,3]	–	VDI 3803 Appendix B, Table B3 (Refer to table 5.6.1(ii))
5.6.11	Maximum particulate size (diameter)	µm	135

[1] It is important that the LLK-Q Connector is always operated in a non-condensing environment, i.e. above the dew point. Refer to Figure 5.1 for a chart showing the relationship between relative humidity, ambient air temperature and cooling water temperature for non-condensing operation.

[2] Use of inhibitors is allowed if the specifications above regarding water quality and particles are met.

[3] When DI water is used, only these materials are allowed in the cooling circuit: high alloyed steel (V2A, V4A), bronze, PVC-U, EPDM, NBR.

Table 5.6.1(i): External Chiller Unit Requirements – LLK-Q Beam Delivery optic

Parameter		Symbol	Unit	Specification
5.6.12	Appearance			Clear and without sediment
5.6.13	pH Value			7.5 – 9.0
5.6.14	Total Salt Content	GSG	gm^{-3}	<1800
5.6.15	Electrical Conductivity At 25°C		mSm^{-1}	<220
5.6.16			μScm^{-1}	<2200

Parameter		Symbol	Unit	Specification
5.6.17	Calcium	Ca2+	$Molm^{-3}$	>0.5
5.6.18			gm^{-3}	>20
5.6.19	Carbonate Hardness	KH	°dH	<4
5.6.20	Carbonate Hardness with Hardness Stabilisation	KH	°dH	<20
5.6.21	Chloride	Cl^-	$Molm^{-3}$	<4.2
5.6.22			gm^{-3}	<150
5.6.23	Sulphate	SO_4^{2-}	$Molm^{-3}$	<3.4
5.6.24			gm^{-3}	<325
5.6.25	$KMnO_4$ Consumption		gm^{-3}	<100
5.6.26	Germ Count		$CFUml^{-1}$	<10000
5.6.27	Legionella Bacteria		$CFUml^{-1}$	<10

Table 5.6.1(ii): Summary of VDI 3803 Appendix B, Table B3

5.6.2 QBH Beam Delivery Optic

	Parameter	Units	Specification
5.6.28	Connections at QBH BDO	–	SMC MS-5H-6
5.6.29	Connection hose	–	Outer diameter: 6mm Inner diameter: 4mm
5.6.30	Cooling water flow rate	l/min	1.7 ± 0.2
5.6.31	Maximum return pressure	bar	1
5.6.32	Pressure drop between flow and return (at 1.7l/min)	bar	<1
5.6.33	Pressure drop over hose with 4mm ID	bar/m	0.2
5.6.34	Maximum cooling water temperature	℃	45
5.6.35	Minimum cooling water temperature [1]	℃	> 5 above dew point
5.6.36	Cooling water type/quality [2]	–	Distilled Water Deionised Water Drinkable tap water
5.6.37	Maximum particulate size (diameter)	µm	100
5.6.38	Maximum conductivity	µS/cm	500
5.6.39	pH of cooling water	–	5.5 – 9.0

[1] It is important that the QBH Connector is always operated in a non-condensing environment, i.e. above the dew point. Refer to Figure 5.1 for a chart showing the relationship between relative humidity, ambient air temperature and cooling water temperature for non-condensing operation

[2] Use of inhibitors is allowed if the specifications above regarding water quality, particles, conductivity and pH are met.

Table 5.6.2: External Chiller Unit Requirements – QBH Beam Delivery optic

6.0 System Operating Specifications

6.1 Laser System Specifications

Parameter				Units	Specification	
6.1.1	Rated Output Power (CW)	Air Cooled Products		W	200	– 0% +10%
6.1.2		Water Cooled Products			250	
6.1.3					400	
6.1.4					500	
6.1.5	Mode of Operation			–	CW / Modulated	
6.1.6	Polarisation			–	Random	
6.1.7	Central Emission Wavelength			nm	1070 ± 10	
6.1.8	Emission Bandwidth (FWHM)	Air Cooled Products		nm	< 4.0	
6.1.9		Water Cooled Products			< 6.0	
6.1.10	Output Power Tunability (CW)	External setpoint		%	1 – 100 (1)	
6.1.11		Internal setpoint			3 – 100 (1)	
6.1.12	Modulation Rise-time at rated power [turn-on delay]			µs	<10	
6.1.13	Modulation Fall-time at rated power			µs	< 10	
6.1.14	Modulation Frequency at rated power			kHz	DC to 10	
6.1.15	Minimum Pulse Width			µs	10	
	Output Power Stability over an 8 hour period					
6.1.16	Air Cooled Products	Full operating temperature range	Open loop	%	< 6.0	
6.1.17		Constant temperature	Open loop		< 3.0	
6.1.18	Water Cooled Products	Full operating temperature range	Open loop	%	< 3.0	
6.1.19		Constant temperature	Open loop		< 2.0	
	Pilot Laser Operation					
6.1.20	Emission Wavelength			nm	630 – 680	
6.1.21	Maximum Output Power			mW	1.0 (2)	
6.1.22	Timeout Period			min	10	

(1) For stable operation at percentage of rated output power

(2) Up to 5mW under a single fault condition – refer to section 6.3

Table 6.1: Laser System Specifications

6.2 Back Reflection Tolerance

When processing highly reflective materials (e.g. gold, copper, aluminium, silicon), and in particular during process setup and optimisation, high levels of optical power reflected from the workpiece may be coupled into the beam delivery optic and into the laser cavity.

The R4.3 OEM Fibre Laser is tolerant to back reflections from the workpiece of up to 100% of the forward going rated power. Back reflected light is managed by the BDO and within the laser by the following mechanisms:

- The BDO contains an internal mode stripper designed to remove light coupled into the fibre cladding in the event of a back reflection from the work piece. Light removed by this mode stripper is absorbed by the connector and the associated heat dissipated by convective and contact cooling. In the event of an excessive and sustained back reflection a thermal sensor in the connector will trigger a BDO over-temperature alarm to protect the connector from damage (refer to sections 5.6 and 10.2.3).
- Back reflected light that is not removed in the BDO head (for instance light directly coupled into the fibre core or low order cladding modes) is managed within the laser. Additional internal mode strippers are incorporated which manage excess optical power and the associated heat is dissipated by conductive and convective cooling. In the event of an excessive and sustained back reflection a thermal sensor in the laser will trigger an over-temperature warning. If no remedial action is taken and the temperature continues to increase then an over-temperature alarm will be triggered to protect the laser from damage (refer to sections 5.5 and 10.2.3).

In both cases tolerance to high levels of back reflection can be increased by improving the cooling and by optimising the process conditions.

	Parameter	Units	Value
6.2.1	Back Reflection Tolerance (1)	W	Up to 100% of the Rated Power for the Laser Product

(1) The R4.3 Fibre Laser is tolerant to back reflections from the workpiece of up to 100% of the forward going rated power. In the event of an excessive and sustained back reflections then thermal sensors in the BDO connector and in the laser will trigger an over-temperature alarm to protect the connector and the laser from damage.

Table 6.2: Back Reflection Tolerance

6.3 Single Fault Ratings

	Parameter	Units	Specification
6.3.1	Maximum Output Power: 1050-1250nm (1,2)	W	Up to 1.5x the Rated Power for the Laser Product
6.3.2	Maximum Output Power: 630-680nm (1)	mW	<5

(1) This parameter defines the maximum expected CW output power under single fault conditions.

(2) When operating in a modulation configuration, peak powers up to 5x the rated CW output power may be generated at the beginning of the pulse

Table 6.3: Single Fault Ratings

6.4 Beam Delivery Specifications

6.4.1 RIC Beam Delivery System (integrated collimator)

Parameter	Units	Specification				
		Single Mode		Multimode		
Output Fibre Parameters						
Fibre Type (1)	-	S	B	Q	K	N
Mode Field Diameter (MFD)	µm	11.5	18.5	-		
Nominal Core Diameter	µm	-	-	35	50	100
Collimated Output Beam Parameters						
Collimated Beam Diameter ($1/e^2$)	mm	5.0 ± 0.7	3.1 ± 0.5	5.5 ± 1.5	7.0 ± 1.8	8.0 ± 2.0
Collimated Full Angle Divergence	mrad	0.3 ± 0.1	0.5 ± 0.1	1.1 ± 0.5	1.6 ± 0.7	3.2 ± 1.5
M^2	-	≤ 1.1		3.5 ± 0.5	6.5 ± 1.0	15 ± 2
Beam Parameter Product (BPP) (Half angle, waist radius definition)	mm.mrad	≤ 0.38	≤ 0.38	1.2 ± 0.2	2.2 ± 0.4	5.1 ± 0.7
Collimated Circularity	%	≥ 90.0				
Astigmatism	Z_R	≤ 0.25				
Eccentricity (Transverse Offset, XY) (2)	mm	≤ ± 1.0				
Concentricity (Pointing Error, Θ) (2)	mrad	≤ ± 1.0				

(1) Refer to table 4.1.1 for fibre type definitions

(2) Measured with respect to the reference surface Ø30mm +0/-0.02mm defined in figure 7.2

Table 6.4.1: Beam Delivery Specifications: RIC Integrated Collimator Option

6.4.2 QCS Beam Delivery System (integrated collimator)

Parameter	Units	Specification	
		Single Mode	Multimode
Output Fibre Parameters			
Fibre Type (1)	–	S	Q
Mode Field Diameter (MFD)	µm	11.5	–
Nominal Core Diameter	µm	–	35
Collimated Output Beam Parameters			
Collimated Beam Diameter ($1/e^2$)	mm	5.0 ± 0.7	3.3 ± 0.8
Collimated Full Angle Divergence	mrad	0.3 ± 0.1	1.5 ± 0.6
M^2	–	≤ 1.1	3.5 ± 0.5
Beam Parameter Product (BPP) (Half angle, waist radius definition)	mm.mrad	≤ 0.38	1.2 ± 0.2
Collimated Circularity	%	≥ 90.0	
Astigmatism	Z_R	≤ 0.25	
Eccentricity (Transverse Offset, XY) (2)	mm	≤ ± 1.2	
Concentricity (Pointing Error, Θ) (2)	mrad	≤ ± 2.0	

(1) Refer to table 4.1.1 for fibre type definitions

(2) Measured with respect to the reference surface Ø14mm defined in figure 7.3

Table 6.4.2: Beam Delivery Specifications: QCS Integrated Collimator Option

6.4.3 LLK-Q Beam Delivery System (divergent output)

Parameter	Units	Specification		
		Single Mode	Multimode	
Output Fibre Parameters				
Fibre Type (1)	–	**B**	**K**	**N**
Mode Field Diameter (MFD)	µm	18.5	–	
Nominal Core Diameter	µm	–	50	100
Output Beam Parameters				
Beam Parameter Product (BPP)	mm.mrad	≤ 0.38	2.2 ± 0.4	5.1 ± 0.7
M^2	–	≤ 1.10	6.5 ± 1.0	15 ± 2
Full Angle Divergence	mrad	80 ± 8	175 ± 30	200 ± 30
Circularity	%	≥ 90.0		
Eccentricity (Transverse Offset, XY) (2)	µm	± 25		
Axial error in position of optical fibre end (Z) (3)	µm	± 20		
Concentricity (Pointing Error)	mrad	≤ 8		

(1) Refer to table 4.1.1 for fibre type definitions

(2) The XY positioning accuracy of the fibre with respect to the mechanical housing

(3) Optical fibre end position is defined in Figure 7.4

Table 6.4.3: Beam Delivery Specifications: LLK-Q Connector

6.4.4 QBH Beam Delivery System (divergent output)

Parameter	Units	Specification		
		Single Mode	Multimode	
Output Fibre Parameters				
Fibre Type (1)	–	B	K	N
Mode Field Diameter (MFD)	µm	18.5	–	
Nominal Core Diameter	µm	–	50	100
Output Beam Parameters				
Beam Parameter Product (BPP) (Half angle, waist radius definition)	mm.mrad	≤ 0.38	2.2 ± 0.4	5.1 ± 0.7
M^2	–	≤ 1.10	6.5 ± 1.0	15 ± 2
Full Angle Divergence	mrad	80 ± 8	175 ± 30	200 ± 30
Circularity	%	≥ 90.0		
Eccentricity (Transverse Offset, XY) (2)	µm	< 10		
Axial error in position of optical fibre end (Z) (3)	µm	± 50		
Concentricity (Pointing Error)	mrad	≤ 20		

(1) Refer to table 4.1.1 for fibre type definitions

(2) The XY positioning accuracy of the fibre with respect to the mechanical housing

(3) Optical fibre end position is defined in Figure 7.5

Table 6.4.4: Beam Delivery Specifications: QBH Connector

7.0 Mechanical Specifications

7.1 Fibre Laser Enclosure

	Parameter	Units	Specification
7.1.1	Dimensions	mm	507.0 x 482.6 x 221.4
7.1.2		in	19.96 x 19.00 x 8.72
7.1.3	Weight	kg	<48
7.1.4	Water Connections	-	3/8" John Guest Speedfit
7.1.5	Electrical connections	-	See Section 8.0

Table 7.1: Mechanical Specifications

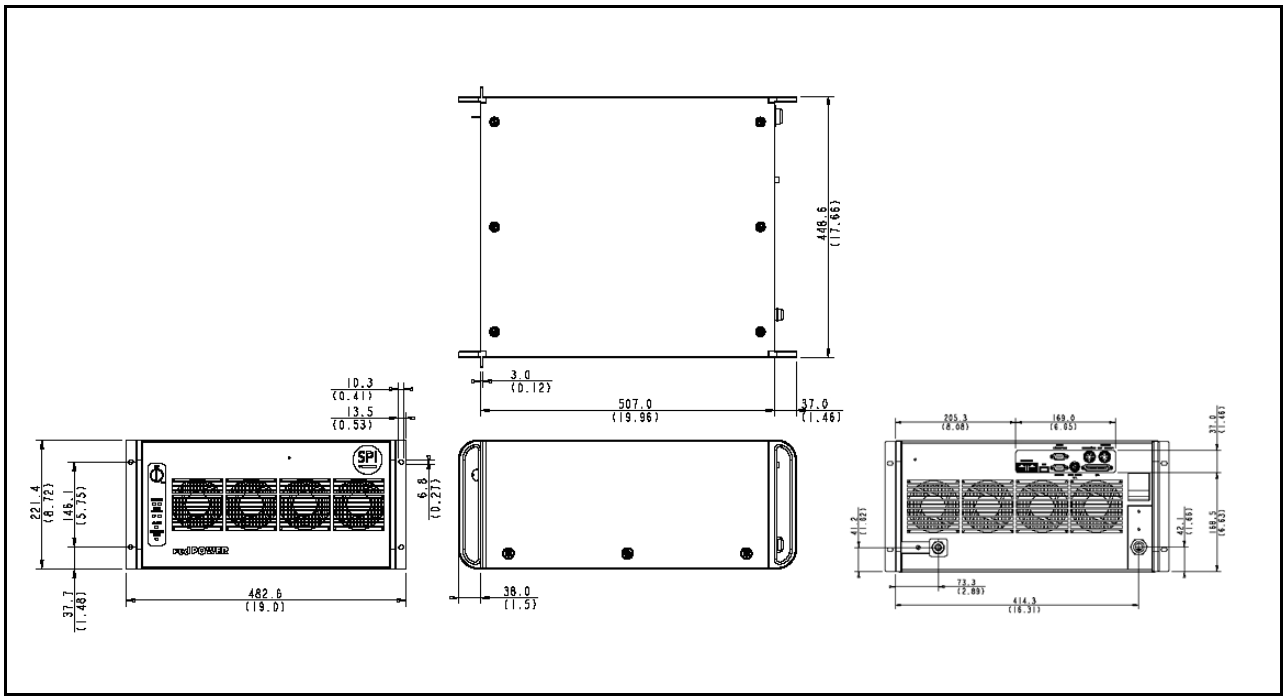


Figure 7.1.1: Outline Drawing – Laser System – Air Cooled Variants

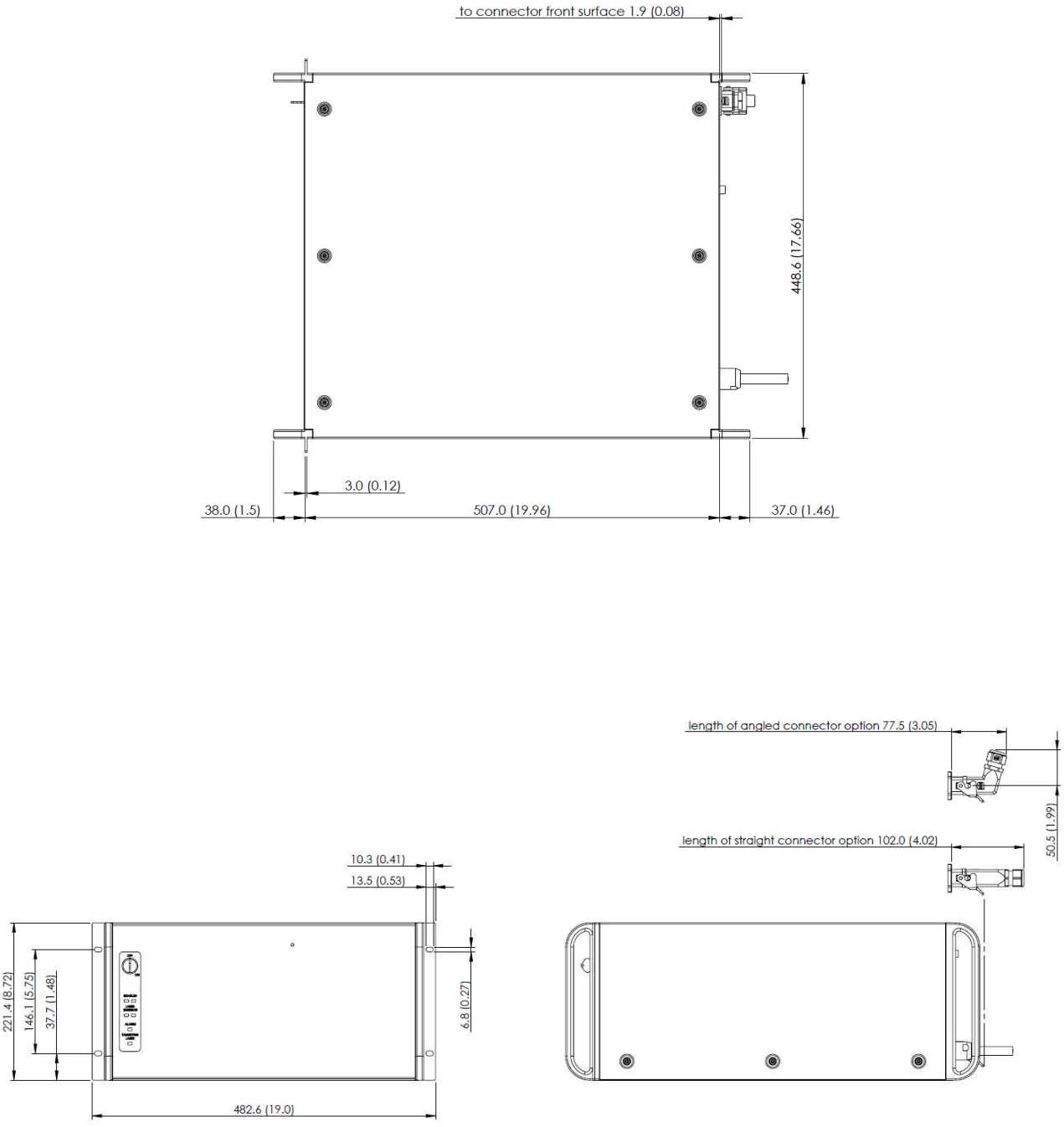


Figure 7.1.2: Outline Drawing – Laser System – Water Cooled Variants

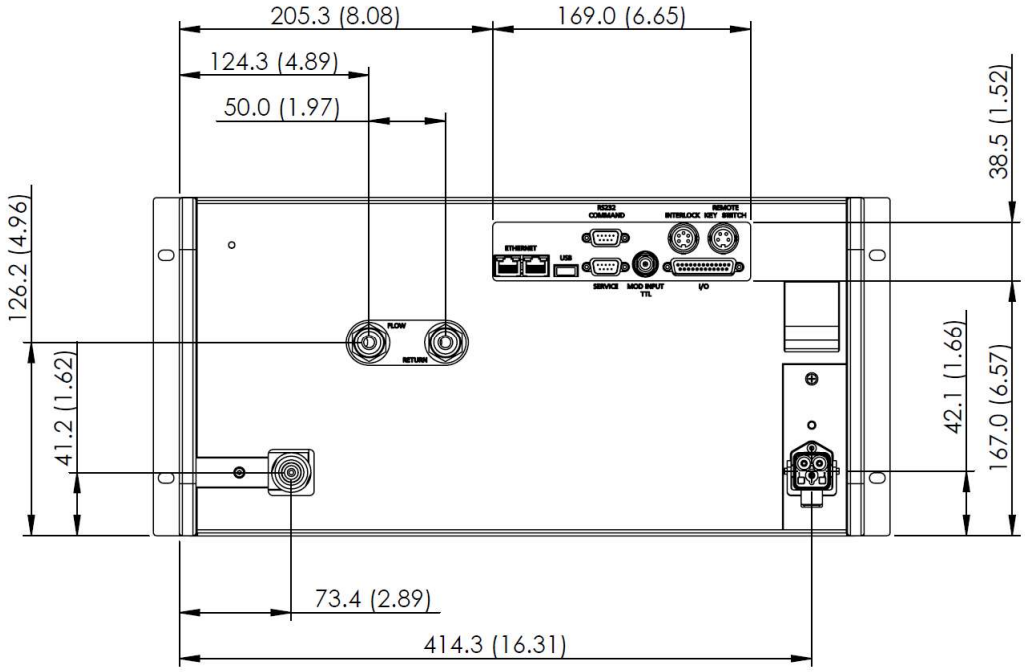


Figure 7.1.3: Rear Panel Detail – Water Cooled Variants

7.2 Optical Output Interface – RIC Beam Delivery System

Parameter			Units	Specification
7.2.1		Connector Optic Length	mm	178.0
7.2.2		Connector Optic Diameter (Reference surface) (1)	mm	30.00 (-0.02, +0.00)
7.2.3		Cable Diameter	mm	10.2 (-0.2, +0.0)
7.2.4		Cable Material (External)	-	PVC
7.2.5			m	6.1 ± 0.1
7.2.6		Cable Length	m	10.1 ± 0.1
7.2.7			m	20.1 ± 0.1
7.2.8		Static Bend	mm	80
7.2.9	Minimum Bend Radius	Dynamic Bend	mm	120
7.2.10		Coil	mm	150

(1) This surface should be used for clamping and contact cooling

Table 7.2: Mechanical Specifications: RIC Beam Delivery System

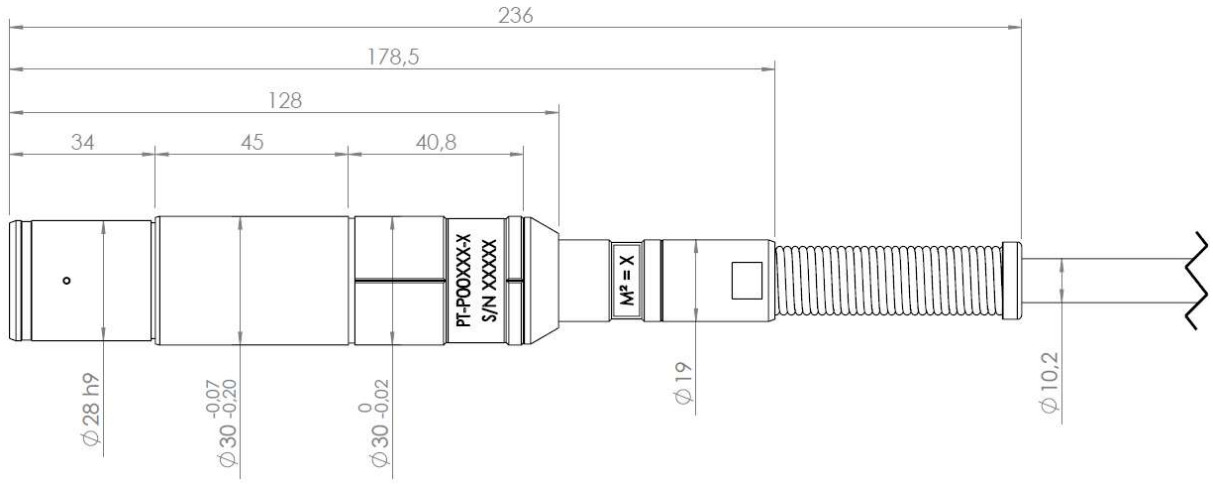


Figure 7.2: Outline Drawing: RIC Beam Delivery System

7.3 Optical Output Interface – QCS Beam Delivery System

Parameter			Units	Specification
7.3.1	Connector Optic Length		mm	151.0 ± 0.7
7.3.2	Connector Optic Clamping Length		mm	101.0 ± 0.4
7.3.3	Connector Optic Diameter (Reference surface) (1)		mm	14.00 (+0.00, -0.03) h8
7.3.4	Cable Diameter		mm	7.5 ± 1.0
7.3.5	Cable Material (External)		-	Stainless steel round lock tube
7.3.6	Cable Length		m	6.4 ± 0.4
7.3.7			m	10.2 ± 0.3
7.3.8	Minimum Bend Radius	Static Bend	mm	120
7.3.9		Dynamic Bend	mm	120
7.3.10		Coil	mm	120

(1) This surface should be used for clamping and contact cooling

Table 7.3: Mechanical Specifications: QCS Beam Delivery System

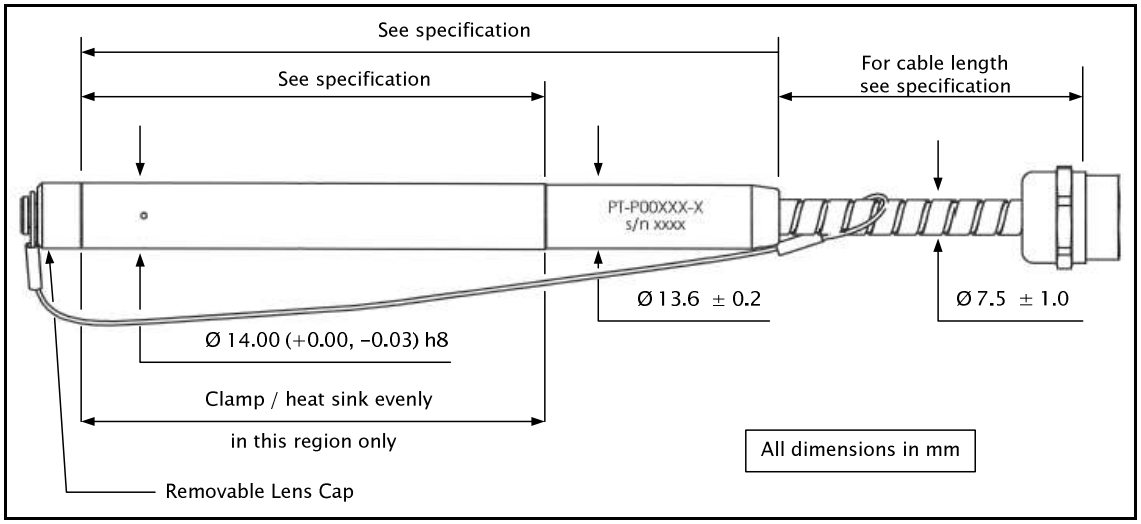


Figure 7.3: Outline Drawing: QCS Beam Delivery System

7.4 Optical Output Interface – LLK-Q Beam Delivery System

Parameter			Units	Specification
7.4.1	Connector Optic Length		mm	165.35
7.4.2	Connector Optic Diameter		mm	32.0
7.4.4	Cable Diameter		mm	12.5
7.4.4	Cable Material (External)		-	Steel / PU
7.4.5	Cable Length		m	6.1 ± 0.1
7.4.6			m	10.1 ± 0.1
7.4.7			m	20.1 ± 0.1
7.4.8	Minimum Bend Radius	Static Bend	mm	150
7.4.9		Dynamic Bend	mm	150
7.4.10		Coil	mm	150
7.4.11	Locking Mechanism		-	Bayonet with two-stage locking - Bayonet rotation: 37° - Coupling force >25N

Table 7.4: Mechanical Specifications: LLK-Q Beam Delivery System

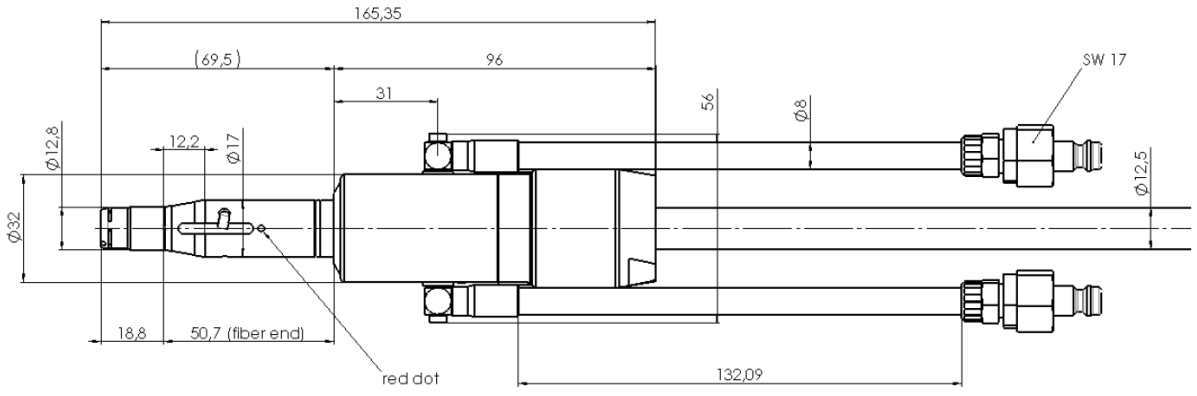


Figure 7.4: Outline Drawing: LLK-Q Beam Delivery System

7.5 Optical Output Interface – QBH Beam Delivery System

Parameter			Units	Specification
7.5.1	Connector Optic Length		mm	199.4
7.5.2	Connector Optic Diameter		mm	19.0
7.5.3	Connector Flange Diameter		mm	25.8
7.5.5	Cable Diameter		mm	12.5 (+0.2, -0.0)
7.5.5	Cable Material (External)		-	PVC
7.5.6	Cable Length		m	6.15 ± 0.15
7.5.7			m	10.15 ± 0.15
7.5.8			m	20.15 ± 0.15
7.5.9	Minimum Bend Radius	Static Bend	mm	150
7.5.10		Dynamic Bend	mm	150
7.5.11		Coil	mm	150
7.5.12	Locking Mechanism		-	Bayonet with two-stage locking - Bayonet rotation: 37° - Coupling force >25N

Table 7.5: Mechanical Specifications: QBH Beam Delivery System

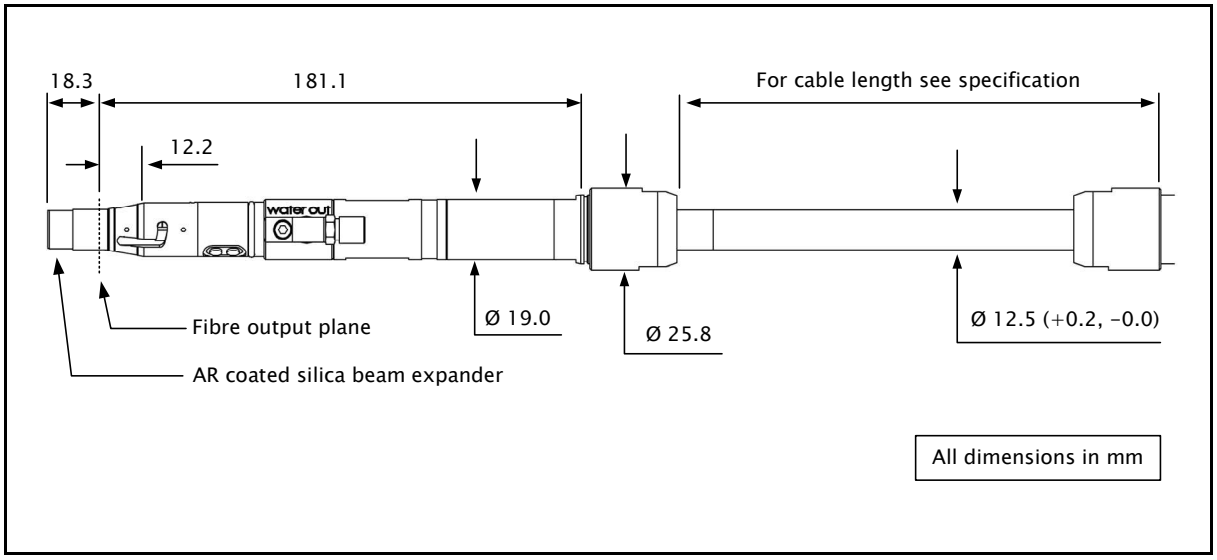


Figure 7.5: Outline Drawing: QBH Beam Delivery System

8.0 Control and Communication Interfaces

8.1 Rear Panel Connections

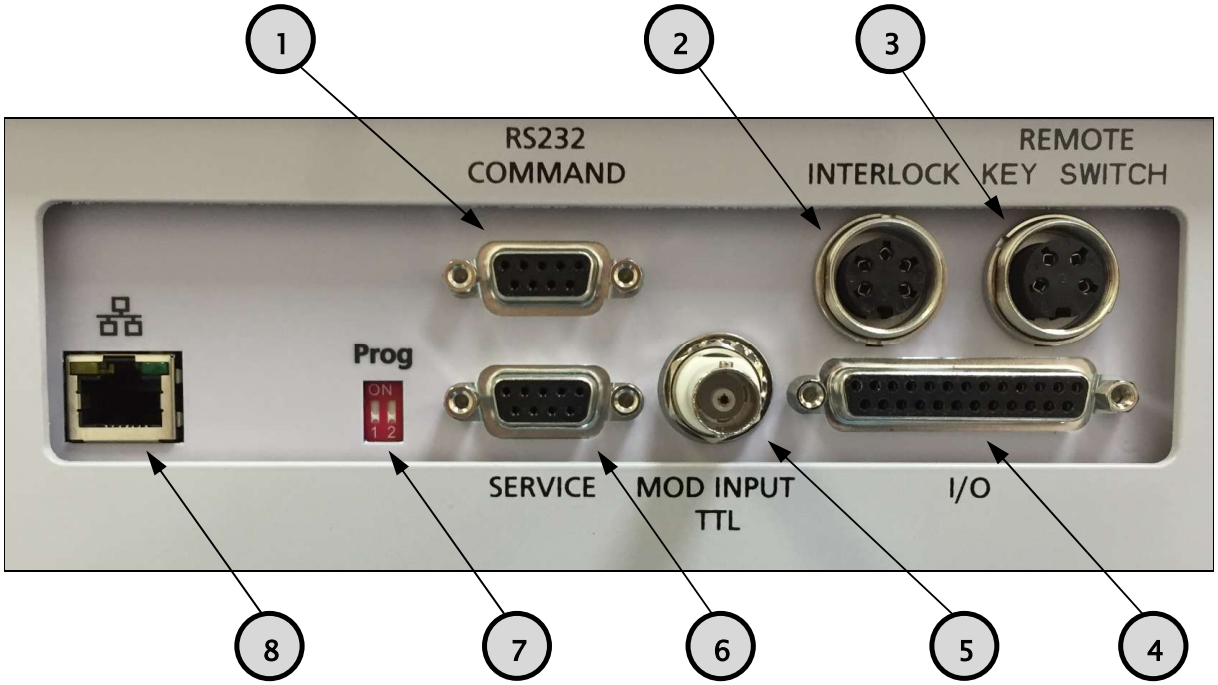


Figure 8.1: Rear Panel Connections

Label	Description	Connector Type	Refer to section
1	RS232 comms port	9-Pin Female D-Type	8.6
2	Interlock	5-Pin circular DIN	8.2
3	Remote Key-switch	4-Pin circular DIN	8.3
4	I/O connector	25-Pin Female D-Type	8.4
5	Modulation connector	BNC 50Ω	8.5
6	Service comms port	9-Pin Female D-Type	SPI Use only
7	Programming Switch	2-Way DIP switch	SPI Use only 8.8
8	Ethernet comms port	RJ45	8.7

Table 8.1: Side and Rear Panel Descriptions

8.2 Rear Panel Interlock Connector

A rear panel connection is provided for integration with the customer safety interlock circuit. The laser interlock circuit includes a safety relay and dual redundant monitored input circuits that are compatible with the safety and integration requirements of EN ISO 13849-1 PL'e' when connected to the customer side safety interlock circuit closures that conform to the same safety level.

The five-pin circular DIN socket situated on the rear panel provides a 24V dual circuit which must be wired into a dual switch closure provided by the customer.

An unwired plug is supplied to facilitate customer integration. The rear panel socket pin designation is as shown below.

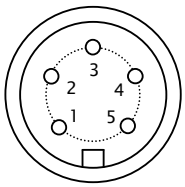


Figure 8.2: Remote Interlock Connector Pin Diagram

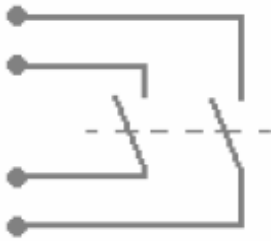
Pin	Signal Description	Diagram	Notes
1	Interlock return circuit 1 (input)		**IMPORTANT** The dual circuit interlock connections require switch closures only. Do not connect any external voltages to these pins
2	Interlock return circuit 2 (input)		
3	No connection		
4	Interlock feed circuit 2 (output)		
5	Interlock feed circuit 1 (output)		

Table 8.2 Interlock Connector Pin Designation

If either or both of the two interlock circuits are opened the interlock circuit will disable the Fibre Laser output and make the unit safe. Both circuits must both be closed in order to operate the unit.

8.3 Rear Panel Remote Key-switch Connector

The rear panel remote key-switch is a four-pin circular DIN socket enabling connection of a remote key-switch. The pin designations are shown in Table 8.3 , however the laser is supplied with a pre-wired jumper plug should a remote key-switch not be required.

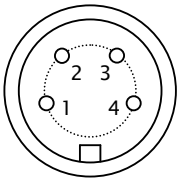


Figure 8.3: Remote Key Control Pin Diagram

Pin	Signal Description
1	+24 V DC Closure Feed
2	+24V DC Closure Return
3	Safety relay status monitor zero voltage contacts OPEN = INTERLOCK ENABLED CLOSED= INTERLOCK OPEN
4	

Table 8.3: Remote Key Control Pin Designations

8.4 Analogue Input and Output Interface Specifications

The I/O control interface is used to monitor the laser system status and provide analogue control of the laser output in conjunction with the RS232 communications interface. The I/O connector is a 25 pin female D-Type situated on the rear of the unit with the following pin designations:

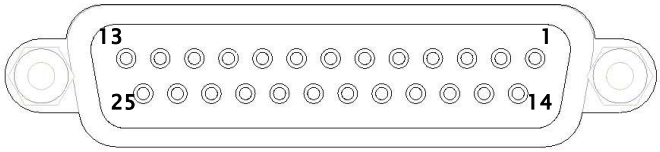


Figure 8.4: Analogue I/O Port 25-Pin Numbering

PIN	TYPE	SIGNAL DESCRIPTION	LEVEL	ACTIVE	FUNCTION
1	INPUT	MODULATION	0V -24V	TTL level switching threshold HIGH = LASER EMISSION	Laser will emit when HIGH provided ENABLE (pin 2) is LOW or ENABLE is disconnected.
2	INPUT	ENABLE	0V -24V	TTL level switching threshold LOW = ENABLE	Enables MODULATION (pin 1) when LOW. When HIGH laser does not emit. To emit MODULATION must be HIGH and ENABLE LOW or ENABLE disconnected.
3	INPUT	USE EXTERNAL INTERFACE	0V -24V	TTL level switching threshold HIGH = USE EXTERNAL I/O	Specifies this interface to be used for control. When active this will disable some computer interface commands.
4	N/A	NOT USED	N/A	NO CONNECTION	
5	INPUT	TARGET LASER CONTROL	0V -24V	TTL level switching threshold HIGH = Pilot laser ON	Visible pilot laser control
6	INPUT	ALARM RESET 1	0V -24V	TTL level switching threshold HIGH = Reset Last Alarms	Reset alarms with user level authorisation
7	INPUT	ALARM RESET 2	0V -24V	TTL level switching threshold HIGH= Reset Last Alarms	Reset alarms with supervisor level authorisation
8	N/A	NOT USED	N/A	NO CONNECTION	
9		DIGITAL I/P GND			This pin must be used as a ground for any of the digital inputs in this table

Table 8.4: Analogue I/O Port Pin Diagrams

10	OUTPUT	ALARM INDICATOR	O/C	Open collector (no pull up) LOW = ALARM PRESENT	Indicates an alarm is present. Replicates ALARM LED on front panel.
11	OUTPUT	EMISSION INDICATOR	O/C	Open collector (no pull up) LOW = EMITTING	Indicates that laser emission is taking place. This output will persist for 0.5 seconds after the rising edge of the modulation signal. Replicates the EMISSION LED on front panel.
12	N/A	NOT USED	N/A	NO CONNECTION	
13	OUTPUT	LASER ENABLED INDICATOR	O/C	Open collector (no pull up) LOW = LASER ENABLED	Indicates the laser is ready to emit. Replicates the ENABLED LED on front panel
14	OUTPUT	TARGET LASER STATUS	O/C	Open collector (no pull up) LOW = PILOT LASER ON	Indicates if the pilot laser is on.
15	OUTPUT	STATUS 1	O/C	Open collector (no pull up)	Indicates the state of unit in combination with Status 2, Status 3 and Status 4. Up to 16 states available.
16	OUTPUT	STATUS 2	O/C	Open collector (no pull up)	See Status 1
17	OUTPUT	STATUS 3	O/C	Open collector (no pull up)	See Status 1
18	OUTPUT	STATUS 4	O/C	Open collector (no pull up)	See Status 1
19	OUTPUT	WARNING	O/C	0V= Warning ON	Warning level. Indicates that a level is close to triggering an alarm.
20		NOT USED	O/C	Open collector (no pull up)	
21		DIGITAL O/P GROUND			This pin is connected to the grounds of all the O/C outputs.
22	INPUT	SET POWER	0V –10V	Protected against inputs up to 24V DC 0V = 0 watts 10V = rated power in watts	Sets the optical power output
23	OUTPUT	POWER LEVEL INDICATOR	0V –10V	0V = 0 watts 10V = rated power in watts	Indicates the power level.
24	OUTPUT	PHOTO DIODE	0V–0.7V	Output impedance of 50Ω	Buffered analogue output of output power photodiode.
25		ANALOGUE GROUND			This pin must be used as the ground for both analogue inputs and analogue outputs.

Table 8.4: Analogue I/O Port Pin Diagrams – Continued

8.5 External Modulation Input

An alternative modulation input to the laser is provided by a high impedance BNC connector situated on the rear panel of the unit.

CAUTION: Do not use this connector if the modulation input provided by Pin 1 of the Analogue I/O port is connected. Refer to section 8.4.

The modulation signal is used to switch the laser output power between the Mark power level and the Idle power level. This is a TTL voltage level signal with corresponding electrical requirements as given in Table 8.5(i) below:

Parameter	Units	Value	
		Minimum	Maximum
High Level Input Voltage	V	3.2	24
Low Level Input Voltage	V	0	0.8

Table 8.5(i): TTL Signal Levels

The following pin designation applies to the connector:

Pin	Signal
Centre	Positive: 0-5V/24V DC
Case	Ground

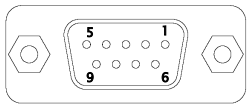
Table 8.5(ii): Modulation Input Connector Pin Designation

8.6 RS232 Communications

The RS232 interface is a ±12V DC voltage level implementation of the RS-232C standard. It is used to exchange messages, commands and enquiries between the Fibre Laser and the host PC.

The RS232 connector is a 9 pin female D-Type situated on the rear of the unit with the following pin designations:

RS232



Pin	Signal	Description
1	N/C	
2	Receive RS232	The communications data received from the PC. ±12VDC voltage levels are used
3	Transmit RS232	The communications data transmitted to the PC. ±12VDC voltage levels are used
4	N/C	
5	Ground	0V line, connected to case ground.
6	N/C	
Shell	Ground	The cable screen or drain wire should be connected to ground. The cable screen should be attached through 360° to the laser end of the metal connector shell.

Table 8.6(i) : RS232 Pin Designations

RS232 communications protocol and data format is described in the following table:

Parameter	Value
Baud Rate	Variable: 9600 – 115200
Start Bits	1
Data Bits	8
Parity	Even
Stop Bits	1
Flow Control	None

Table 8.6(ii): RS232 Communications Protocol

8.7 Ethernet Communications Interface

The Ethernet connector is a standard RJ45 type situated on the rear panel of the laser as shown in figure 8.1. The pinouts for the RJ45 connector are given in figure 8.7 and table 8.7.

The Fibre Laser supports 10base-T (10Mb/s) and 100base-T (100Mb/s) Ethernet communication using the standard TCP/IP protocol. Both static and dynamic IP addressing (DHCP) are supported and with dynamic addressing the Fibre Laser will automatically be allocated an IP address by the network DHCP server. When the connection is made through a router or LAN a standard Ethernet cable is used and if connection is made directly from a PC a crossover cable is required.

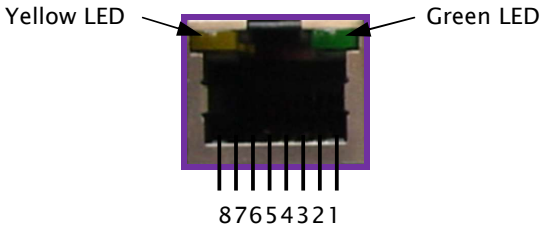


Figure 8.7: Ethernet RJ45 Socket – Pin Numbering

Pin	Signal	Description
1	Tx+	Transmit Data +
2	Tx-	Transmit Data -
3	Rx+	Receive Data +
4	N/C	No connection
5	N/C	No connection
6	Rx-	Receive Data -
7	N/C	No connection
8	N/C	No connection
Yellow LED		Connection made
Green LED		Data packets are being sent/received

Table 8.7 : RJ45 Ethernet Pin Designations

8.8 Programming Switch

The Programming Switch is located on the rear panel and labelled “Prog” as shown in figure 8.8 below and also in figure 8.1 which shows its location on the rear panel. This switch is used to place the Laser into firmware upgrade mode which can be carried out under instruction from the SPI Lasers Product Support Team.

Figure 8.8: Programming Switch

8.9 Front Panel LEDs

Figure 8.9: Front Panel LEDs

The LEDs on the front panel of the unit indicate the operational and alarm status of the Fibre Laser. When the LED colour is RED, an alarm function is being reported or a function is disabled. When the LED is GREEN, a function has been enabled. The Amber emission LEDs indicate that the Laser is active.

LED	Function	Modes
Laser Enabled (x2)	Indicates that the laser driver circuit is enabled and laser emission is under software control. Two laser enabled status LEDs are provided for component redundancy	RED = Laser disabled. RED/GREEN FLASHING = Laser driver circuit arming warning (default 5 second delay) GREEN = Laser driver circuit enabled
Laser Emission (x2)	Indicates a TTL Voltage Signal is present. Two laser emission status LEDs are provided for component redundancy	OFF = Laser TTL signal low (Laser OFF) AMBER = Laser TTL signal high (Laser ON)
System Error	Reports a system fault	RED = Alarm active. GREEN = No faults detected.
Pilot Laser	Indicates the status of the red pilot laser	AMBER = Pilot laser ON Not illuminated = Pilot laser OFF

Table 8.9: LED Status

8.10 LLK-Q and QBH Proximity Detector Contacts

An additional function is provided with the LLK-Q and QBH connectors which ensures that the laser cannot be enabled until the BDO is installed in a mating connector such as an external collimator or process head. This comprises two contact pads wired in series with the BDO integrity monitor circuit which must be electrically connected (short circuited) to complete the integrity circuit (refer to figure 8.10.1 below for the LLK-Q variant and to figure 8.10.2 for the QBH variant.

In order to prevent the contacts from being accidentally short-circuited when the connector is not installed the LLK-Q connector incorporates an additional protective shroud which retracts as the connector is inserted into the external collimator or process head. The white shroud is shown in figure 8.10.1.

The pin designations are shown in table 8.10.1. Pin 1 should be connected to pin 2 and isolated from ground. Note that the laser may be supplied with the mechanical positions of pin 1 and pin 2 reversed.

Figure 8.10.1: LLK-Q Proximity Detector Contacts and Retractable Shroud

Figure 8.10.2: QBH Proximity Detector Contacts

Pin	Signal Description
1	+5 V DC Closure Feed or Return
2	+5 V DC Closure Return or Feed

Table 8.10: LLK-Q and QBH Proximity Detector Contact Designations

9.0 Cooling Water Connections and Requirements (water cooled variants only)

The water cooled R4.3 Fibre Laser System must be operated with a source of chilled water in accordance with the specifications listed in Table 5.5. The cooling circuit is terminated with 3/8" push-fit John Guest 'Speedfit' water connections as shown in figure 9.0.

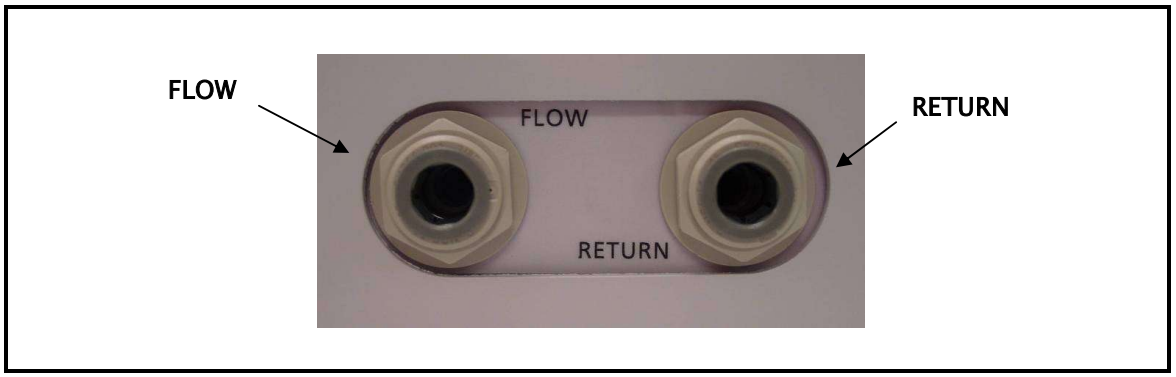


Figure 9.0: Water Cooling: Laser Connections

The LLK-Q and QBH connectors must also be cooled with a separate source of clean, chilled water in accordance with the specifications listed in tables 5.6.1 and 5.6.2 respectively. Both connector types contain an internal mode stripper designed to remove light coupled into the fibre cladding in the event of a back reflection from the work piece. Operating the laser without an adequate flow of cooling water may result in catastrophic damage to the connector.

The LLK-Q cooling circuit is terminated with Parker Rectus type 21 couplings as shown in figure 9.1.

The QBH cooling circuit is terminated with 4mm SMC water connections as shown in figure 9.2.

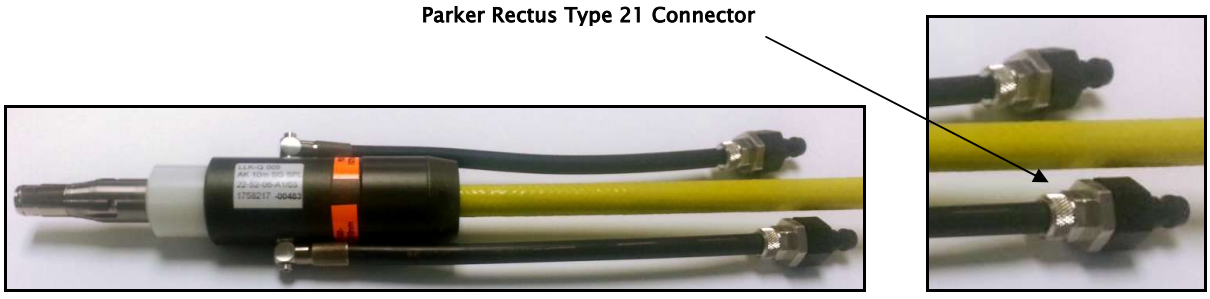


Figure 9.1: Water Cooling: LLK-Q BDO Connections

Figure 9.2: Water Cooling: QBH BDO Connections

CAUTION: To avoid corrosion to the cooling circuit components within the Fibre Laser the use of deionised water is not permitted.

CAUTION: An approved overpressure safety device should be installed when connecting the Laser to an external chiller or factory water supply. This should comply with ISO4126-1 (or equivalent) and be rated to protect the laser against a flow or differential water pressure in excess of that specified in Table 5.5.

10.0 Compliance and Safety

10.1 Compliance

This product is specifically designed to be an OEM laser product for incorporation or integration into other equipment. It is CE marked and is compliant with the requirements of the Low Voltage Directive, 2006/95/EC, and the EMC Directive 2004/108/EC if used and installed according to the recommendations in this document. It is the responsibility of the laser integrator to meet all of the regulatory requirements for the full system.

10.1.1 Laser Safety

CAUTION: This product is a Class 4 laser.

The product is specifically designed to be an OEM laser product for incorporation or integration into other equipment. As such, it DOES NOT MEET the full requirements for a stand-alone laser system as defined by 21 CFR 1040.10 and IEC/EN 60825-1.

Within the EU, the equipment is supplied with a Declaration of Conformity indicating the harmonised standards with which this product conforms. Within the USA, the equipment is shipped with an appropriately completed FDA 2877 form. It is the responsibility of the laser integrator to meet all of the regulatory requirements for the full system. Nonetheless, most of the electronic and labelling requirements have been incorporated into the product to facilitate final system compliance with regulatory requirements.

During installation it is vital that the laser hazard is fully managed. In particular, the laser integrator is required to provision the engineering requirements detailed in IEC/EN 60825-1. These include, but are not limited to:

- Provision of a fail-safe or redundant audible or visible emission indicator. This should be repeated at the laser aperture if it is located more than 2m from the original emission indicator (IEC 60825-1 section 4.7).
- Provision of one or more permanently attached means of attenuation (e.g. beam stop, attenuator or switch). The beam stop or attenuator shall prevent access to laser radiation in excess of Class 1M (IEC 60825-1 section 4.8)

Note that the visible Pilot Laser carries a Class 3R laser rating as defined by IEC/EN 60825-1.

Where there is potential for exposure to radiation above the Maximum Permitted Exposure limit (IEC/EN 60825-1) the end user is advised to complete a documented risk assessment before operating the laser. If this risk assessment determines that protective eyewear should be considered then an appropriate specification for alignment eyewear is defined in section 10.1.2.

10.1.2 Protective Eyewear

WARNING: In circumstances where the laser beam path is exposed protective eyewear must be worn to prevent accidental exposure to laser radiation. Based on the product specification detailed in this document, the following ratings are advised for protective eyewear in accordance with the European Standard for Personal Eye Protection EN 207:

Laser Rated Output Power	200W – 500W
Maximum Output Power [under single fault conditions]	800W
Wavelength Range	1050-1250nm
CW Mode	D LB8
Modulated Mode	I LB8

Wavelength Range	400-700nm
Alignment Goggles	RB1 (EN 208)

It is a requirement of the European Laser Safety Standard (IEC/EN 60825-14) and the US Laser Safety Standard (ANSI Z136.1) that a Laser Safety Officer (LSO) is appointed when operating Class 3B and Class 4 lasers.

The information provided above is for guidance only and your local LSO should be consulted to determine the correct level of protective eyewear for your installation.

Ensure that you select protective eyewear according to the laws, regulations and requirements applicable to your local geographical region. Contact the appropriate national and local agencies for these requirements.

WARNING: Any reduction in beam diameter conducted by the end user, e.g. resulting from the use of focus optics, will increase the optical density required for protective eyewear. It is the responsibility of the end user to ensure correct protection is in place.

WARNING: When operating in a modulation configuration, peak powers up to 5x the rated CW output power may be generated at the beginning of the pulse. Ensure that all safety eyewear is rated accordingly.

10.1.3 Safety Related Control Circuitry

This equipment is specifically designed to be an OEM laser product for incorporation or integration into other equipment. The safety related control circuitry contained within the Equipment is compliant with:

- EN ISO 13849-1: part 1- Safety related parts of control systems
  - Performance Level E : PL'e'

The control standard EN954-1 has been replaced by EN ISO 13849-1 which introduces several new requirements including performance levels.

It is the responsibility of the laser integrator to meet all of the regulatory requirements for the full system.

10.1.4 EMC

This equipment is specifically designed to be an OEM laser product for incorporation or integration into other equipment and is compliant with the EMC Directive 2004/108/EC when installed according to the installation instructions.

Within the EU, the equipment is supplied with a Declaration of Conformity against the EMC Directives. The equipment is compliant with:

- IEC/EN 61000-6-1: Electromagnetic compatibility (EMC) – Part 6.1: Generic standards-Immunity for residential, commercial and light-industrial environments
- IEC/EN 61000-6-2: Electromagnetic compatibility (EMC) – Part 6.2: Generic standards-Immunity for industrial environments
- IEC/EN 61000-6-3: Electromagnetic compatibility (EMC) – Part 6.3: Generic standards-Emission standard for residential, commercial and light-industrial environments
- IEC/EN 61000-6-4: Electromagnetic compatibility (EMC) – Part 6.4: Generic standards-Emission standard for industrial environments
- IEC/EN 61000-3-2: Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16A per phase)
- IEC/EN 61000-3-3: Electromagnetic compatibility (EMC). Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

In addition, the equipment is compliant with:

- FCC CFR47:Part 15, subpart B: Unintentional Radiators

It is the responsibility of the laser integrator to meet all of the regulatory requirements for the full system.

10.1.5 Electrical Safety

This equipment is specifically designed to be an OEM laser product for incorporation or integration into other equipment and is compliant with the Low Voltage Directive 2006/95/EC when installed according to the installation instructions.

Within the EU, the equipment is supplied with a Declaration of Conformity against the Low Voltage Directive. This equipment is compliant with:

- IEC/UL/CSA/EN 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General Requirements

In addition, the equipment is compliant with the following National differences:

- USA & Japan

It is the responsibility of the laser integrator to meet all of the regulatory requirements for the full system.

10.1.6 RoHS Directive

Beam Delivery Connector Type: RIC and QCS (with Collimated Output)

This OEM Fibre Laser is RoHS compliant. Within the EU, the equipment is supplied with a Declaration of Conformity against the RoHS Directive.

Beam Delivery Connector Type: LLK-Q and QBH (with Divergent Output)

This OEM Fibre Laser is not compliant with the RoHS directive 2002/95/EC. However, when incorporated into large-scale stationary industrial tools as defined in the directive, the OEM Fibre Laser is exempt from the requirements for RoHS compliance in Europe. Further information can be provided by request to SPI Lasers.

10.1.7 WEEE Directive

This symbol indicates that, at end of life this product should be separately collected from unsorted waste with a view to meeting the recovery and recycling targets specified in the appropriate national regulations implementing Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) for a product of its class.

10.2 Safety Features

The following safety features are incorporated within the Fibre Laser System:

Feature	Location	Description
Remote Interlock Circuit Connector	Rear Panel	Dual redundant monitored safety interlock circuit compliant with EN ISO 13849-1 PL'e'. Dual circuit connector provided for connection to safety interlock system on customer process equipment or similar. Key-switch recycle required to reset safety relay.
Key Control	Front Panel	Enables or disables the fibre laser output when safety relay is closed. Hardware controlled, overrides all system inputs. Key non-removable in the ON (laser enabled) position.
Remote Key Connector	Rear Panel	Connector provided at rear of unit for connection to remote key-switch. Wired in series with the front panel key control.
Thermal Shut Down	Internal	Thermal over-temperature protection switches to isolate the power supply to the laser pump diodes.
BDO integrity monitor: Over-temperature Sensor	Internal to Delivery Optic	A hardware thermal protection sensor is incorporated in the beam delivery optic [BDO]. If the BDO temperature exceeds the control limit the interlock circuit will open.
BDO integrity monitor: Fibre Break Sensor	Internal to Beam Delivery Optic Cable	An electrical circuit designed to detect a break in the external delivery fibre cable is wired in series with the over temperature sensor. In the event of a fibre break the interlock circuit will open.
BDO connection monitor: LLK-Q and QBH connectors only	External to Beam Delivery Connector	Proximity detection contacts are provided on the beam delivery optic which must be electrically connected when installed into a mating connector. This is wired in series with the BDO integrity monitor circuit and must be integrated such that closure enables operation of the laser.
Status Indicators (LED)	Front Panel	Series of LEDs indicating operating status of Fibre Laser. Includes Laser Emission Indicator. LED status reported on I/O to facilitate provision of remote emission indicator.
Safety Labels	Unit Exterior Unit Interior	Various location and type to warn of potential hazard or danger and to provide product and supplier contact information.

Table 10.2: Safety Features

10.2.1 Safety Interlocks

A rear panel connection is provided for integration with a closure switch operated by the customer's interlock circuit. The laser interlock circuit includes a safety relay and dual redundant monitored input circuits that are compatible with the safety and integration requirements of EN ISO 13849-1 PL'e'.

When either pair of the terminal pins are open-circuit the Fibre Laser output will be immediately disabled and the front panel LED – ENABLED – will turn from GREEN to RED. Re-arming of the laser requires either the front panel or remote key control to be recycled. These are both hardware only based protection circuits.

10.2.2 Front Panel / Remote Key-Switch Control

There are two key controls which are connected in series, the front panel key control and the rear panel remote key control interface. Both the front panel and the remote key controls must be in the **ON** position for the laser to recognise the key state as **ON**. If either key control is switched to the **OFF** position then the laser will recognise the key state as **OFF**. While the system is running, the key control can be operated at any time. The front panel key cannot be removed when in the **ON** position.

If system power has been interrupted then either the front panel or rear panel remote key control must be reset to the **OFF** position before the Fibre Laser output can be re-enabled.

Switching either key control to **OFF** will immediately disable the Fibre Laser output. Switching the key control to **ON** will cause the front panel indication LED – ENABLED – to flash continuously from RED to GREEN during a preset arming delay (default value = 5 seconds) after which the ENABLED LED remains GREEN and laser output is enabled.

10.2.3 Thermal Protection

For safety compliance the laser is fitted with a hardware level over temperature switch that will shut down the laser if the internal temperature exceeds 60℃. Once activated, the unit will not be able to be reset until the internal temperature falls below 45℃.

In addition, if the laser cooling subsystem temperature exceeds a preset value the laser output may be disabled as a protection measure. It will not be possible to reset the alarm status until the sub-system temperature falls below the preset threshold.

Beam delivery optic

A thermal sensor is incorporated to disable the laser output if the delivery optic reaches a preset temperature. This could be caused by high ambient temperature, inadequate heat-sinking of the mounted BDO, or excessive levels of light reflected from the work piece. Once activated, the laser will not be able to be reset until the BDO temperature falls below the reset temperature at which point the reported alarm will need to be cleared (refer to table 10.2.3).

Beam Delivery Option	Activation Temperature	Reset Temperature
RIC Connector	70℃ ± 5℃	50℃ ± 5℃
QCS Connector	50℃ ± 7℃	35℃ ± 7℃
LLK-Q Connector	65℃ ± 5℃	42℃ ± 7℃
QBH Connector	70℃ ± 7℃	55℃ ± 7℃

Table 10.2.3: BDO Thermal sensor activation and reset temperatures

11.0 Product Labelling – Safety and Compliance

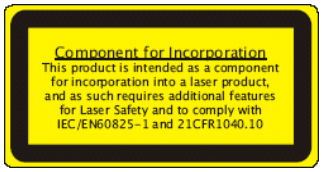
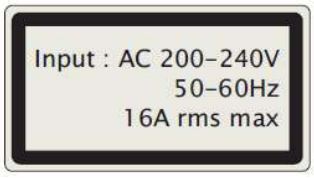
	
Component for Incorporation Top panel	Class 4 Laser Product Front panel
	
Wavelength and output power Rear panel	Class 3R Laser Product for Pilot Laser Front panel
	
Laser aperture warning Beam Delivery Output	Laser Emission Front panel
	
Mains input rating Rear panel	Electrical hazard Rear Electrical Connection Panel

Figure 11.1: Safety and Compliance Labels

Additional Labels – Safety and Compliance:

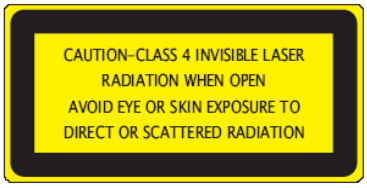
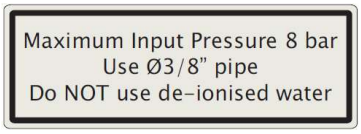
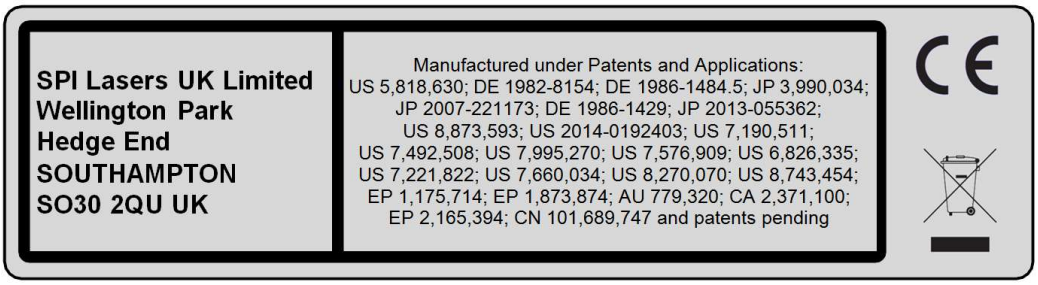
	
Protective Earth Label Internal to Electrical Connection Panel	Mains input conductor terminal designations Internal to Electrical Connection Panel
	
Product I.D. Label Front and Rear panels	Beam Delivery Optic handling warning Beam Delivery Output
	
Warning for Class 4 Radiation behind non-interlocked access panels Internal	Warning for Class 3R and Class 4 Radiation behind non-interlocked access panels Internal
	
Replace Bungs Warning – Rear Panel Water Cooled Lasers Only	De-ionised Water and Pressure Warning Rear Panel Water Cooled Lasers Only

Figure 11.1: Safety and Compliance Labels – Continued

Additional Labels – General:



Combined label comprising:

Manufacturer Identification, CE Mark, WEEE and Intellectual Property

Note : The Intellectual Property information is for illustration purposes only and is subject to change without notification. Refer to the SPI web site as detailed in section 12.0

Rear Panel

Figure 11.2: Additional Labels – General

12.0 Contact Information

UK Head Office and Manufacturing Facility	US Corporate Office	China Office	Korea Office
SPI Lasers UK Limited 6 Wellington Park Hedge End Southampton SO30 2QU UK Tel: +44 (0)1489 779696	**SPI Lasers LLC** 4000 Burton Drive Santa Clara CA 95054 USA Tel: +1 408 454 1169	**SPI Lasers (Shanghai) Co., Ltd.** Room 108, Building 3 No. 7 Guiqing Road Caohejing Hi-tech Park Shanghai 200233 China Tel: +86 (0) 21 6171 9470	**SPI Lasers Korea Ltd.** #508, DMC Tower 1622 Sangam-dong Mapo-gu Seoul Korea Tel:+82 2 3151 9591
Customer Services customerservices@spilasers.com Tel: +44 (0)1489 779696 – Option 5		**Company Web Site** www.spilasers.com	
Product Support productsupport@spilasers.com Tel: +44 (0)1489 779696 – Option 2 productsupportasia@spilasers.com Contact your local office number		Or contact your local distributor.	

Table 12.0: Contact Information