Lightning Series Fiber Laser

User Manual

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1. Introduction

Welcome to use the fiber lasers produced by BWT. This user manual is applicable to Lightning series fiber lasers, and the product model covers BFL-CW500, BFL-CW1000, BFL-CW1500, BFL-CW2000, BFL-CW3000 and BFL-CW6000.

This user manual contains safety instructions, product description, installation, usage, maintenance as well as trouble shooting. Please read this manual carefully before installing and operating the products and also strictly follow the safety instructions in this manual, otherwise personal injury or equipment damage may occur.

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2. Safety Instructions

2.1. Laser Safety Level

This product is a Class 4 laser product. It outputs a high-power invisible laser beam with a wavelength of 1080±10nm. It will cause damage to the eyes or skin which is directly or indirectly exposed to this strong laser, and may also cause on-site fire. Therefore, please strictly follow the EU EN60825-1:2014 standard, and every operator or anyone who close to the laser must be aware of these special hazards, wear wavelength-matched and certified laser safety glasses, and take adequate safety precautions.

	**There is a safety risk, which may cause serious personal injury or even endanger life safety.**

2.2. Security Precautions

NO	Item	Description
1	Safety/Warning Signs	Warning of possible hazards to persons who installs or operates this product..
2	Self-locking, Interlocking and Alarm	Built-in safety control sensors monitoring temperature, current and voltage, optical path, QBH, etc, to realize automatic safety and self-locking. It also can be connected to chiller and other safety interlock signals for external interlock connection control.
3	External Communication Safety Control	The communication interfaces can be used to realize external emergency stop control.

2.3. Safety Labels

Laser safety labels include: safety warnings, laser output warnings, laser radiation signs, product nameplates, etc. The details of these safety labels are shown in Table 1 below.

Table 1 Laser Labels

Labels	Description
	Dangerous Laser Radiation. Please wear laser protective glasses. It is strictly forbidden to expose any part of your body to the laser.
	Laser Radiation. Please wear laser protective glasses. It is strictly forbidden to expose any part of your body to the laser.
	Class 4 Laser Product. Avoid direct exposure to human eyes. Please wear laser protective glasses. It is strictly forbidden to expose any part of your body to the laser.
	2M Class Laser Product. Avoid direct exposure to human eyes. Please wear laser protective glasses. It is strictly forbidden to expose any part of your body to the laser.

	Hazardous Electrical Voltage. Confirm the electricity demand before use and pay attention to electricity safety.
	CAUTION. There is a safety risk which may cause serious personal injury or even endanger life safety.
	Nameplate. Including the information of product model, SN, etc.
Example description	 Labels locates on the rear panel and the top cover of the laser

2.4. Other Safety Rules

1) Before the laser is powered on, make sure the protective cap on the QBH has been removed, and carefully check and wipe the quartz block surface of the QBH to ensure its clean in case of laser damage. See the QBH interface connection instructions for details.
2) After initiating the aiming beam, it is strictly forbidden to expose the eyes to the aiming beam in case of any injury.
3) The laser is infrared invisible light. After intiating the laser beam, it is strictly forbidden to expose any part of the body to the laser in case of any personal injury.
4) When installing and operating this product, laser protective glasses must be worn. Please select laser protective glasses according to the laser wavelength range and power level. When the laser is powered on, it is strictly forbidden to directly view the output head even already wearing laser protective glasses.
5) Replace the water in the chiller regularly to avoid the blockage of the laser water cooling module due to the water decay.
6) When operating the laser in winter, please add antifreeze to the cooling water with an appropriate proportion according to the local temperature, so as to avoid the internal damage of the laser caused by freezing.
7) If the laser is not going to use for a long time, please empty the cooling water in the laser in time. Cover the output head protection cap to prevent dust.
8) Please ensure that the PE wire of the power cord is reliably grounded.
9) Ensure that the AC power supply is normal. The wrong wiring connection or power supply voltage will cause irreversible damage to the product.
10) There is no component that needs maintenance inside the laser, so please do not open the laser chassis to avoid personal injury.
11) Do not damage the tamper-evident label on the laser chassis to avoid loss of warranty.

3. Product Description

3.1. Product Advantages

BWT Lightning series fiber lasers have excellent beam quality, and the laser beam can be focused close to the diffraction limit, which makes them the perfect choices for precision processing. The two operation modes, continuous and modulated pulse, minimize the heat-affected zone. Reliable performance, modular and all fiber design, and robust case to enclose all optical and electronic components make the products can be used under strict industrial application conditions.

BTW Lightning series fiber lasers can be used in wide application like precision machining, 3D printing, sheet metal processing, lithium-ion battery manufacturing, etc. The lasers can process various types of metal, including aluminum-based and nickel-based alloys, titanium alloys, alumina ceramics and so on.

Features

- Cost effective and maintenance free
- Continuous and modulated pulse work modes to optimize the machining quality
- Excellent power stability
- Good beam quality for precision processing
- High electro-optical conversion efficiency
- Excellent system stability
- Maximum modulation frequency up to 5kHz
- Easy-to-use control interface

Application

- Precision cutting
- Precision welding
- Surface treatment
- Drilling
- 3D printing
- Sheet metal processing

3.2. Product Specifications

The technical specifications of BWT Lightning series fiber lasers are shown in Table 2 below.

Table 2 Product Specifications

Model	**BFL-CW500**	**BFL-CW1000**	**BFL-CW1500**	**BFL-CW2000**	**BFL-CW3000**	**BFL-CW6000**
Power	500W	1000W	1500W	2000W	3000W	6000W
Wavelength	1080±10nm					
Fiber core diameter	20/50μm or customized		25/50μm or customized	34/50μmor customized	50μm or customized	100μm or customized
Fiber length	12m or customized		12/15m or customized		12/20m or customized	25m or customized
Output connector	QBH					
Aiming beam	Red					
Operation Mode	Continuous or modulated					
Power adjustment scope	10%~100%					
Power stability (25℃)	< ±1.5% (2h)					
Max modulation frequency	5kHz					
Weight	~ 15kg			~ 17kg	~ 30kg	~ 65kg
Dimension H*W*D, mm	80*402*296			80*402*346	80*402*466	93*482*830
Voltage	Single phase ,220±20V,AC,PE,50/60Hz				3phases ,380±20V,AC,PE,50/60Hz	
Power consumption	1.5kW	3.0kW	4.5kW	6.0kW	10.0kW	18.0kW
Control interface	RS-232/AD					
Minimum water cooling capacity	⩾1kW	⩾2.5kW	⩾3.5kW	⩾4.5kW	⩾7.0KW	⩾13.0kW
Temperature settings	25℃ (Laser Module), 30℃ (QBH)					
Cooling water flux	>8L/min	>10L/min	>15L/min	>18L/min	>27L/min	>55L/min
Cooling water pressure	⩽0.5MPa					
QBH cooling water flux	1.5~2.0L/min					
Cooling tubes size	O.D. φ12mm				I.D. φ19mm	I.D. φ25mm

3.3. Unpacking and Inspection

The laser is carefully packaged before shipping out from the factory for safe transportation, but in case of any unpredictable situation in transportation process, you need check the packaging box for the crack, soaking, etc., when you receive the laser. If any damage is found, please contact BWT representative in time.

If no damage on package, you can unpack the laser. After unpacking, please carefully check whether the contents in the box are consistent with the packing list.

When removing the packing foam, do not pull hard the output fiber. Remove the protective cap on the end of the output fiber, and check the end surface. There should be no stains or cracks on it. If there is any damage, please contact BWT representative in time. Please note, do not contaminate the output end surface when you check it.

When taking out the laser from the package box, avoid collision and strong vibration to the laser and the laser output head. When taking out the coiled output fiber, do not bend, twist or pull the output fiber.

The laser should be placed on a flat and firm table in a room with good ventilation.

Table 3 Laser packing list example

No.	Item	Qty.	Note
1	Laser system	1	
2	Power cable	1	
3	Control interface cable	1	DB25
4	Communication interface cable	1	R232
5	DB9 extension cable	1	
6	8-pin wiring plug	1	For connection of switch interlock interface
7	USB flash drive	1	Contains PC software and electronic manuals, etc.
8	Quick guidance	1	
9	Gas tube	1	Outer diameter φ6mm
10	Throat hoop	4	For BFL-CW3000 and BFL-CW6000 only
11	O-ring 1	1	Inner diameter φ11.2 × wire diameter φ1.8
12	O-ring 2	1	Outer diameter φ16×wire diameter φ1.5
13	cotton swab	1	Can be used for surface cleaning of QBH quartz block
14	dust-free cloth	10	Can be used for surface cleaning of QBH quartz block
15	Rubber dust cover	1	
Note: the packing list may be different in terms of configuration. Please refer the packing list delivered with laser.			

3.4. Panel Description

The laser panel and definition description are shown in the figure below.

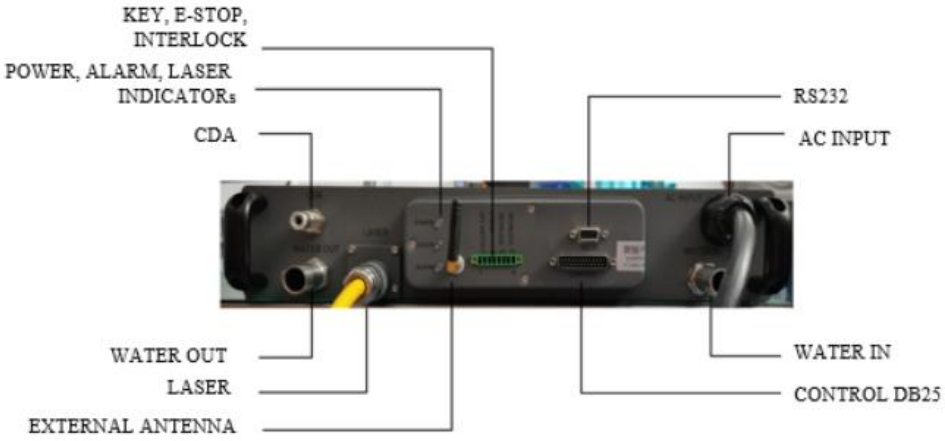


Figure 1 Laser Rear Panel Instructions

1) WATER IN and WATER OUT are the cooling water inlet and outlet of the laser. Refer *4.4 Cooling System Requirements* for details.
2) AC INPUT is the AC 220V/380V voltage input interface, please refer to the power supply requirements in *3.3 Product Specifications* for details.
3) Power-on indicator (POWER): After powering on, this indicator flashes. The indicator will light up with no flash when the laser is ready. The indicator will light off when there is some fault.
4) Alarm indicator (ALARM): When there is some fault, the alarm indicator lights up.
5) Laser indicator (LASER): This indicator lights up when the laser beam is output, and lights off when the laser beam output is shut down.
6) Control interface (CONTROL): This is a DB25 interface. The external signal control board can be connected to the laser through this interface for laser external control and operation.
7) Communication interface (RS232): This is a DB9 interface. The computer with operating software can be connected to the laser through this interface to for laser internal control, operation and status check.
8) Key, emergency stop and interlock ports: PIN1~PIN2 are connected to the key switch, PIN3~PIN4 are connected to the emergency stop button, PIN5~PIN6 are connected to the water cooling interlock, and PIN7~PIN8 are connected to the safety interlock which is used for the connection and control of external switch interlock.
9) Laser output (LASER): fiber armored cable for laser output.
10) CDA: clean and dry air port. CDA supply (0.1MPa, free of moisture and oil) is connected to this port to prevent laser from condensation.
11) External antenna for Bluetooth connection.

3.5. Definition of Control Interface

Control mode: As the rear panel shown in Figure 1, Lightning Series fiber laser include RS-232 communication interface, DB25 control interface and switch interlock interface.

1) The definitions of RS-232 communication interface are shown in Table 4:

Table 4 RS-232 Communication Interface Definition

No.	Function and description
2	RS-232 communication reception
3	RS-232 communication sending
5	RS-232 communication ground
Other	N/A

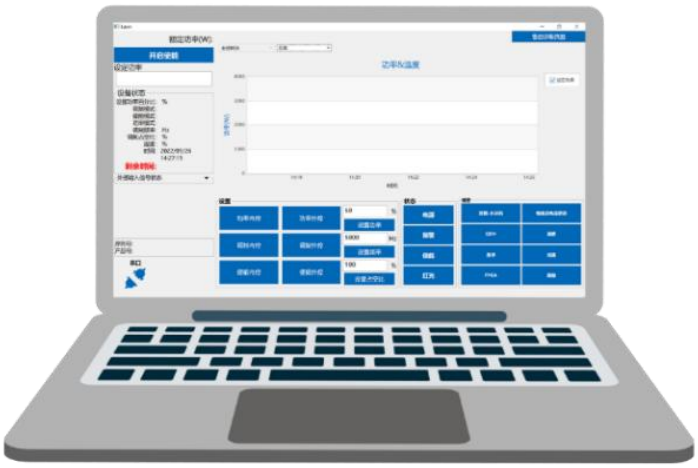


Figure 2 RS-232 PC operation software

2) The specific parameter requirements of the communication control interface are shown in Table 5:

Table 5 RS-232 Interface configuration parameters

No.	Configuration parameters
Baud rate	115200
Data bits	8
Stop bit	1
Polarity	N/A
Stream control	N/A

3) Control interface DB25 (CONTROL): It is used to connect the control wiring for remote AD mode. The pin numbers are marked at the end of the control wiring, and the definitions are shown in Table 6:



Figure 3 Control interface DB25

Table 6 DB25 Wiring Definition of Control Interface

PIN No.	Definition	Function	Drive capability	Note
7	fault signal-	Fault signal output -		When there is some fault, ports 7 and 20 will be short-circuited. The maximum short-circuit current here should not exceed 1A. Please add the series resistance according to the actual operating condition; when the laser works well, ports 7 and 20 will be open-circuited.
20	fault signal+	Fault signal output+		
6	Enable-	External enable input signal-	Input current≥ 5mA	High level 18V-24V valid.
19	Enable+	External enable input signal+		
8	PWM-	External modulation input signal-	Input current≥ 5mA	Modulate output laser control, high level 18V-24V valid.
21	PWM+	External modulation input signal+		
14	AD-	Analog input -	Input current≥ 1mA	1V-10V controls the output power of the laser, 10V corresponds to 100% output power. Please ensure that the maximum analog voltage does not exceed 10.3V.
15	AD+	Analog input+		
10	Safety Interlock+	External on-off signal (normally on)		Client interlock signal, can be connected to the emergency stop switch of the system.
23	Safety Interlock-			
12	Chiller interlock+	External on-off signal (normally on)		Connect the "failure signal+" and "Failure signal-" of the chiller separately.
25	Chiller interlock-			
9	red light+	External control red light signal+	Input current≥ 5mA	External signal high red light mode: high level 18V-24V valid; external signal low red light mode: low level 0-5V valid
22	red light-	External control red light signal-		

	signal -	Connect to control board ground		Connect to the cover of processing equipment
Other		NC		N/A

4) Key, emergency stop and interlock ports: This is used for the switch interlock interface. There are labels on the panel. The water-cooling interlock interface and the safety interlock interface are in parallel connected with the water-cooling interlock and the safety interlock of external control connection separately, so connecting either of them will be all right. The definitions are shown in Table 7:

Table 7 Definition of switch interlock interface

PIN No.	Definition	Function	Note
1	key switch+	External key switch signal (on when turned on)	Client key switch signal, can be connected to the system key switch
2	key switch-		
3	Emergency stop+	External emergency stop signal (normal when turned on)	Client emergency stop signal, can be connected to the system emergency stop switch
4	Emergency stop-		
5	Water cooler interlock+	External on-off signal (normal when on)	When the product is used, the water cooler is connected separately. Signal+" and "Failure Signal-"
6	Water cooler interlock-		
7	Safety Interlock+	External on-off signal (normal when on)	Client interlock signal, can be connected to the on/off switch of the system
8	Safety Interlock-		

5) Connection reference:

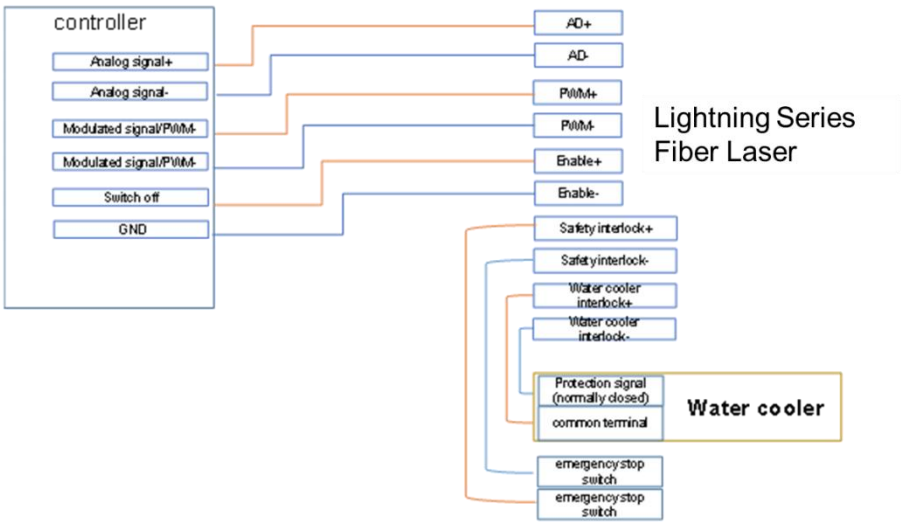


Figure 4 Connection diagram between laser and external controller (for reference)

3.6. Control Timing Program

The product control sequence can be seen in Figure 6 below.

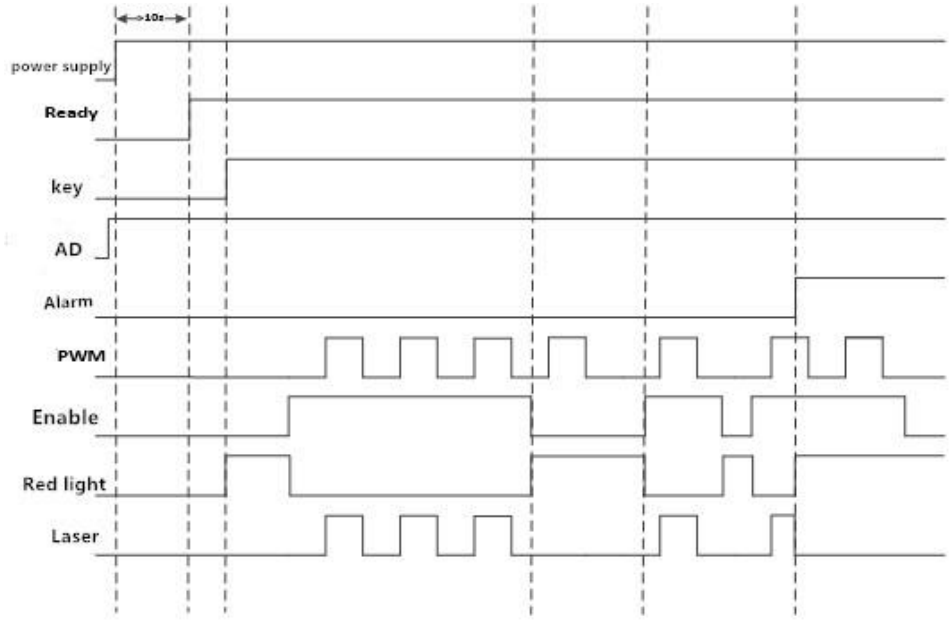


Figure 5 Control Timing Program - Continuous, Pulse

3.7. Power Requirements and Wiring Definitions

Table 8 Power Requirements and Wiring Definitions

Laser model	Power consumption	Maximum operating current	Input power	Definition of power supply wiring
BFL-CW500	1.5 kW	8A	220V/50Hz-60Hz	1-L- live wire, 2-N-Neutral wire, 3-PE-Ground wire.
BFL-CW1000	3.0 kW	18A		
BFL-CW1500	4.5 kW	21A		
BFL-CW2000	6.0 kW	36A		
BFL-CW3000	10.0 kW	16A	AC 380V/50-60Hz	L1-Live wire, L2-Live wire, L3-Live wire, PE-ground wire.
BFL-CW6000	18.0 kW	30A		

If the local voltage fluctuation exceeds ±5%, which means out of the limits required by the laser, please use a regulated power supply with appropriate power.

4. Laser Installation

4.1. Overall Size

The appearance and installation dimensions of this laser product are shown in the figures below.

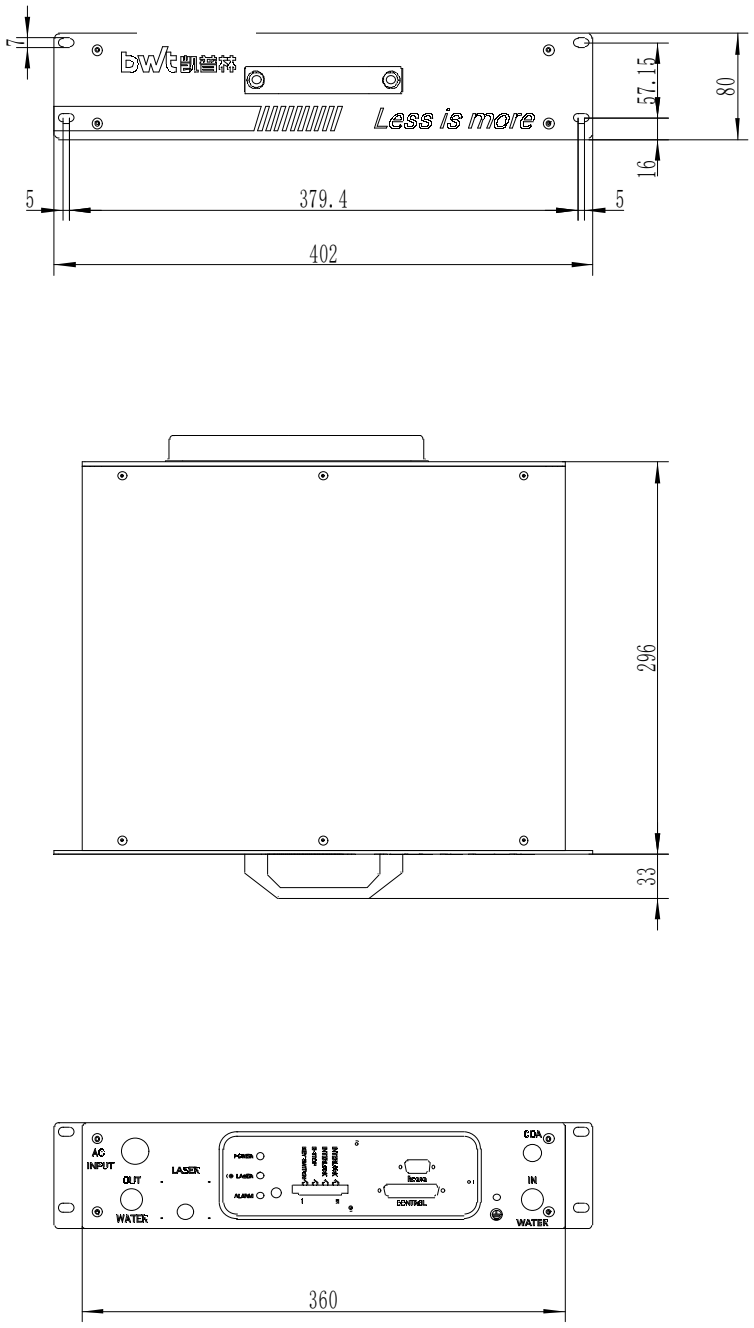


Figure 6 BFL-CW500, BFL-CW1000 and BFL-CW1500 Dimensions

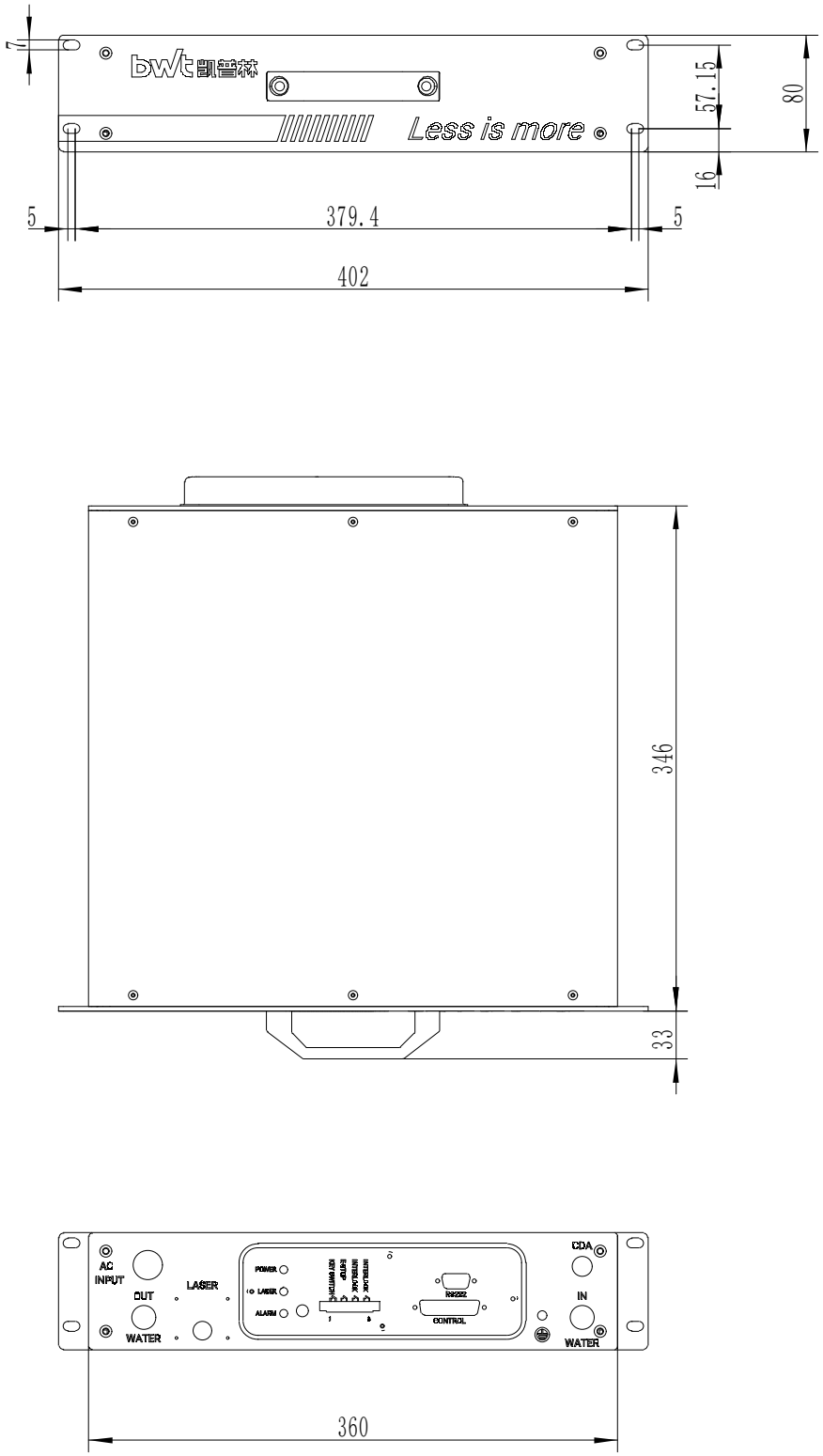


Figure 7 BFL-CW2000 Dimensions

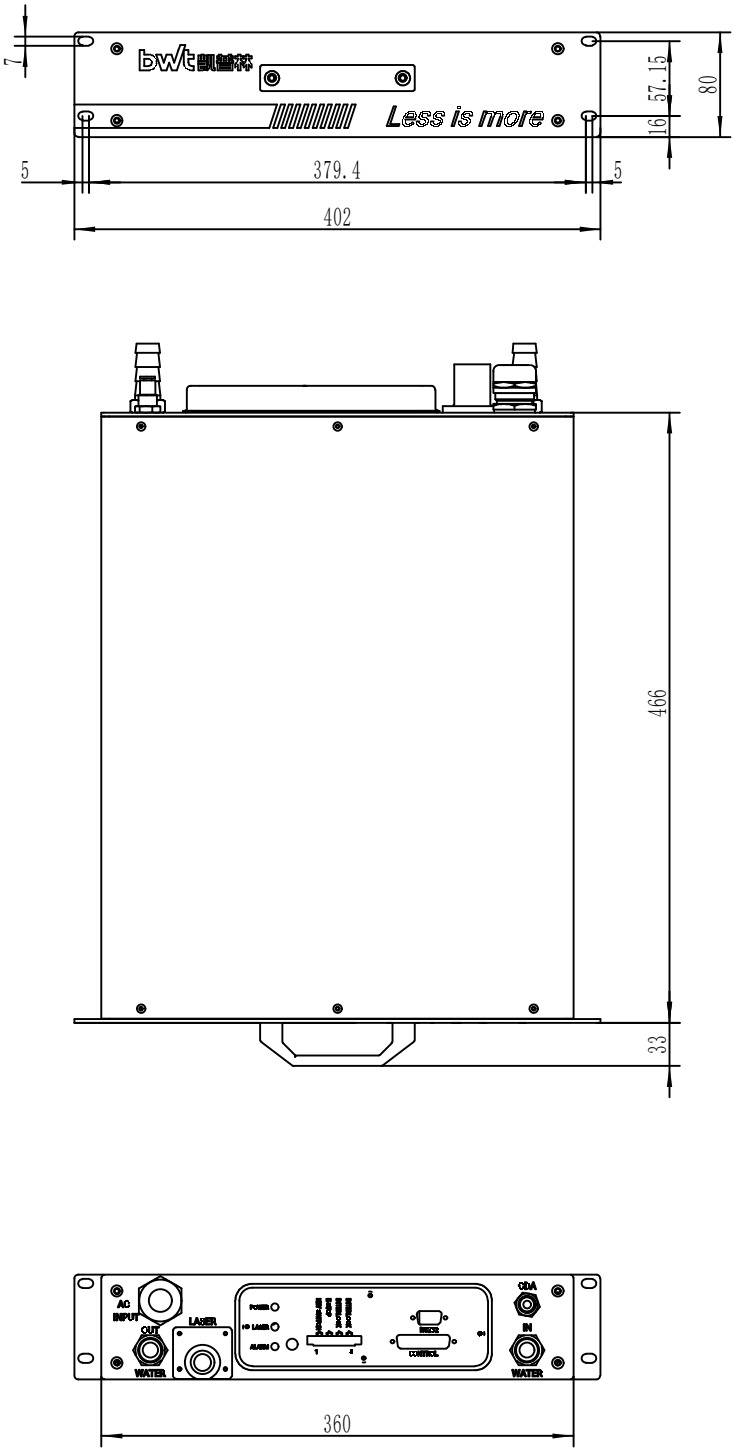


Figure 8 BFL-CW3000 Dimensions

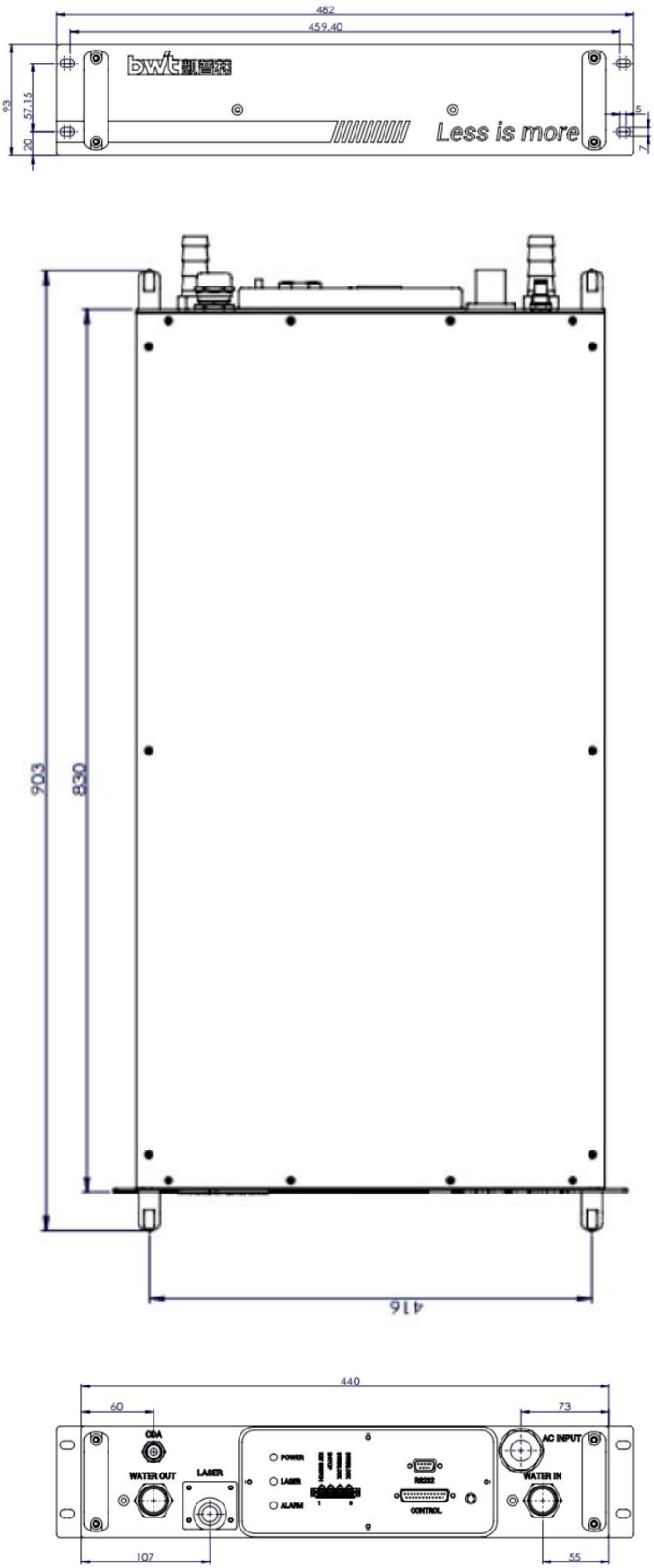


Figure 9 BFL-CW6000 Dimensions

4.2. Output Cable QBH Size

The output cable of this laser product is a self-made QBH output cable. The specific appearance and size are shown in the figure below.

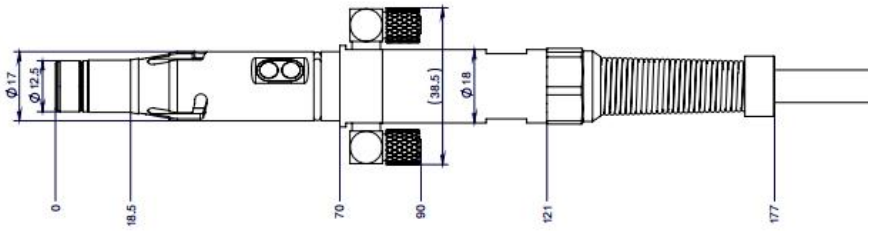


Figure 10 QBH output cable size (front view)

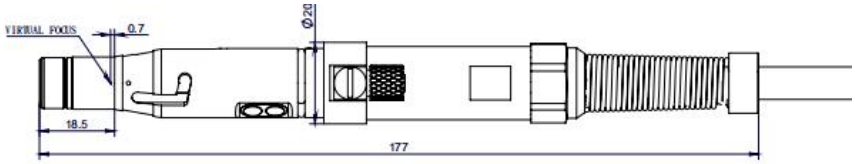


Figure 11 QBH output cable size (side view)

4.3. Installation Precautions

Before installation, please read the following precautions and follow the corresponding requirements.

1) Please check carefully whether the external circuit connections are correct and the power supply voltage meets the product requirements.
2) In order to extend product lifetime, please place the laser in a cabinet with temperature and humidity control and dust-proof function. Do not expose the laser to high temperature and high humidity environment.
3) Check whether the temperature and flow rate of cooling water meet the requirements.
4) Before installing the output head (QBH) into the processing head, please carefully protect the output head.
5) Make sure to press the emergency stop button (external) and disconnect the laser power. After removing the QBH protection cap, check whether the quartz block end surface has any contamination. Otherwise, it must be cleaned before operating the laser.

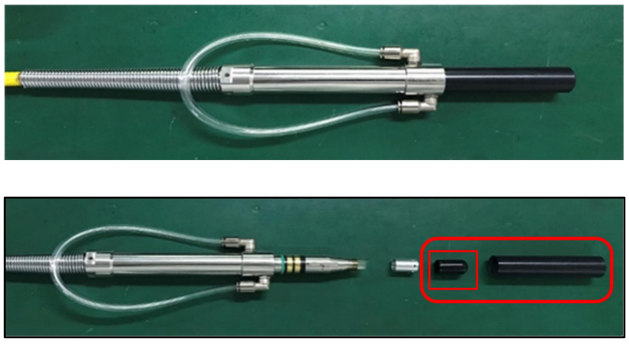


Figure 12 Remove the QBH cap

a) Clean the contaminants by using suction ball or clean compressed air form the side;
b) Referring to Figure 13 and Figure 14, use cotton swab or lens paper dipped in alcohol or acetone to wipe the surface in one direction. DO NOT blow it with your mouth. Repeat the action above to make the the quartz block end surface clean.
c) If the quartz block end surface cannot be cleaned or has some damage, please contact BTW representative immediately.

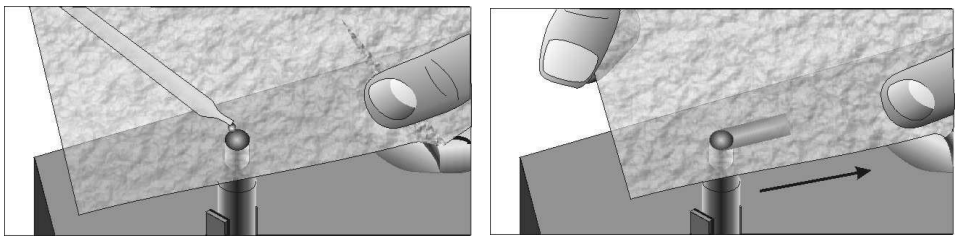


Figure 13 Clean the QBH quartz block with lens paper dipped in alcohol

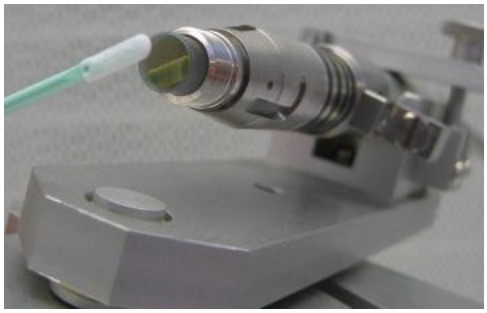


Figure 14 Clean the QBH quartz block with a cotton swab dipped in alcohol

6) The minimum bending diameter of the QBH fiber is 400mm, and the minimum bending diameter in the light-emitting state shall not be less than 600mm. Too small bending diameter will cause damage to the product.
7) When operating the laser, please wear laser protective glasses of the corresponding wavelength and protection level.
8) When the laser is turned on, the POWER (green) indicator will flash, and when the POWER (green) indicator lights up, the laser is ready to work.
9) All 3 indicators on the real panel will be flashing after the expiration of trial period. When it occurs, please contact BWT representative to update the password.
10) When using the CDA function, the air must be dry and cool that is treated by freeze dryer followed by filtering through 5μm and 0.3μm particulate filters and 0.1μm oil mist filter. The CDA temperature must be within 5-40°C, and the pressure less than 0.1MPa. CDA tube is connected to the port by 4mm or 6mm push-in connector.
11) When using the CDA function in a high temperature humidity environment, CDA must be supplied to the laser at least 30min before the laser is turn on. This will help reduce the internal temperature, avoiding any condensation. When the ambient temperature is below 10°C, the CDA function is not necessary.
12) QBH and laser processing head connection: Before the laser is powered on, it must be ensured that the QBH and the laser processing head are connected reliably. When checking the QBH quartz block or installing the QBH, it is strictly forbidden to power on the laser.
    a) Spread out the output cable, and the length should be enough to let the

processing head reach the farthest end of its movement. The cable must not be twisted in case of damage caused by long-term movement.

b) Cleaning the QBH: Put the QBH connector into a dust-free box or a clean table. Use a dust-free cloth to dip in isopropyl alcohol, and then wipe the surface of the laser processing head, QBH connector, microscope, cables and cooling water tubes near the QBH connector (as shown in Figure 15). Make sure that the area near the QBH connector is free of dust. Operators should wear rubber gloves, wash the hands, and keep the hands clean and dust-free.

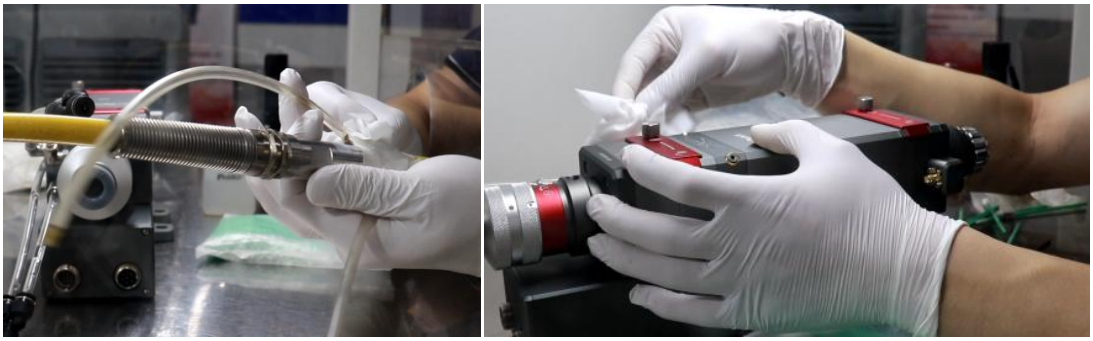


Figure 15 Cleaning QBH connector and laser processing head

c) Cleaning the laser processing head: Take out the laser processing head and put it into a dust-free box, and clean the surface of the laser head with a dust-free cloth, especially the surface of the QBH interface, the surface of the collimation protection lens module, and the surface of the focusing protection lens module , making sure there is no dust (as shown in Figure 15).

d) Insert QBH into laser processing head: Place the laser head horizontally to prevent dust from falling into it, and align the clean QBH connector horizontally with the QBH interface. Find the red dots on the QBH and the connector of laser head, align the red dots to connect them into a straight line, and plug the QBH into the laser head. Rotate the QBH locking ring clockwise to fix it, lift the locking ring up, and turn the locking ring clockwise again to complete the locking. Check whether the QBH locking ring is secure, as shown in Figure 16.

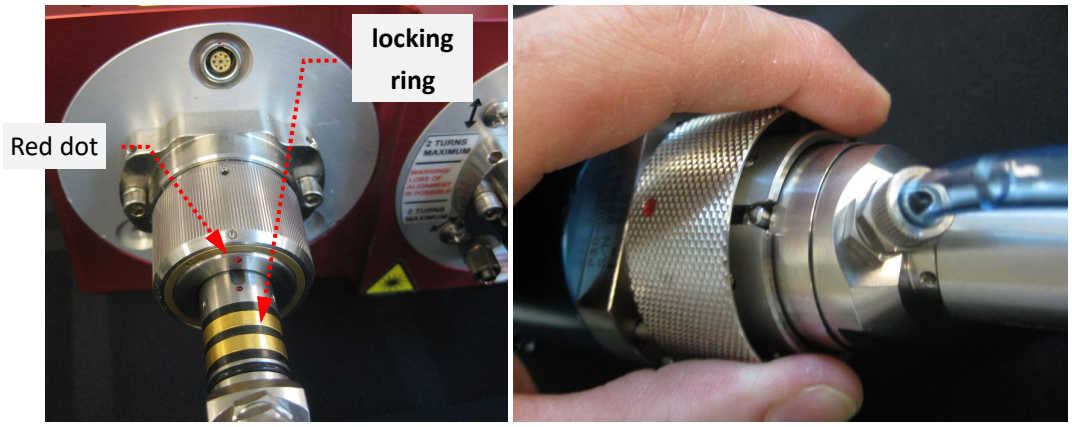


Figure 16 QBH insertion into the laser head

4.4. Cooling system requirements

For the stable and reliable operation of the laser, a dual-temperature-controlled chiller (with

both heating and cooling functions) must be used and works uninterrupted.

When installing and using the cooling system for the first time, you should check the entire water loop and joints for any water leakage. The water tubes from the chiller must be connected correctly to the ports on the laser rear panel, otherwise the laser may not work normally.

The Lightning Series fiber laser products have two places that require cooling water for heat removing, as shown in Figure 17. The first is the laser itself, and the water inlet and outlet ports are located on the rear panel of the laser. The second place is the QBH output cable.

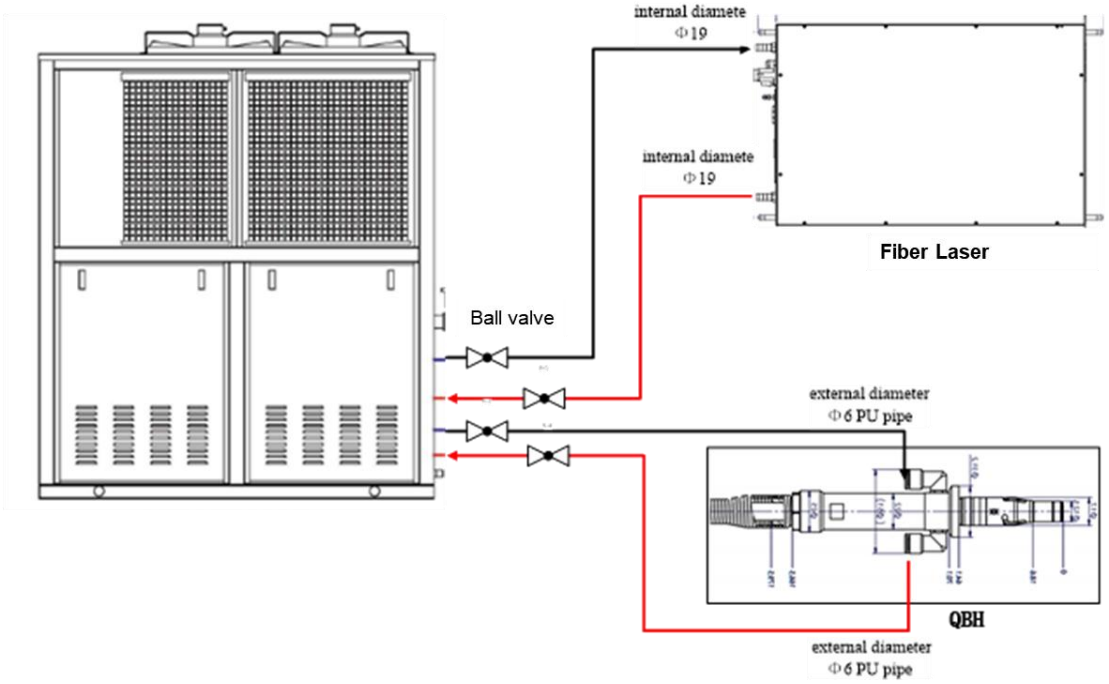


Figure 17 BFL-CW3000 Water cooling connection diagram

The specifications for the cooling system are shown in Table 9.

Table 9 Cooling System Specifications

Models		BFL-CW500	BFL-CW1000	BFL-CW1500	BFL-CW2000	BFL-CW3000	BFL-CW6000
Laser cooling	Cooling capacity	⩾1KW	⩾2.5KW	⩾3.5KW	⩾4.5KW	⩾7.0KW	⩾13KW
	Flow	>8 L/min	>10L/min	>15L/min	>18L/min	>25L/min	>55L/min
	Laser interface	Push-in connector, connected to outer diameter 12mm/inner diameter 8mm PU tube				Pagoda, inner diameter 19mm hose	Pagoda, inner diameter 25mm hose
	Pressure	⩽0.5Mpa					
	Temperature setting	25±1℃					

QBH cooling	Temperature setting	28~30℃
	Flow	1.5~2.0L/min
	Chillier water pipe	DN>8 Soft tube, length < 15m
	QBH Water cooling interface	Push-in connector, connected to PU tube with outer diameter of 6mm, length <1m

Note: The deionized water or distilled water should be used and monthly replace. Do not use tap water. The filter element in cooling system should be replaced periodically.

Adding 5-10% anhydrous alcohol to the cooling water can effectively prevent the reproduction of microorganisms, which ensures the reliable operation of the laser.

In winter, an appropriate amount of antifreeze should be added into the water to prevent the water loop in the laser and the chiller from any freezing. The freezing point of the antifreeze must be 5°C lower than the minimum ambient temperature.

Since ethylene glycol antifreeze commonly used is corrosive, it is necessary to add ethylene glycol inhibitor when replacing the antifreeze before winter.
Note: The addition amount of inhibitor is different for different brands and models. Please adding according to the instruction of inhibitor company.

When shutting down the laser for a long time, please empty the cooling water in the laser and QBH in time, otherwise the laser equipment may be damaged. When draining the water stored in the QBH, the air pressure used must be less than 0.1Mpa as higher air pressure may cause the damage of fiber.

In summer, condensation risk must be considered. Once the cooling temperature of the chiller is lower than the dew point of the environment inside the laser, the moisture in the air will condense on the electrical and optical modules, and then on laser appearance if without effective preventive actions. Therefore, once you see condensation on the laser cover, it means that condensation has occurred inside the laser, so you must power off the laser immediately, stop working and optimize the operating condition of the laser.

In order to mitigate the condensation risk, it is recommended to supply the clean and dry compressed air into the laser through the CDA port on the rear panel. The gas pressure needs to be controlled at 0.1MPa. The compress air must be moisture and oil free.

Table 10 Dew points at different ambient humidity

Ambient temperature	Dew point temperature at different relative humidity ℃								
	40%	50%	60%	70%	75%	80%	85%	90%	95%
16℃	2	6	8	11	12	13	13	14	15
18℃	4	7	10	12	13	14	15	16	17
20℃	6	9	12	14	15	16	17	18	19
22℃	8	11	14	16	17	18	19	20	21
24℃	10	13	16	18	19	20	21	22	23
26℃	11	15	18	20	21	22	23	24	25
28℃	13	17	19	22	23	24	25	26	27
30℃	15	18	21	24	25	26	27	28	29
32℃	17	20	23	26	27	28	29	30	31
34℃	18	22	25	28	29	30	31	32	33
36℃	20	24	27	30	31	32	33	34	35
38℃	22	26	29	32	33	34	35	36	37
40℃	24	28	31	33	35	36	37	38	39

Note: Laser damage caused by condensation is not covered by the warranty!

4.5. Turning On/Off the Laser

After the laser is turned on, it will enter the external control mode. In this mode, the output power is controlled by the external analog voltage signal; the laser beam output is controlled by the external enable and PWM signal.

Connect the cooling water tubes to the ports on rear panel according to the marks. The cooling system must meet the specifications and correctly be connected power supply cable with reliable grounding. Connect the external control cable to the control interface of the laser, and the other end to the corresponding control interface of the processing machine. The pins definitions are shown in Table 6. The key switch and emergency stop button (provided by client) need to be connected to the corresponding 8-pin interface on the laser rear panel, and the pin definition can be found in Table 7. The water-cooling interlock interface and the safety interlock interface are in parallel connected with the water-cooling interlock and the safety interlock of external control connection separately, so connecting either of them will be all right.

Before powering on the laser, please check if the laser meets the following requirements:

1) The flow rate and temperature of the water cooling system meet the requirements;
2) Correct connection of power supply and control cable, respectively. The power supply voltage meets the product requirements;
3) The emergency stop button is released;
4) The interlock signal of the laser is connected in series with the output fault signal of the chiller and the door switch signal to better protect the laser and the operator safety;

Power on the laser. The POWER indicator flashes, and the laser starts the self-checking program. The laser can receive analog signals after 5 seconds.

In the external control mode, when the external enable signal is provided as required, the laser can output the laser beam according to the external PWM high level signal and analog input signal. The output power is 10-100%, corresponding to 1-10V analog input signal.

When the laser fails and needs to be power off, waiting for 20s after power off and then power on again.

4.6. Operating Software

For the installation and usage of operating software on PC, please refer to the software manual.

4.7. Bluetooth APP

For the installation and usage of the Bluetooth App, please refer to the Bluetooth APP manual.

5. Troubleshooting

The laser has different sensors inside to measure optical path, temperature, current, input voltage, QBH, etc. If there is an abnormality during the laser running, the fault will be displayed in the alarm area of operating software.

The common faults and solutions are listed in Table 11.

Table 11 Common faults and solutions.

NO.	Fault	Description and Solution
1	Circuit breaker tripped	Check whether the power cable is connected correctly.
2	Interlock - Water Cooling Failure	The chiller is powered off or shut down due to the failures. Check the chiller and make it work well.
3	QBH	QBH is not connected to the processing head. Connect QBH to process head, and then power on the laser.
4	Emergency stop alarm	Interlock signal is open or the emergency stop is pressed. Make sure the interlock signal is close. Recover the emergency stop button. Then power on the laser.
5	Password alarm	Password has expired when the 3 lights on front panel flash.. Contact BWT representative for new password.
6	Optical path 1, 2, 3, 4	Optical path alarm. Re-power on the laser and then enable the red guide light. If it is normal, turn on the laser. If no red guide light output, contact BWT representative.
7	Temperature failure	Cooling water flow rate does not meet the requirement. Set the chiller flow rate based on specification required and then turn on the laser.
8	Temperature 1, 2, 3, 4	Flow rate or temperature of cooling water does not meet the requirements. Set the flow rate and temperature to meet the specification required.
9	Drive overcurrent	Drive circuit output overcurrent alarm. Check the analog signal and make sure it is smaller than 10.5V.
10	Overvoltage protection	Power supply voltage is out of range. Make sure the power supply voltage is in the range of ±10%.
11	Overheat	Switching power supply is overheat. Make sure the operating temperature meets specification. Make sure the chiller works well with flow rate and temperature satisfying the specification.
12	AC input failure	Power supply is out of the range. Make sure the power supply satisfies the specification.
13	Light Path Alarm Lock	Optical path is locked due to consecutive failures reaching the set times. Contact BWT representative.

When a fault occurs and the laser needs to be powered off, please wait for about 20s after the laser is powered off, and then power on the laser again for subsequent operations.

If the fault cannot be fixed after above actions, please contact BWT representative.

6. Warranty and Repair

6.1. General Warranty

BWT provides warranty for all products manufactured within the warranty period in the contract, and has the right to selectively repair or replace any product with material or technical problems during the warranty period.

6.2. Limitation of Warranty

Products and components are not covered by the warranty in the following cases:

1) Damages due to tampering, opening, disassembly, misinstallation or modification by person not from BWT;
2) Damage caused by improper use, negligence or accident;
3) Damage caused by operating the laser beyond the scope of technical specification;
4) Indirect damage due to the failure of the customer's software or interface;
5) Damage caused by improper installation, maintenance or other improper operation which is not stated in the manual.

It is the customer's responsibility to understand the above information and use the laser in accordance with the user manual and specifications, otherwise the failure will no longer be covered by the warranty.

6.3. Service and Repair

In the warranty period, the client must notice BWT within 30 days of after the fault occurs. BWT has not authorized any third party partner to repair the product or component.

All products that need repairing or replacing repaired or replaced must be delivered in the original packaging box provided by BWT, otherwise BWT has the right not to provide free repair or replace.

When the client receives BWT products, please check whether the product is intact or not in time. If there is any abnormal situation, please contact the delivery company and BWT in time.

Please do not ship the product back if without communicating and confirming with BWT representative, otherwise it will be rejected and returned, and the client will.

BWT keeps upgrading and optimizing the products as to improve the performance. The information in the manual may be changed without prompt notice. All technical specifications are subject to the terms of the contract.

The warranty and service terms above are only for reference, and the official service and warranty content is subject to the agreement in the contract.