Serial No_____

IBP - YAG

Users Guide

Version No. 1.0

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Chapter 1 General Information

The **IBP-YAG** system is a precision instrument designed to measure critical parameters of High Power Industrial type laser beams. As is indicated by the name it is optimized for 1064 nm YAG lasers.

The **IBP-YAG** includes a measurement head for use on lasers of greater than 2 Watts and up to 4000 watts. The instrument is designed to measure collimated beams only, any focusing optics must be removed before attempting any measurements.

There are three Models of **IBP-YAG**.

IBP-YAG for beam sizes from 1 to 4 millimeters.

IBP-YAG for beam sizes from 4 to 16 millimeters.

IBP-YAG for beam sizes from 8 to 30 millimeters.

The **IBP-YAG** measurement head is used in conjunction with the Spiricon Inc. software package **LBA-PC**, which provides a complete, easy to use, highly graphical interface.

Each instrument is shipped with a serial number keyed setup file that contains specific calibration information used by the software application.

Appendix C contains specific calibration information for your particular **IBP-YAG** unit.

1.1 How To Use This Manual

We suggest that you read this manual before setting up your **IBP-YAG** to become familiar with the setup and use procedures. We also suggest that you read the software manual to become familiar with the controls and the measurements provided.

Chapter 1 contains general Information and specifications of the **IBP-YAG**.

Chapter 2 contains setup and operating instructions.

Chapter 3 contains maintenance and storage information.

1.2 IBP System Components

The **IBP-YAG** system consists of the following components:

A measurement head that is placed in the laser beam's path to attenuate the laser beam to a measurable level and convert the laser's energy profile into an electronic video signal. A water-cooled beam dump absorbs the excess laser energy.

A Computer system with a Spiricon Inc. Frame Grabber Card and an LBA-PC software package installed. The frame grabber card controls the Measurement head and digitizes the video signal.

An optional cart system with a built in heat exchanger and computer is available to make the system more mobile.

If the system was purchased complete, the software and the frame grabber card will be installed in the purchased computer. All files with specific hardware information will have been installed. The **IBP-YAG** will have been connected and tested.

If the system was purchased to be used with an existing computer, the software and the frame grabber card will need to be installed in the users computer before connecting the IPB-YAG.

1.3 Specifications

1.3.1 Operating Limits

Beam Diameter:	1 to 4 mm	model **IBP-YAG 4mm**
	4 to 16 mm	model **IBP-YAG 16mm**
	8 to 30 mm	model **IBP-YAG 30mm**
Beam Power:	4000 Watts Max	
Pulse Rate:	CW to 60Hz	
Wavelength	1064 nm	

1.3.2 Damage Limits

Optics:	100 kiloWatts/cm²
Beam Dump:	4000 Watts average power

Operating the measurement head with incorrect attenuation settings may damage the video sensor even though the input beam is below the damage threshold of the optics

1.3.3 Environmental

Storage Temperature:	-30°C to +65°C (-22°F to 150°F)
Storage Humidity:	95% max. (non-condensing)

Note: When storage temperature may drop below 5°C, all cooling water must be removed from the unit to prevent damage due to freezing.

Operating Temperature:	10°C to 50°C (50°F to 122°F)
Operating Humidity:	90% max. (non-condensing)

Note: In high humidity conditions where the cooling water may be chilled to below the dew point, dry air purge must be provided to prevent condensation from occurring inside the unit.

1.3.4 Electrical Requirements

Measurement Head:	12VDC @ 500 mA

This power is supplied from the computer, through the camera cable.

1.3.5 Facilities Requirements

Purge Gas: (Optional)	5 liters/min (.18 STD cubic feet/min) of nitrogen or oil free air with a dew point 10°C lower than the cooling water temperature.
Cooling Water:	3 liters/min (.8 gallon/min), 200 kPa (30 psi) max. See appendix A

1.3.6 Physical Dimensions

Weight: 12 kg (26 lb)

Dimensions: 24 x 50 x 32 cm (9.6” x 19.5” x 12.6”)

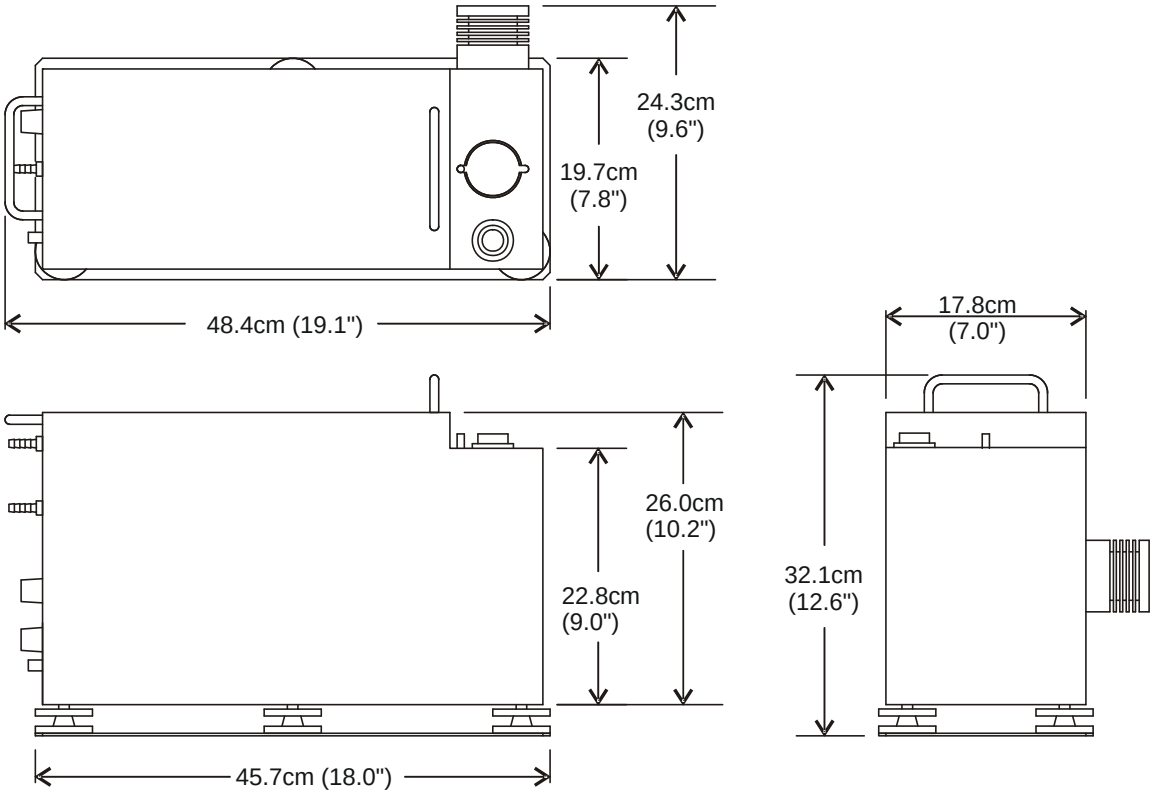


Figure 1-1 Overall Dimensions

1.4 Connections and Controls

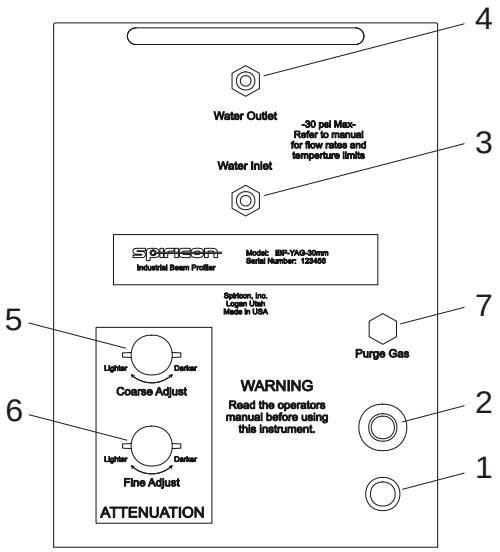


Figure 1-2 The IBP-YAG rear panel

1. Power

   Power is supplied to the **IBP-YAG** from the computer via the LBA-7xx frame grabber card and the supplied cable.

2. Video

   A standard BNC cable to connect the **IBP-YAG** to the LBA-7xx frame grabber card.

3. Cooling Water Inlet

4. Cooling Water Outlet

   These fittings are standard barbed hose connectors for 5/16” ID Hose.

   Refer to appendix A for water flow and temperature requirements.

5. Attenuation – Coarse

6. Attenuation – Fine

   These knobs will increase/decrease the attenuation of the sampled beam.

7. Purge Gas

   Optional dry air / nitrogen purge.

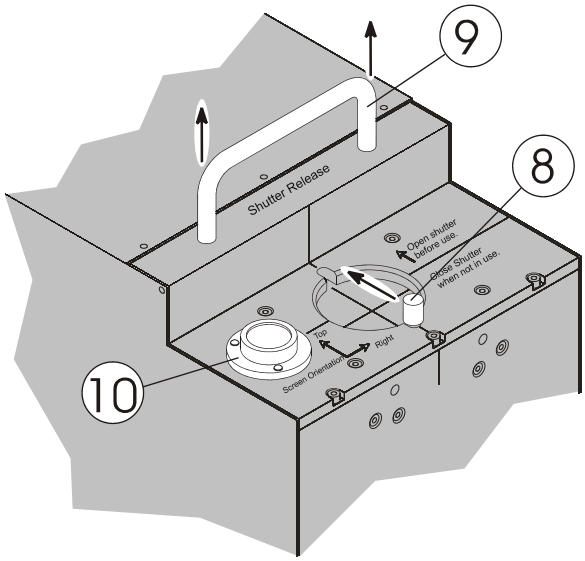


Figure 1-3 The IBP-YAG top panel

8. Beam Input Aperture

   Slide the knob toward the back as indicated to open the shutter. Leave the shutter closed except when the laser is directed into this opening.

9. Shutter Release

   Lift up on the top handle to close the shutter.

10. Bubble Level

11. Leveling Adjusters

    Use the leveling adjusters to level the instrument as indicated by the bubble level.

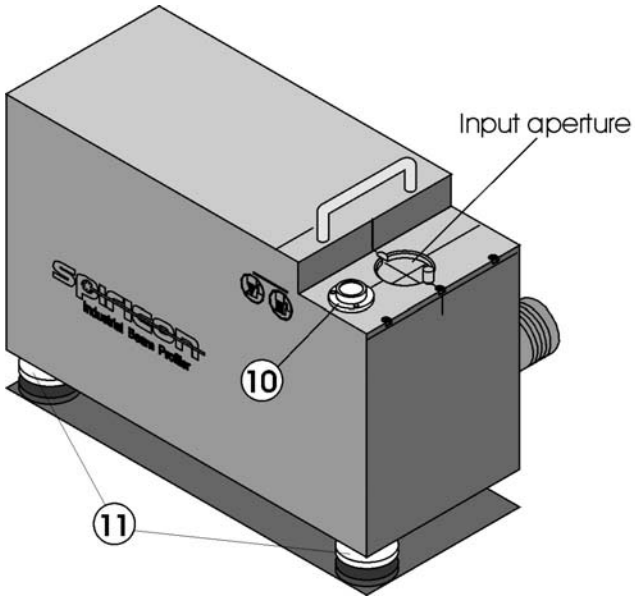


Figure 1-4 IBP-YAG leveling adjustments

1.5 Safety

The **IBP-YAG** is intended for use with high power YAG lasers. Precautions must be taken to prevent accidental exposure to reflected and scattered beams. The safe use of high power lasers requires that everyone near a laser be aware of the dangers involved.

1.5.1 Precautions for safe operation

- Keep the open beam path as short as possible. When practical, enclose the entire beam path or set up shields to block reflections.
- Wear the appropriate protective eyewear when operating the laser.
- Do not set up the **IBP-YAG** or any optical components at eye level.
- Do not wear reflective jewelry or watches while operating this equipment to reduce the possibility of causing accidental reflections.
- Establish a controlled area around the laser while in operation. Post prominent signs near the laser operation area and limit access to individuals who are trained in laser safety.
- Use an IR detector or energy detector to verify that the laser is off before working on or moving the equipment
- Keep the ambient light levels around the laser as high as practical. This will cause eye pupils to constrict and reduce the possibility of hazardous eye exposure.

Chapter 2 Setup and Operation

2.1 Unpacking the equipment

The IBP-YAG has been carefully packed for shipment. If the container arrives damaged in any way, please contact the shipper. Inspect each item as it is unpacked, looking for dents, scratches or other damage. If damage is evident , immediately file a claim against the carrier and notify Spiricon.

2.1.1 Optional Cart system

If ordered, the cart system will be shipped separately and will include separate unpacking and setup instructions.

2.2 Setting up the IBP-YAG

2.2.1 Frame Grabber and Software Setup

The IBP-YAG operates in conjunction with Spiricon's LBA-PC software program and LBA-7xx frame grabber. If the IBP-YAG was ordered with a computer system, the software and frame grabber card will already be installed in the computer. If you are installing the frame grabber yourself, please refer to the LBA-PC Operator's Manual for instructions.

2.2.2 Connections

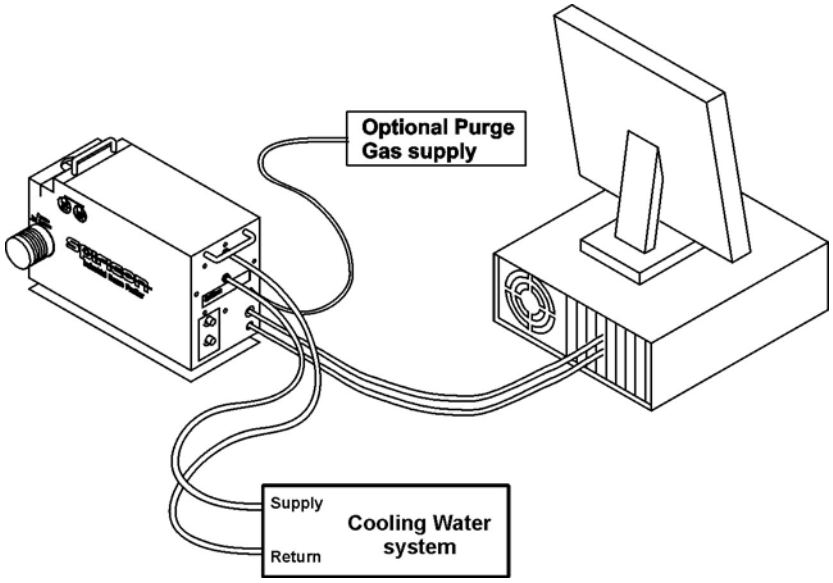


Figure 2-1

2.2.2.1 Cooling Water connection

See Figures 1-2 and 2-1

The IBP-YAG requires a reliable source of cooling water for proper operation. This can be a re-circulating heat exchanger, chilled facilities cooling water, city water, etc.

Connect the “Cooling Water In” fitting to the cooling water source. Connect the “cooling water out” to a return or a drain depending on your system. These fittings are standard barbed hose connectors for 5/16” ID Hose.

A set of cooling hoses are included with the IBP-YAG. If extension or replacement of the cooling hoses is required, replace with the same type.

Refer to appendix A for cooling water requirements and flow rates.

2.2.2.2 Purge Gas connection

See Figures 1-2 and 2-1

A purge gas connection is available on the IBP-YAG. The use of purge gas will help keep the optics cleaner and increase the effective lifetime of the primary sampling optics. If the IBP-YAG will be operated in high humidity conditions or where the cooling water will be near the Dew point of the ambient air, The Purge gas is required to prevent condensation on the optics and subsequent damage.

To make this connection, remove the plug from the back of the instrument and replace it with an 1/8” NPT hose fitting. Connect to a supply of clean dry nitrogen or air at about 5 psi.

2.2.2.3 Power and Video connection

See Figures 1-2 and 2-1

Connect the supplied cables between the Frame Grabber Card in the computer and the IBP-YAG.

2.3 Frame Grabber Setup

2.3.1 Refer to you LBA-PC Operators Manual

Follow the equipment setup section, Chapter 2, in the supplied LBA-PC Operator’s Manual. This will instruct you on how to install the LBA frame grabber card that came with you IBP system. When you’ve completed Step 3, which installs LBA-PC software, return here to this manual to start operating with the IBP head.

2.3.2 Starting LBA-PC for the first time

Before running LBA-PC application, you may want to take a few moments to examine the LBA-PC operators manual and the contents of the **Readme.txt** file included with the software. This will inform you of any last minute changes or errata to LBA-PC application.

From the Windows Start menu,

Select: **Start | Programs | Spiricon | LBA-PC |** Run **LBA-PC.**

2.3.3 Choose an initial Setup

The first time you start LBA-PC, it will open in a default configuration. To make it operate correctly with your IBP hardware you will need to select a configuration (.cfg) setup file that matches the model of your IBP optical system.

Two setup files have been provided with each IBP-YAG measurement head. The setup files contain calibration information and are unique to each IBP-YAG head. The setup files are associated with the serial number of the IBP-YAG hardware in the form:

~YAG<Serial number>_CW.cfg or

~YAG<Serial number>_PULSED.cfg

For the initial checkout, select the '**CW**' setup file. If you have more than one measurement head, make sure that you select the file with the serial number matching the IBP hardware.

To select the configuration file click: **File**, **Restore Config…**, and the …**CW.cfg** file shown.

2.3.4 Verify that the system is operating.

Click **Start!** If everything is working correctly LBA-PC will automatically start collecting data from the detector and displaying it on the screen. Since we aren't using a laser yet, the Beam display window will be dark.

The first indications you will have that frames are being accepted from the detector are the displayed results on the left side of the screen and the frame counter in the bottom right hand corner of the screen. If the numbers in the results are changing and the frame counter is incrementing, then LBA-PC is accepting frames from the detector, even though no beam is shown on the display.

If the software does not appear to be collecting frames, verify that LBA-PC is operating in CW mode. Click **Stop!**. Open the **Options, Capture**… dialog box and under **Method** select the **Continuous** option. Then click **OK**.

If there still is no indication of operation, verify in the lower status bar that the Video "V" enunciator is illuminated Green. If this indicator is red, it is an indication that the frame grabber is not seeing an operating camera. In this case, refer to the troubleshooting sections of the software manual or contact the Spiricon Service Dept.

2.4 Prepare the laser for collecting data

Follow these steps to prepare the laser for taking measurements.

- Verify that the operating settings for the laser will cause the power levels and beam size to fall within the ranges indicated in Appendix B. You may want to use a lower output power while aligning the IBP-YAG to the laser
- Remove any focusing optics from the delivery system of the laser.

> The IBP-YAG is designed to operate with collimated lasers only. Using a focused Laser beam with the IBP-YAG will damage the instrument.

- If the laser is equipped with assist gas, temporarily disable the gas delivery.
- The computer system must be set up close enough to the laser so that the cables will reach to the IBP-YAG. Place the IBP-YAG on the work surface with the input aperture under the beam delivery tube. Route the hoses and cables out of the way. Make sure that the controls on the back of the IBP-YAG are accessible.
- Level the IBP-YAG using the leveling adjusters and bubble level. Center the input aperture of the IBP-YAG in the beam path. If the laser is equipped with a visible aiming beam, use it on the

alignment target on the shutter to center the beam. Note: The alignment beam can not be viewed by the instrument.

- Take any safety measures necessary to avoid exposing personnel to the laser beam. Refer to section 1.5 for safety recommendations.
- Make sure that the purge air and cooling water are running. In high humidity conditions or when using chilled cooling water, run the purge air for 10 min before starting the cooling water.
- Set fine attenuation knob to the minimum position by turning the knob clockwise until it stops. The attenuation knobs each have 5 positions separated by 180° (1/2 Turn). A detent will be felt as you turn the knob to the correct position. Set the coarse attenuation knob to the position indicated by the table of attenuation settings in appendix B for the anticipated beam diameter and power.

2.5 Begin data collection

- If the program is not already running, start the LBA-PC software on the computer by Clicking on the Windows '**Start**' button, then '**Programs**', '**Spiricon**', '**LBA-PC**', and 'run **LBA-PC**'. When the program starts, verify that the correct configuration file is being used... the name of the configuration file in the title bar should match the serial number of the IBP-YAG head.

  Click **Start!** and the LBA software will begin capturing video frames from the IBP-YAG immediately. If your laser is pulsed, the image may be flashing on and off in the display. This is normal when the software is in Continuous Capture Method mode.

- Open the Shutter on the IBP-YAG by sliding the knob on the input aperture towards the back of the instrument.

  > Never attempt to block the laser beam by closing the IBP-YAG shutter. The IBP-YAG shutter is not designed to handle high energy beams and doing so will damage the instrument.

- Start the Laser
- The LBA-PC should immediately change to display the laser beam hitting the detector. If the alignment of the IBP-YAG and the attenuation settings were close, you should see the image of the laser beam on the display
- Adjust the attenuation: Decrease or increase the coarse attenuation until the beam is just saturated (portions of the displayed beam will turn white when saturated). Increase the fine attenuation until beam is just below saturation.
- Center the Beam image in the display by adjusting the leveling adjusters and/or moving the instrument to center the beam in the input aperture.

2.5.1 Troubleshooting

If the beam image is not visible when the laser is started, the instrument may be too severely misaligned for the laser energy to reach the detector, or the attenuation may be set too high.

- Verify the alignment of the instrument. Use an IR detector to verify that the laser beam enters the center of the IBP-YAG input aperture. If the laser beam is not vertical when it exits the delivery system, you may need to adjust the orientation of the instrument to match.
- Verify the attenuation settings. Verify that both of the attenuation knobs are in detent positions. Verify that the coarse attenuation knob is not in the highest (fully clockwise) position. Check the actual output of the laser with a power meter.

2.6 Taking measurements

This section contains the basic procedures to obtain accurate results from the IBP-YAG. See the software manual for more information.

2.6.1 Software Settings

Select the Computations dialog box and select the calculations that you wish the software to perform. In addition to the calculation settings, make sure that 'Laser Type' matches your laser; CW or Pulsed. Refer

to the software manual for more information on the calculation and monitoring capabilities of the software.

2.6.2 Calibration

Before attempting to take accurate measurements with the IBP-YAG, the instrument must be calibrated with no energy on the detector. The following steps will calibrate the sensor for maximum accuracy.

1. If the software is collecting data Click on the **Stop!** menu item.
2. Block the laser energy from reaching the detector by turning the coarse attenuation knob counterclockwise until it stops, by closing the laser's shutter, or by turning the laser off.

> Never attempt to block the laser beam by closing the IBP-YAG shutter. The IBP-YAG shutter is not designed to handle high energy beams and doing so will damage the instrument.

3. Click on the '**Ultracal**' menu item. The software will perform a calibration cycle to compensate for background energy and shading in the detector. This process may take up to 30 seconds.
4. After the Ultracal process is finished, click **Start!** to begin collecting data. If you turned the laser off, turn it back on. If you closed the laser's shutter, open it now. Turn the coarse attenuation knob back to it's previous position. After a calibration cycle, you may need to make a minor adjustment to the attenuation to return the sensor to below saturation levels.

Chapter 3 Maintenance and Storage

3.1 Storing and transporting the IBP-YAG

If the IBP-YAG will be stored for an extended time, transported, or will be exposed to freezing temperatures, the cooling water must be drained to avoid damage.

Disconnect the electrical and signal cables from the IBP-YAG. Disconnect the Cooling water lines and drain the water into a collection basin. To completely drain the water from the instrument, it will be necessary to invert the instrument so that the water outlet is lower than the inlet.

3.2 Cleaning and Replacing Optics

The Primary sampling mirror must be kept clean and dust free to avoid damaging the coating. Any contamination will increase the absorption of laser energy and lower the damage threshold when exposed to a high power beam

> To reduce the risk of damage to the IBP-YAG optics and minimize the amount of cleaning required, keep the shutter closed whenever not actually taking measurements. Using Purge Air in the IBP-YAG can also reduce the amount of dust that collects on the sampling optics.

3.2.1 Cleaning the sampling optics

To remove small amounts of dust from the primary sampling mirror, open the shutter and use photographic type canned air and lens brushes to carefully clean the sampling mirror. Use care to avoid transferring dust deeper into the instrument. Using purge air during this procedure will greatly reduce the possibility of transferring dust to other optical elements.

> Avoid using shop air to clean optics because it often contains water and/or oil. These can create absorbing films on the optics and destroy the coatings.

If this procedure does not remove the debris, the unit will need to be partially disassembled to remove and clean the optics. Follow the procedure in the next section to disassemble and remove the primary optics for cleaning.

Great Care should be taken when handling optics. Observe the following precautions to reduce the chance of damage:

- Wear powder free rubber/latex gloves or finger cots when handling optics. Skin oils can contaminate the coatings and may cause permanent damage.
- Always place optics on lens tissues for protection.
- never place optics on hard or rough surfaces. The coatings are easily scratched.
- Use high quality lens tissues. The use of reagent grade acetone and isopropanol is recommended.

Cleaning procedure:

1. Blow off the surface of the optic with an air bulb or photographic type canned air. Blow as close to parallel to the optic as possible to push the contaminates off the glass. This step should remove any large particles from the surface. If the surfaces are still contaminated, continue to step 2

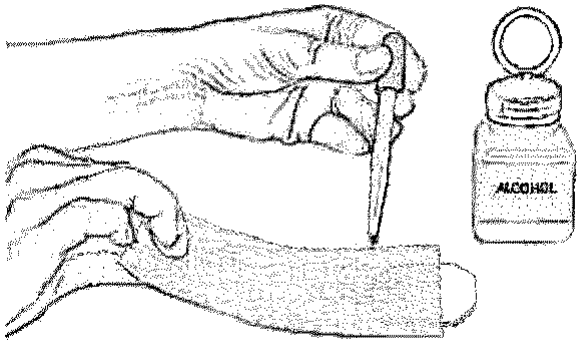


Figure 3-1

2. Lay a piece of lens tissue flat on the optic. Using an eyedropper, squeeze a few drops of acetone or isopropanol onto the lens tissue, wetting the entire surface of the optic. Without lifting the lens tissue, drag the tissue across the optic just fast enough so that the solvent evaporates behind the tissue. Discard the lens tissue after one use. Reusing the tissue will just transfer the contaminants back onto the optic.
3. Inspect the optic. If the surface is not clean, repeat Step 2. If a contaminate is not removed in two or three attempts, it is possible that the surface has been permanently damaged. If it is necessary to repeat step 2, always drag in the same direction.

3.2.2 Removing and Replacing the sampling optics

Replacement of the sampling optics involves partial disassembly of the IBP-YAG. The following procedure will allow access to the sampling optics for cleaning or replacement.

Remove the Leveling Plate to allow access to the bottom of the instrument. The Leveling Plate may be removed by carefully prying down on the plate next to each of the leveling feet The studs of the leveling feet will pop out of the pads attached to the plate.

Remove the screws in the cover and remove the cover by sliding back and up.

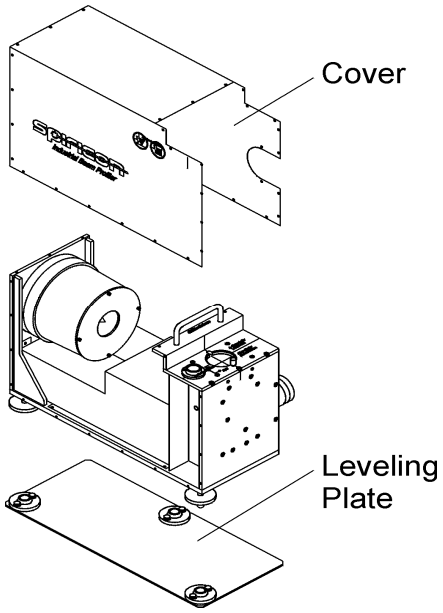


Figure 3-2

Remove the indicated screws to release the front panel. Remove the thumbscrew and spacer from the shutter.

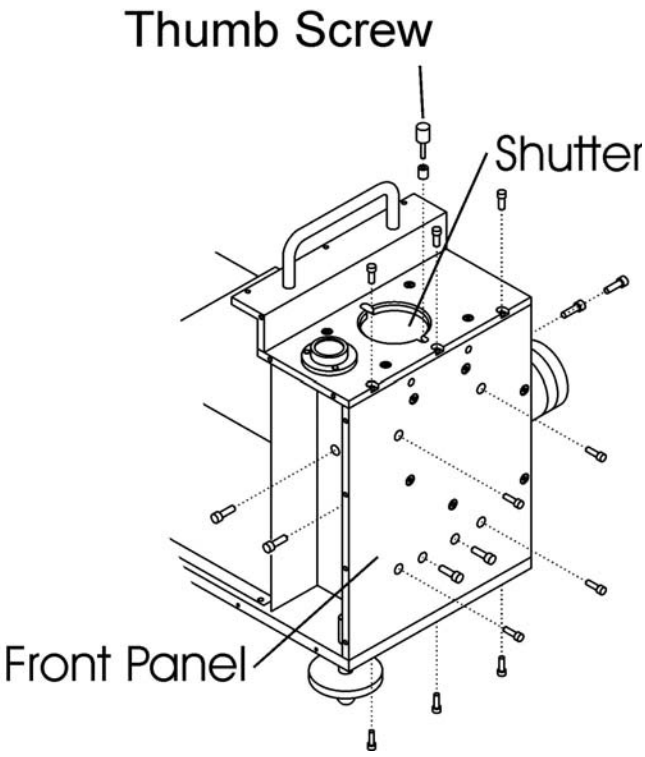


Figure 3-3

Slide the front panel and shutter away from the instrument. The shutter is attached to the front panel with 2 springs. Do not let the shutter or springs touch the sampling mirror.

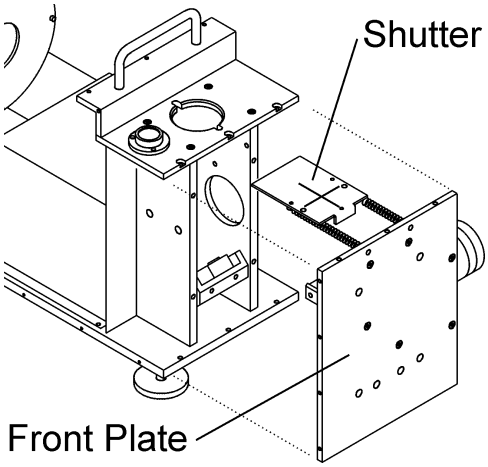


Figure 3-4

The Mirrors may be removed by removing 3 screws and clamps. After cleaning the mirrors replace them on the mirror holders and secure with the original screws and clamps. The mirrors must be

replaced with the mirrored side UP. The mirrored side is not always easy to identify, it is indicated with an arrow mark on the edge of the mirror.

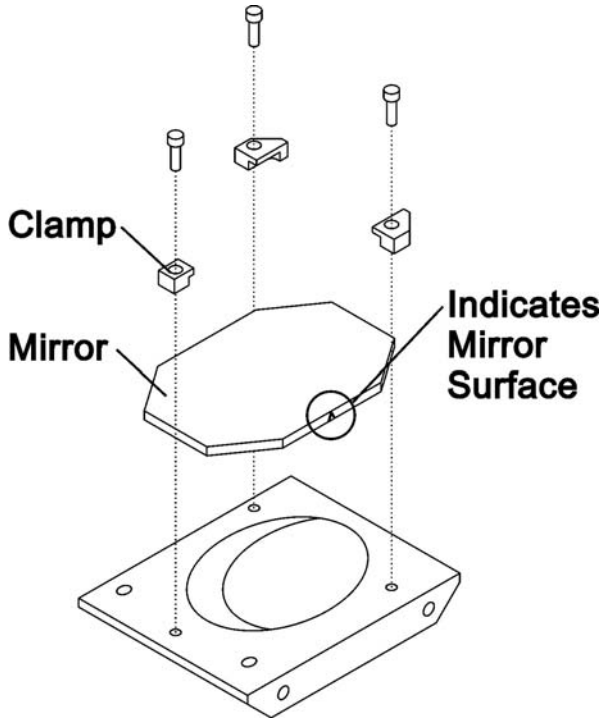


Figure 3-5

Before reassembly make sure that all mechanical and optical surfaces are clean and free of dust. Reassemble the instrument by following the steps in reverse order.

Appendix A Cooling Water Requirements

The **IBP-YAG** needs a reliable flow of cooling water to dissipate the energy of the laser. The required cooling flow is dependant on the laser power level and the initial coolant temperature.

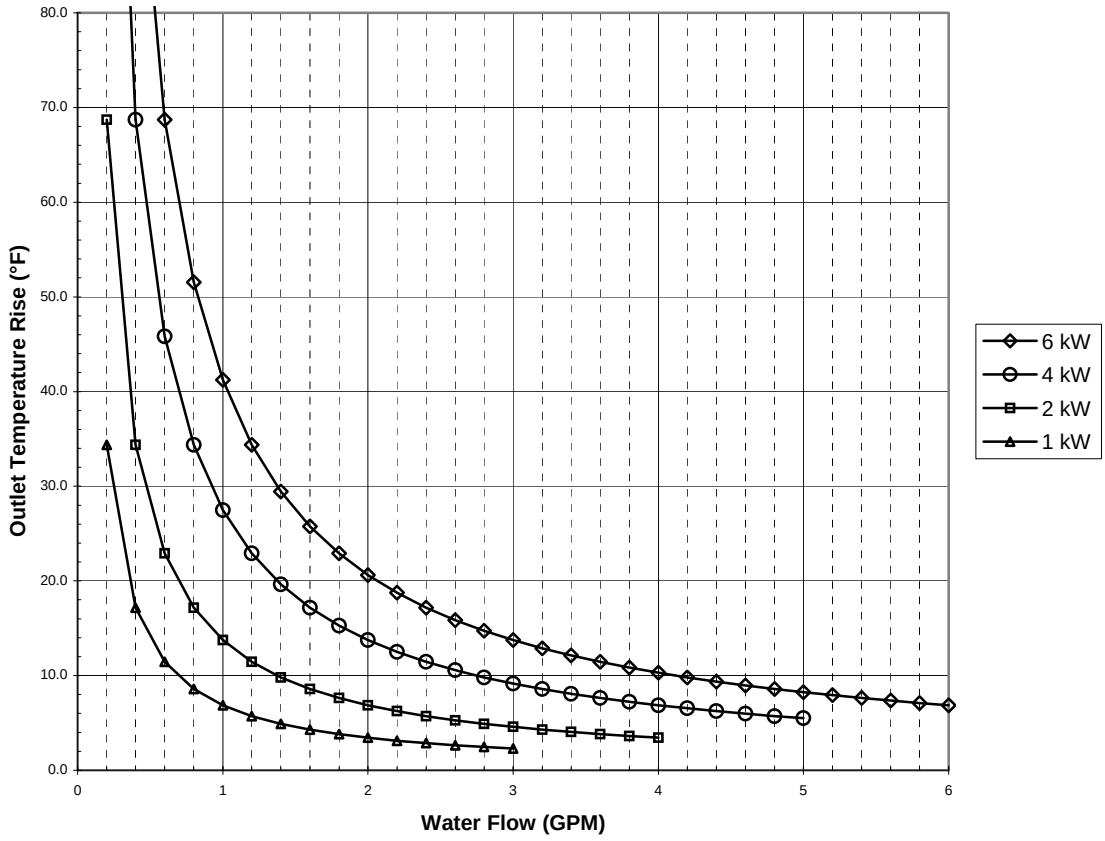
*Note: If the inlet cooling water is chilled to below the dew point, condensation will occur inside the unit. To prevent water damage to the measurement head, purge air **must** be provided*

DO NOT USE DE-IONIZED (DI) WATER. DI WATER WILL QUICKLY CAUSE SEVERE CORROSION OF ALL COMPONENTS THAT CONTACT THE WATER.

Water Pressure not to exceed 200 kPa (30 psi).

To maintain a safe working environment, do not allow the outlet water temperature to exceed 49°C (120°F).

The chart and table below indicate cooling flow requirements for various laser power levels.



Cooling Water Outlet Temperature °C (°F)

Initial Temperature: 27°C (80°F)

Water Flow		Power Input (kW)			
liter/min	Gal/min	1.0	2.0	4.0	6.0
0.8	0.2	45.8 (114.4)			
1.5	0.4	36.2 (97.2)	45.8 (114.4)		
2.3	0.6	33.0 (91.5)	39.4 (102.9)	52.1 (125.8)	
3.0	0.8	31.4 (88.6)	36.2 (97.2)	45.8 (114.4)	
3.8	1.0	30.5 (86.9)	34.3 (93.7)	41.9 (107.5)	49.6 (121.2)
4.5	1.2	29.8 (85.7)	33.0 (91.5)	39.4 (102.9)	45.8 (114.4)
5.3	1.4		32.1 (89.8)	37.6 (99.6)	43.0 (109.5)
6.1	1.6		31.4 (88.6)	36.2 (97.2)	41.0 (105.8)
6.8	1.8		30.9 (87.6)	35.2 (95.3)	39.4 (102.9)
7.6	2.0		30.5 (86.9)	34.3 (93.7)	38.1 (100.6)
8.3	2.2		30.1 (86.2)	33.6 (92.5)	37.1 (98.7)
9.1	2.4		29.8 (85.7)	33.0 (91.5)	36.2 (97.2)
9.8	2.6		29.6 (85.3)	32.5 (90.6)	35.5 (95.9)
10.6	2.8			32.1 (89.8)	34.8 (94.7)
11.4	3.0			31.8 (89.2)	34.3 (93.7)
12.1	3.2			31.4 (88.6)	33.8 (92.9)
12.9	3.4			31.2 (88.1)	33.4 (92.1)
13.6	3.6			30.9 (87.6)	33.0 (91.5)
14.4	3.8			30.7 (87.2)	32.7 (90.9)
15.1	4.0			30.5 (86.9)	32.4 (90.3)
15.9	4.2			30.3 (86.5)	32.1 (89.8)
16.7	4.4			30.1 (86.2)	31.9 (89.4)
17.4	4.6			30.0 (86.0)	31.6 (89.0)
18.2	4.8			29.8 (85.7)	31.4 (88.6)
18.9	5.0			29.7 (85.5)	31.2 (88.2)
19.7	5.2			29.6 (85.3)	31.1 (87.9)
20.4	5.4			29.5 (85.1)	30.9 (87.6)
21.2	5.6				31.1 (87.4)
22.0	5.8				30.6 (87.1)
22.7	6.0				30.5 (86.9)
		Outlet Temperature °C (°F)			

Appendix B Laser settings

B.1 Maximum Power Settings

The following table indicates the maximum recommended IBP-YAG power| energy settings for various beam diameters and pulse widths. The pulsed energy limits are valid for up to 60 Hz repetition rates.

Diameter of Beam (mm)	CW Power (W)	Pulsed Energy (J) *		
		10 ms	1 ms	10 ns
1	450	4.5	0.45	0.022
2	1,800	18	1.8	0.090
3	4,000	40	4.0	0.202
4	4,000	70	7.2	0.359
5	4,000	110	11	0.561
6	4,000	160	16	0.808
7	4,000	220	22	1.1
8	4,000	290	29	1.4
9	4,000	360	36	1.8
10	4,000	450	45	2.2
11	4,000	540	54	2.7
12	4,000	650	65	3.2
13	4,000	760	76	3.8
14	4,000	880	88	4.4
15	4,000	1,010	100	5.0
16	4,000	1,150	110	5.5
17	4,000	1,300	130	6.5
18	4,000	1,450	150	7.5
19	4,000	1,620	160	8
20	4,000	1,800	180	9
21	4,000	1,980	200	10
22	4,000	2,170	220	11
23	4,000	2,370	240	12
24	4,000	2,590	260	13
25	4,000	2,800	280	14
26	4,000	3,030	300	15
27	4,000	3,270	330	17
28	4,000	3,520	350	18
29	4,000	3,770	380	19
30	4,000	4,040	400	20

* not to exceed 4000 W Average Power

B.2 Initial IBP-YAG attenuation settings.

These settings are approximate and may require adjustment after starting data collection. To set the initial attenuation, turn the fine adjust knob fully clockwise and turn the coarse adjust knob to the indicated setting. Knob position 1 is the full clockwise position.

IBP-YAG-4

Beam Diameter (mm)	Input Power/Energy 2 0.03	4 0.06	8 0.13	15 0.25	30 0.5	60 1	120 2	250 4	500 8	1000 16	2000 32	4000 64	125	250	500	1000	Watts Joules
1.0	1	1	1	1	2	2	2	3	3	3	4	4	4	4			
1.25		1	1	1	2	2	2	2	3	3	3	4	4	4			
1.50		1	1	1	1	2	2	2	3	3	3	4	4	4	4		
1.75			1	1	1	2	2	2	2	3	3	3	4	4	4		
2.00			1	1	1	1	2	2	2	3	3	3	4	4	4	4	
2.25				1	1	1	2	2	2	3	3	3	3	4	4	4	
2.50				1	1	1	2	2	2	2	3	3	3	4	4	4	
2.75				1	1	1	1	2	2	2	3	3	3	4	4	4	
3.00					1	1	1	2	2	2	3	3	3	3	4	4	
3.25					1	1	1	2	2	2	3	3	3	3	4	4	
2.50					1	1	1	2	2	2	2	3	3	3	4	4	
3.75					1	1	1	2	2	2	2	3	3	3	4	4	
4.00					1	1	1	1	2	2	2	3	3	3	4	4	
	Coarse Adjust Attenuation Knob Position																

IBP-YAG-16

Beam Diameter (mm)	Input Power/Energy 2 0.03	4 0.06	8 0.13	15 0.25	30 0.5	60 1	120 2	250 4	500 8	1000 16	2000 32	4000 64	125	250	500	1000	Watts Joules
4.0	1	1	1	1	2	2	2	3	3	3	4	4	4	4			
5.0		1	1	1	2	2	2	2	3	3	3	4	4	4			
6.0		1	1	1	1	2	2	2	3	3	3	4	4	4	4		
7.0			1	1	1	2	2	2	2	3	3	3	4	4	4		
8.0			1	1	1	1	2	2	2	3	3	3	4	4	4	4	
9.0				1	1	1	2	2	2	3	3	3	3	4	4	4	
10.0				1	1	1	2	2	2	2	3	3	3	4	4	4	
11.0				1	1	1	1	2	2	2	3	3	3	4	4	4	
12.0					1	1	1	2	2	2	3	3	3	3	4	4	
13.0					1	1	1	2	2	2	3	3	3	3	4	4	
14.0					1	1	1	2	2	2	2	3	3	3	4	4	
15.0					1	1	1	2	2	2	2	3	3	3	4	4	
16.0					1	1	1	1	2	2	2	3	3	3	4	4	
	Coarse Adjust Attenuation Knob Position																

IBP-YAG-30

Beam Diameter (mm)	Input Power/Energy 2 0.03	4 0.07	8 0.13	15 0.25	30 0.5	60 1	120 2	250 4	500 8	1000 16	2000 32	4000 64	125	250	500	1000	2000	Watts Joules
8.0	1	1	1	1	2	2	2	3	3	3	4	4	4	4				
10.0		1	1	1	2	2	2	2	3	3	3	4	4	4				
12.0		1	1	1	1	2	2	2	3	3	3	4	4	4	4			
14.0			1	1	1	2	2	2	2	3	3	3	4	4	4			
16.0			1	1	1	1	2	2	2	3	3	3	4	4	4	4		
18.0				1	1	1	2	2	2	3	3	3	3	4	4	4		
20.0				1	1	1	2	2	2	2	3	3	3	4	4	4		
22.0				1	1	1	1	2	2	2	3	3	3	4	4	4	4	
24.0					1	1	1	2	2	2	3	3	3	3	4	4	4	
26.0					1	1	1	2	2	2	3	3	3	3	4	4	4	
28.0					1	1	1	2	2	2	2	3	3	3	4	4	4	
30.0					1	1	1	2	2	2	2	3	3	3	4	4	4	
	Coarse Adjust Attenuation Knob Position																	

Appendix C Calibration Information