LASERMET LS-20
INSTRUCTION MANUAL

LASER SAFETY SHUTTER

LASERMET LS-20
Instruction Manual

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1 Declaration of Conformity

LASERMET LIMITED

LASER BEAM SHUTTER
MODELS LS-20-24 AND LS-20 SIL24

Drawing Numbers:
Main Unit 00629-00-000
Tandem Unit 00647-00-000

DECLARATION OF CONFORMITY

This is to declare that the LS-20 and LS-20 SIL3 have been found to comply with the requirements of the following Directives and European Standards:

Directives: Machinery Directive 2006/42/EC June 2010

EMC Directive 2014/30/EU

Standards: EN ISO 13849-1:2015
Safety of Machinery: Safety-related parts of Control Systems

EN 61010-1:2010
Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory use.

Supplier: Lasermet Limited
Lasermet House
137 Hankinson Road
Bournemouth
BH9 1HR
Dorset
United Kingdom

Country of Origin: England.

Signed:  Date: 6 May 2017

Quality Assurance Manager

2 Safety Note

This beam shutter can only successfully divert and absorb a laser beam if no part of it becomes overheated.

Users must read and understand the section, ‘Using with Powerful Lasers’ later in this manual.

Be aware that once degradation starts to occur rapid failure is likely, possibly leading to the beam passing unhindered through the shutter.

Due to the huge number of different types, powers and beam sizes of lasers Lasermet cannot guarantee suitability of this shutter in every case and testing may be necessary to ensure that the shutter provides the desired level of protection.

Always ensure that the beam dump port is closed, unless a separate beam dump is fitted.

3 Concept

The Lasermet LS-20 Laser Safety Shutter is intended to provide a means of preventing accidental exposure to a potentially harmful laser beam.

When closed, the shutter deflects the incoming laser beam onto an internal beam dump where the energy is converted to heat which is dissipated in the aluminium casing of the shutter.

When the shutter is open, the laser beam passes through the shutter without interruption.

The shutter has been designed to form part of a high-integrity safety system and features a gravity-close blade and force-disconnect proving contacts.

A 'SIL3' version is available which, when correctly wired to a Lasermet Interlock Control System can provide a safety interlock which meets SIL-3 and EN13849-1 up to performance level 'e'.

4 Control Options

The shutter is usually powered by a laser interlock system such as Lasermet's ICS Interlock Control System. These systems will provide power to allow actuation of the shutter once all safety interlocks (for example, doors, covers etc.) have been closed. If the interlock system is tripped out, the shutter will immediately close. It then cannot be opened until the interlock system is re-armed.

The shutter may be wired to operate in one of three different ways:

1. The Arming of the interlock system enables operation of the shutter. The buttons on top of the shutter may then be used to open and close it as desired.

2. The Arming of the interlock system enables operation of the shutter. The shutter may then be remotely opened and closed by external controls or buttons such as Lasermet's LS-20 LS-RS units. The buttons on top of the shutter may also be used.

3. The arming of the interlock system causes the shutter to open immediately.

The shutter may also be wired into bespoke custom systems.

The shutter operates on 24VDC and draws typically 100mA when open and 20mA when closed. There is an initial impulse of approximately 1A on opening and the specification of power supplies and cabling must take this into account.

SIL3 shutters draw twice as much current as standard units.

Note that the LS-20 will not operate on 12V systems as used for LS-10 and LS-100. Lasermet interlock systems can be reconfigured to provide the necessary 24V.

5 Indications

The shutter has two sets of isolated volt-free monitor contacts which are available on its connector. For maximum integrity the 'shutter closed' contacts are directly mechanically driven by the blade- they do not rely on opto sensors or other non-contact methods. This means that the blade cannot open without opening the 'shutter closed' contacts.

Each contact set has a common terminal which is connected to either the 'open' or the 'closed' terminal according to the state of the shutter. Each contact is rated at 100mA resistive load at 30VDC. The two sets of contacts are isolated from each other and from the control circuitry of the shutter.

These contacts may be used by external circuitry to monitor and indicate the state of the shutter.

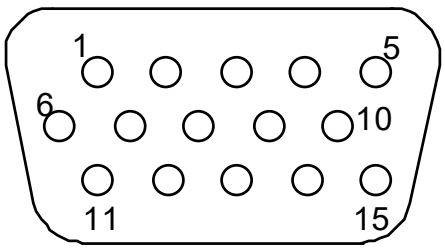
The shutter also has two low power indication outputs, one for open and one for closed. These output 24VDC at 50mA maximum and are typically used to operate LED indicators on remote control buttons.

The buttons on the shutter illuminate to show the state. A red light means the shutter is open, a green indicates the safe condition, i.e. closed.

6 Wiring

The LS-20 shutter is supplied with a permanently connected 3m lead terminated in a 15-way high density 'D' plug. The connector makes available all of the various control and indication features of both the standard and the 'SIL3' versions. The pin connections are as follows:

1	0V
2	Monitor Contact 1 'Open'
3	Monitor Contact 1 Common
4	Monitor Contact 1 'Closed'
5	Monitor Contact 2 'Open'
6	'Open' +24V output
7	Monitor Contact 2 Common
8	Remote Open Command +24V Input
9	Monitor Contact 2 'Closed'
10	Monitor Supply +24V
11	'Closed' +24V output
12	Control Supply +24VDC input
13	Not used
14	Not used
15	Not used



View looking at plug pins

See 'Detailed Pin Descriptions' below for more information.

Lasermet produce a range of Distribution Boxes and Remote Switches fitted with sockets specially for use with LS-20, which provide convenient screw terminals to make installation neat and simple. Units are available in both free-standing and fixed installation versions and full wiring instructions are supplied with each one.

Lasermet also supply extender cables to lengthen the shutter lead.

Connection to Lasermet Interlock Control Systems

Diagram 1 below shows the usual basic control wiring between a Lasermet ICS-6 Interlock Control System and LS-20.

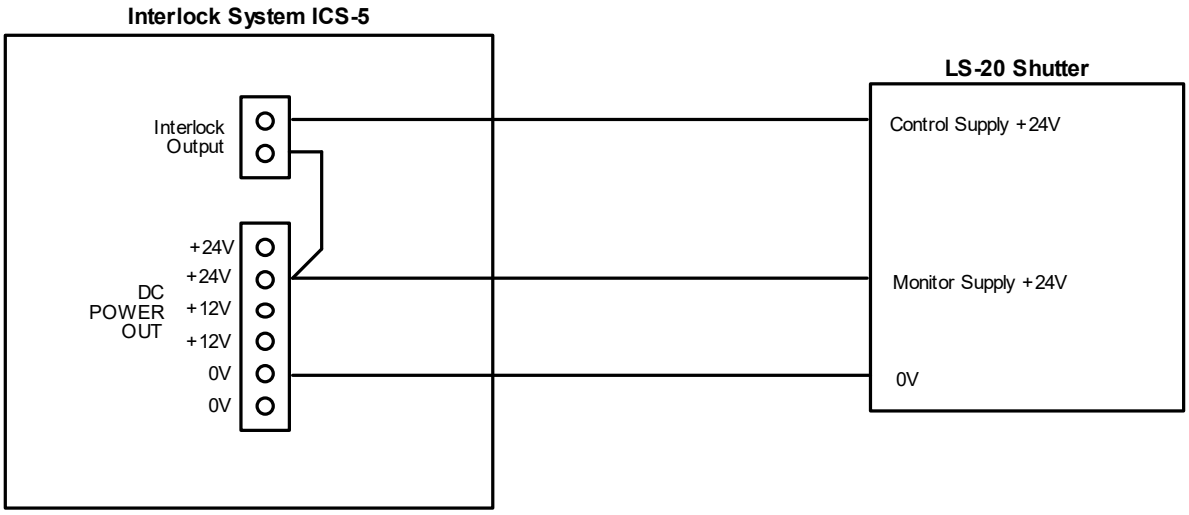


Diagram 1: Basic Control Wiring between ICS-6 and LS-20

In this arrangement the shutter buttons are operative allowing the shutter to be opened and closed when the ICS-6 is armed.

If it is necessary for the shutter to open immediately when the ICS-6 is armed, fit a link to connect the Remote Open Command input to the Control Supply +24V. Make sure the link is not connected to the Monitor Supply.

Diagram 2 below shows how to implement a SIL-3 / EN13849 PL'e' safety system using the 'SIL3' version of LS-20.

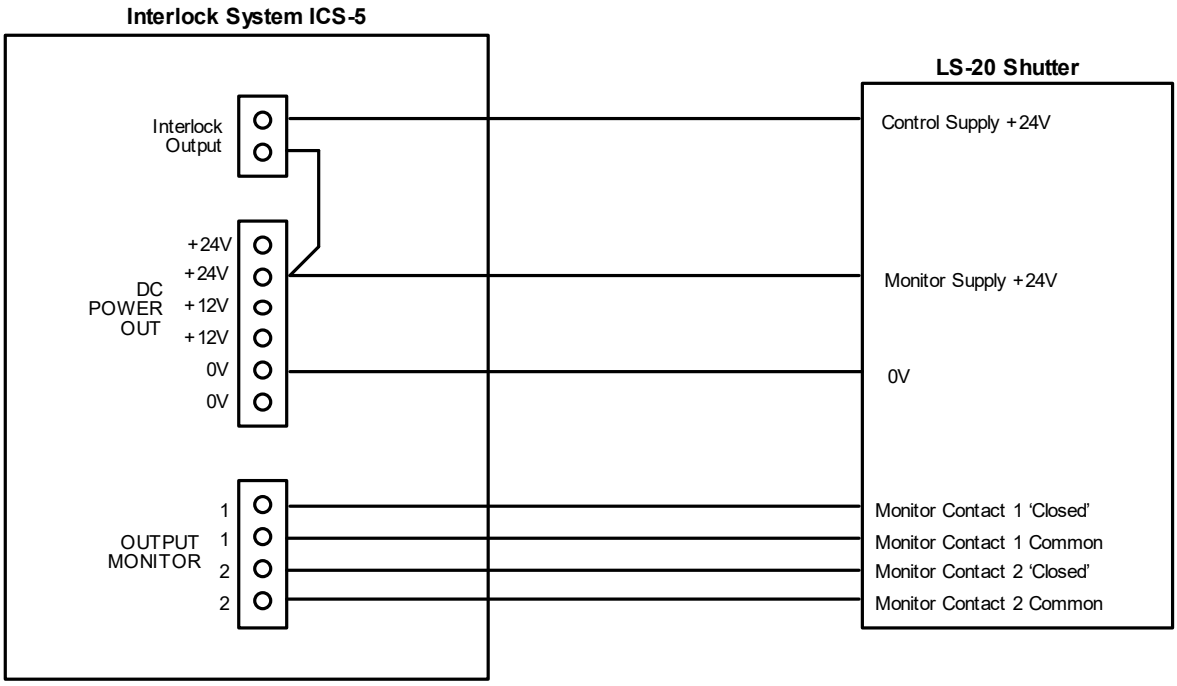


Diagram 2: Implementing a SIL-3 system using 'SIL3' LS-20

Note for correct operation, installation wiring should use at least 16/0.2mm wire to avoid problems of voltage drop on the wiring run. On very long distances, when using 'SIL3' shutters, or in situations where two shutters may be connected simultaneously 24/0.2mm wire may be advisable for the 24V supply wires.

Detailed Pin Descriptions

The LS-20 shutter can be wired in various ways. The simplest configuration is to connect pins 10 and 12 to +24V and pin 1 to 0V. The shutter can then be operated using its buttons. Other pins may be connected as required giving a wide variety of control and monitoring options.

The functions of each pin are given below.

1 **0V**
Negative of 24V Power Supply / Interlock Controller feeding shutter.

2 **Monitor Contact 1 'Open'**
Volt-free contact which is connected to pin 3 when the shutter is open. The contact is rated at 100mA 24V maximum resistive load.

3 **Monitor Contact 1 Common**
Common contact for pins 2 and 4.

4 **Monitor Contact 1 'Closed'**
Volt-free contact which is connected to pin 3 when the shutter is closed. The contact is rated at 100mA 24V maximum resistive load.

5 **Monitor Contact 2 'Open'**
Volt-free contact which is connected to pin 7 when the shutter is open. The contact is rated at 100mA 24V maximum resistive load.

6 **'Open' +24V output**
This pin outputs 24V when the shutter is open. It can source a maximum of 50mA resistive load. Used to operate the 'open' indicator light on Lasermet's LS-RS-20 remote switches.

7 **Monitor Contact 2 Common**
Common contact for pins 6 and 9.

8 **Remote Open Command +24V Input**
Apply 24V to this pin to make the shutter open immediately. If the Control Supply is present on pin 12 the voltage need only be applied momentarily (approximately 1 second) as the shutter latches open. If there is no control supply on pin 12 the shutter will remain open until the Remote Open signal is removed. For remote button operation a normally open pushbutton switch can be connected between this pin and pin 12.

9 **Monitor Contact 2 'Closed'**
Volt-free contact which is connected to pin 7 when the shutter is closed. The contact is rated at 100mA 24V maximum resistive load.

10 **Monitor Supply +24V**
Connect this pin to an 'always on' 24VDC supply. The negative of this supply should be pin 1, in common with the negative of the control supply. This pin powers the indicator lights on the shutter and provides power to operate pins 6 and 11.

11 **'Closed' +24V output**
This pin outputs 24V when the shutter is closed. It can source a maximum of 50mA resistive load. Used to operate the 'closed' indicator light on Lasermet's LS-RS-20 remote switches.

12 **Control Supply +24VDC input**
Applying 24VDC to this pin allows the shutter to be opened using its buttons.
Once the shutter is open it latches open until the 'Close' button is pressed on the shutter, or until this supply is removed. To close the shutter, remove the supply from this pin (and pin 8, if used). For remote button operation a normally closed pushbutton may be inserted in this line such that the supply is interrupted when the button is pressed.

For other options including the use of illuminated signs in conjunction with the shutter please discuss your requirements with Lasermet.

7 Mounting and Beam Containment

The shutter is equipped with an M6 female thread in the base, located under the beam centreline. An anti-rotation slot is also provided in the base into which a second M6 stud should be located to prevent the shutter turning or coming unscrewed. The slot allows for posts on imperial and metric optical breadboards.

The shutter has a through aperture of Ø16mm. The beam and beam dump ports are threaded M17 X 1. Lasermet can provide containment tubes and adaptors to order. Please contact us for details at the address at the end of this manual.

Ensure that the laser beam is travelling in the direction of the arrow shown on the top of the shutter.

See the section, 'Dimensions' later in this manual.

8 SIL-3 Version LS-20-SIL24

To achieve EN13849-1 performance level ‘e’ the ‘SIL3’ version must be used wired as shown in diagram 2. The ‘SIL3’ version is a twin unit which has one shutter behind another. Both shutters must be open to allow the beam to pass through.

In this unit one set of monitor contacts is dedicated to one of the shutters, the other contact to the other shutter, so the state of both blades can be monitored. When correctly interfaced to a Lasermet ICS, the interlock system cannot be armed if either one or both blades are not detected closed.

It is theoretically possible to achieve SIL 4 with the SIL3 shutter however the method of control in this case is outside the scope of this manual.

9 Blade and Beam Dump Options

The LS-20 beam dump is removable which allows an external beam dump to be used. This could potentially enable the shutter to be used with more powerful lasers than can be dissipated by the shutter itself. In this instance it is vital that the external beam dump is mounted as close as possible to the shutter and that the beam path is suitably contained to avoid risk of exposure.

It is also possible to locate a laser power meter in place of the beam dump so that the laser power can be determined while the shutter is closed. In this arrangement it is essential that the power meter head damage threshold is sufficient to withstand the laser beam for the length of time for which the laser may be active with the shutter closed.

If using an external option in place of the integral beam dump, consideration should be given to the type of blade fitted, see below.

Note that the unit is primarily intended as a safety shutter rather than a precision beam diverter or timing shutter. Due to the free moving nature of the blade the exact exit angle of the beam through the beam dump aperture is variable, therefore any external apparatus must be mounted as close as possible to the shutter, it must have an aperture the same size or bigger than the port and be able to accept small variations in beam position and angle.

Blade Type

The standard LS-20 has an angled bare stainless-steel blade with a non-precision surface which deflects and to some extent scatters the beam. This surface is generally suitable for most applications when the integral beam dump is used. To prevent permanent damage and invalidation of warranty it is essential that the energy density of the laser is insufficient to ablate the blade.

It is possible to order the LS-20 with other blade materials which may be more appropriate particularly when the integral beam dump is removed.

The ceramic blade option is recommended for Q-switched lasers where the standard stainless-steel blade may become ablated.

There are a number of mirror blade options featuring a front silvered or dielectric mirror for various wavelengths. These allow the shutter to be used with higher power lasers than the standard blade but note that an external beam dump will be required. The mirror blade option is also advisable when mounting a laser power meter at the beam dump port.

For SIL3 shutters the laser beam will normally be directed out of the beam dump port nearest the laser, however consideration should be given to the consequences if the first shutters fail to close and the beam is directed to the second shutter beam dump port.

Note: The use of a beam tube which screws into the threaded aperture of the shutter is adviseable, especially at the input port of the shutter. Some specialised mirrors are only manufactured in widths of 16mm. If the shutter is used without a beam tube the aperture of the threaded ports is also Ø16mm and there is a possibility that such a mirror may not completely cover the aperture. The user should ensure that the laser beam is small enough and aligned centrally such that there is no risk of any part of the beam missing the mirror surface. It may be necessary to set up an aperture in front of the shutter to ensure this condition is complied with.

Observe the warnings given in the next section, ‘Using with Powerful Lasers.’

10 Using with Powerful Lasers

If the blade or beam dump become overheated, they will be permanently damaged. Moreover, once damage has started to occur the situation is likely to deteriorate further unless immediate action is taken to turn off the laser.

Modern lasers which cut or burn are now readily available. Regarding the shutter blade, it is essential that it absorbs insufficient energy for it to be damaged, which means that the excess must be reflected away towards the beam dump.

At 20°C ambient the standard stainless-steel blade can dissipate about 2W.
The copper blade option can dissipate no more than about 1W.
Glass mirror options can dissipate less because they are not such good conductors.

Heating of metal or metal-surfaced glass blades is likely initially to cause oxidisation which darkens the metal causing it to absorb and heat more.

Furthermore, there may be localised damage if the laser has a high-power density, i.e. the beam is concentrated in a small diameter. For metal blades this appears as ablation, in which the area where the beam impinges reaches the melting point of the metal before conduction can carry the heat away. For glass mirror blades the localised heating expands the glass causing it to crack.

In all cases once the point of contact of the laser beam ceases to reflect as well, it will heat and fail. If the laser is left running when this happens, the shutter will be progressively damaged and burn-through of the beam may occur. Once damage has occurred a 100W laser may burn through the stainless-steel blade. More powerful lasers will burn through quite quickly. Also, any optional blade mirror that has been fitted will detach if it exceeds several hundred degrees Celsius.

Ultimately users must be aware of the hazards of operating powerful lasers and the suitability of any shutter being used. Tests may need to be undertaken to establish the suitability of any shutter when used with powerful lasers.

The blade should be checked before use to ensure that it is spotlessly clean, unoxidised and unblemished. Appropriate optical cleaning methods may be required to clean the blade. It must be understood that whilst a perfectly clean blade will successfully divert a beam, should a speck of contamination at the surface occur rapid progressive failure and burn-through are possible. Risk assessments should be undertaken to determine the effects of such an event and identify any mitigation measures that may be necessary.

11 Dimensions

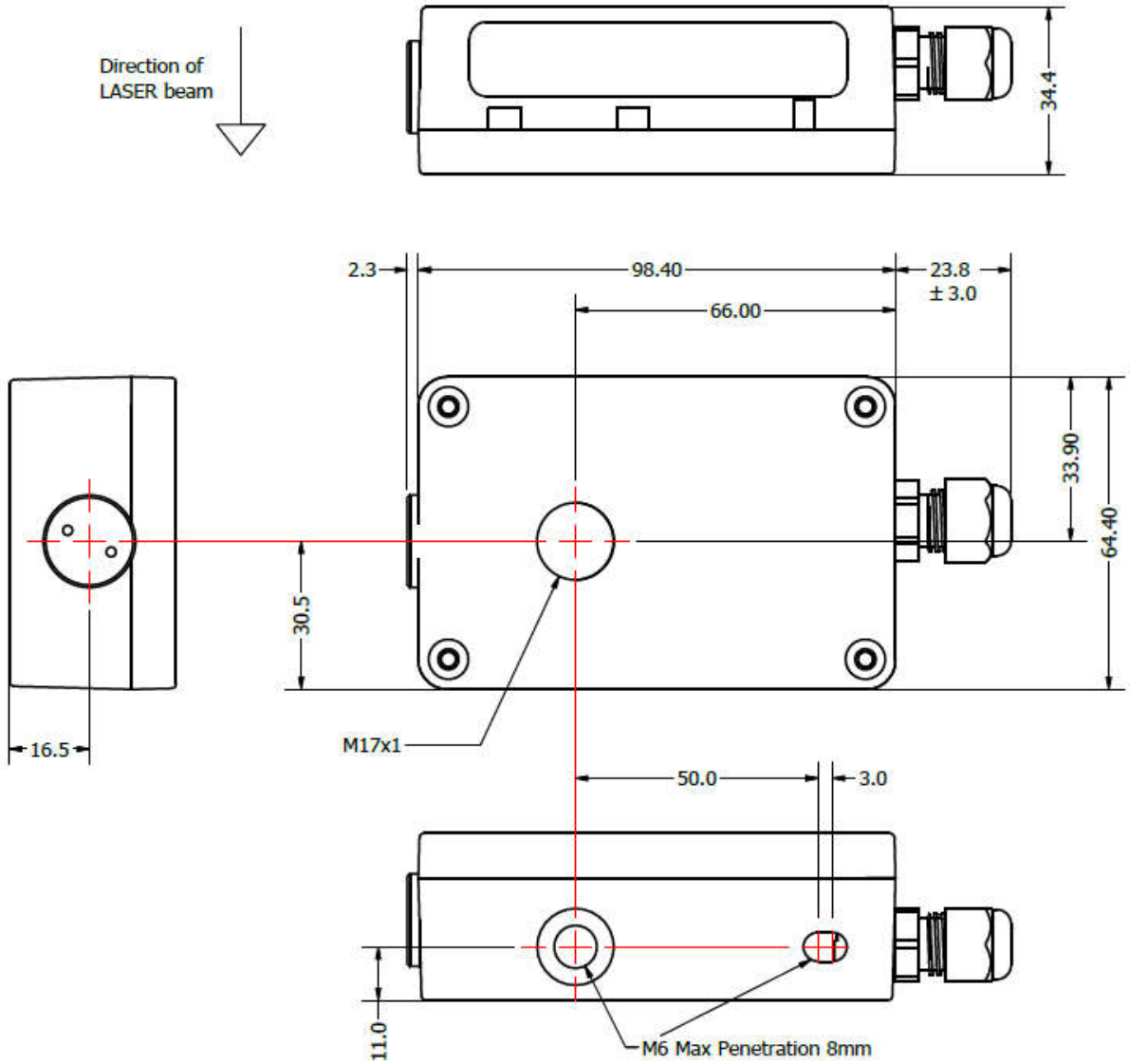


Diagram 3: Standard LS-20 Dimensions in mm.

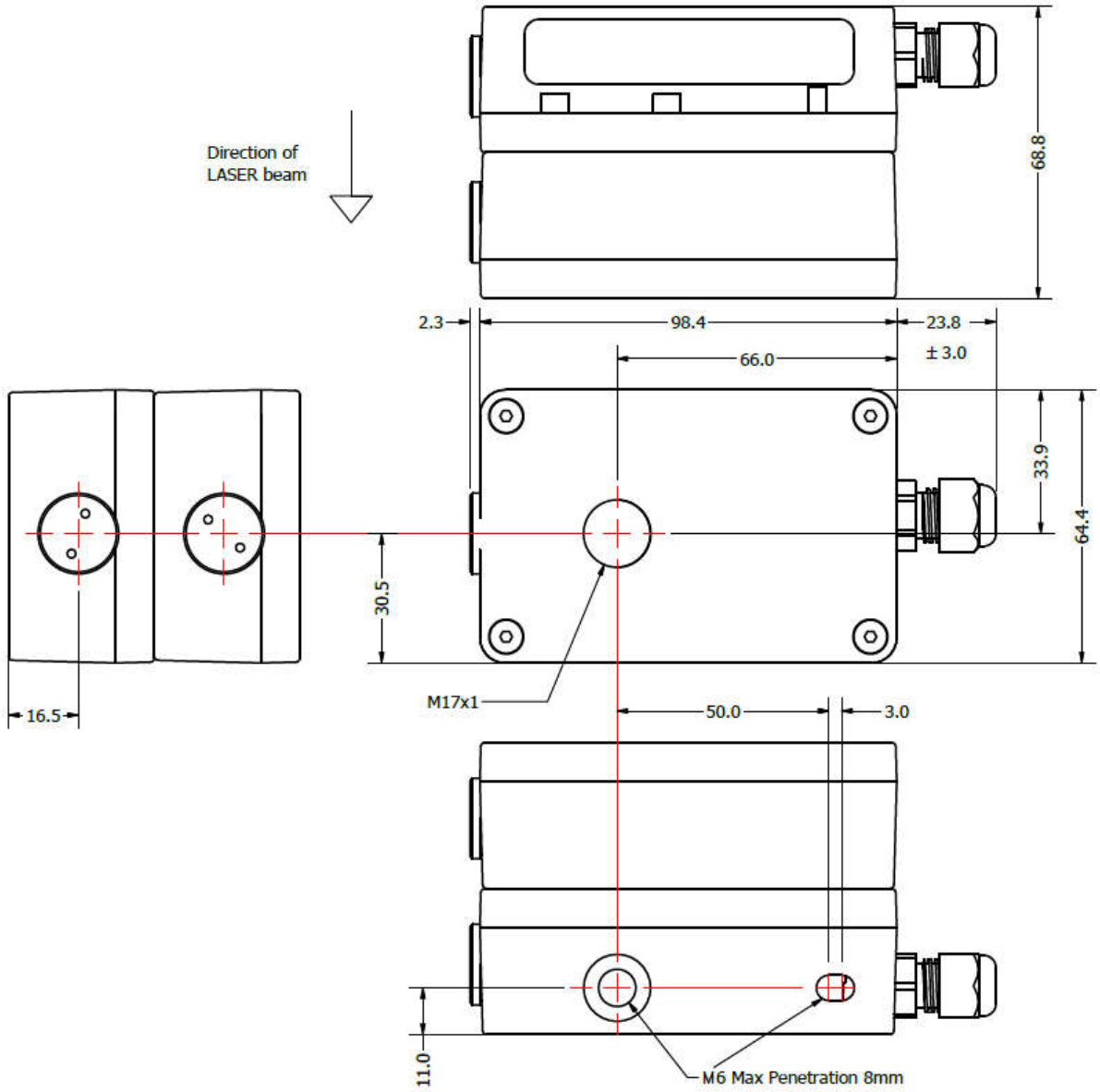


Diagram 4: 'SIL3' LS-20 Dimensions in mm.

12 Specifications

Weight

LS-20-24	600g
LS-20SIL-24	1000g

Response Time[1]

Opening	45ms typical
Closing	70ms typical

Operating Voltage

22 – 26VDC

Operating Current

LS-20-24

Closed	30mA typical
Open	200mA typical
Surge	281.82mA typical
Surge Time	100ms typical

LS-20SIL-24

Closed	30mA typical
Open	330mA typical
Surge	545.45mA typical
Surge Time	140ms typical

Note: The shutter has a peak current draw of typically 1A for <100ms during opening. The supply voltage must not fall below the minimum operating voltage during this time, else the shutter may fail to open.

Laser Blocking Specification

Maximum average beam power:

Using standard blade	20 W
Using integral beam dump	20 W
Using mirror blade	As per mirror specification[2]

[1] These values are typical but not guaranteed
[2] See section on Using with Powerful Lasers

Safety Specification

Standard LS-20	EN 13849-1 performance level ‘c’
LS-20 SIL-24	EN 13849-1 performance level ‘e’ IEC 61508-1 SIL 3

The safety ratings may be achieved when correctly wired to a suitably rated control system.

The LS-20 SIL-24 is a dual channel electromechanical safety laser shutdown device.

System Type	Type A System
Hardware Fault Tolerance	1

When connected to an ICS-6 control system as shown in this manual, the LS-20SIL-24 has the following characteristics. This can also be achieved by correctly connecting to another suitable safety control system which has dual channel monitoring of the shutdown device.

Safe Failure Fraction	95%
PFD	1.56×10^{-7}

When used as described above, the LS-20SIL-24 is suitable for use as the sole laser shutdown device in a system which is required to achieve Safety Integrity Level 3 (SIL 3) or lower as defined in IEC 61508.

NB. The actual SIL rating of the entire system will depend on the other system components, how they are connected together and how the system is used.

Reliability

Mean time to dangerous failure (MTTFd)	100 years
Number of operations after which 10% of units have failed (B10d)	$> 1 \times 10^{7}$

13 Warranty

Lasermet provide a 12-month warranty for defects in materials and manufacture, from the date of installation or delivery. Installations completed by Lasermet are covered against defects in workmanship for 12 months.

Damage or defects caused by other factors are not covered. For example, industrial contamination, incorrect cleaning, storm damage. Consequential loss is not covered under warranty. Compensation for indirect or direct loss or damage is expressly excluded. Rectification of the defects or a replacement does not initiate a new warranty period.

For all deliveries, payments and other legal transactions, English law takes precedence for any litigation.

14 Contact Details

Lasermet provides a full range of laser interlock equipment including interlock switches, illuminated warning signs, laser shutters, entry keypads with built-in fail-safe override timer, door locks, external power supplies etc. which can be interconnected to provide a complete system. We also supply equipment and consultancy covering all aspects of laser safety. Full support, design and installation is available from Lasermet, please contact us for any queries. Please visit our website.

For sales and technical support:

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