# LAHEL

## System for testing High Energy Lasers

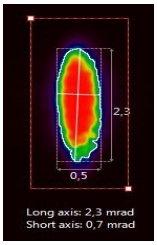
a)  b) 


Fig. 1. LAHEL240 test system: a)photo, b)angular spatial intensity distribution of tested HEL

## 1 What are HELs?

High-power lasers (HELs) have been used for decades as common tools for cutting and welding of metal sheets located at very short distance from laser output. This market has been originally dominated by bulky CO2 lasers that emit beam of rather wide divergence angle even after integration with collimating optics.

However, within last decade powerful but compact laser modules emitting at shorter wavelengths (NIR or SWIR ranges – most common 1064nm wavelength ) become commonly available. Technology of collimating optics has been improved, too. These technology changes in laser modules enabled design of high power lasers emitting beams of narrow divergence angle. These new HELs can be divided into two classes:

1. HELs for defense applications as directional weapons,
2. HELs for remote machining of metal sheets.

HELs from the first group enables blinding or mechanically damaging electro-optical systems used in military applications (laser effectors). HEL from second group enable machining (welding, cutting) of metal sheets from distance up to several meters.

In both industrial and military applications, precision testing HELs is a metrological challenge. Commonly used methods based on idea to put tested laser at collimator output and measure parameters (power, dimensions) of laser spot at collimator focal plane cannot be used. HELs generate laser beam of so high optical power that immediately damages not only optical meter located at collimator focal plane but also mirrors of the collimator.

In addition, power of HEL lasers is so high that even small reflections on test system can be dangerous for human even when protected by laser glasses.

## 2 Characterization of HELs

HEL laser systems can be characterized by a set of six parameters:

1. Laser power (mean power of CW or high frequency pulse lasers)
2. Laser wavelength
3. Laser divergence angle (enable to estimate size of laser beam at specified distance)
4. Laser aperture (diameter of optics of laser)
5. Total aperture (diameter of circle that can overlap both laser optics and optics of aiming imager)
6. Boresight error between aiming imager and laser.

## 3 What is LAHEL?

LAHEL is a system for testing High Power Lasers used in both industrial and defense applications capable to measure three important group of parameters:

1. Temporal function of optical power. Mean power and temporal non stability are calculated on basis of measured data.
2. Temporal function of angular spatial intensity distribution. Divergence angle ( mean and temporal non stability) is calculated on basis of such measured data.
3. Boresight error between aiming channel and HEL laser.

Measured parameters deliver information on tested HEL lasers to answer three main questions:

1. What is true value of optical power emitted by laser during required irradiation time interval? Power of some HELs deteriorates quickly with time.
2. What is angular size and uniformity of laser beam during required irradiation time interval? Angular size and uniformity of laser beam is of crucial importance to evaluate effectiveness of HEL to heat/damage target of interest.
3. What is accuracy of aiming of tested laser (real angle between line of sight of aiming imager and axis of laser beam)?

## 4 How LAHEL is built?

LAHEL is a modular system built using a set of blocks:

1. CDIL collimator,
2. LAIP imaging meter
3. Set of of LABSO absorbers (integrated with CDIL collimator)
4. Set of collimator masks.
5. PC set
6. BOR computer program
7. LMET computer program.

CDIL is a special hardened version of CDT series off axis reflective collimators capable to withstand laser beam of ultra high power without damage of its optical elements. In addition, returning beam effect is fully eliminated. It means that laser beam emitted at any position within collimator aperture shall not be reflected and hit back any part of this aperture circle in noticeable way. The latter change improves system safety as it reduces possibility that returning laser beam damages HEL optics or human operator. Two versions of different aperture/focal lenght are offered to fit to different applications.

LAIM is a special imaging meter capable to measure power and create imager of laser spot at collimator focal plane.

Set of of LABSO absorbers are two absorbers located at way of laser beam capable to absorb, convert to heat, and dissipate to air over 99% of energy of tested laser. Two versions of different linear FOV are offered.

Set of collimator masks is a set of opaque plates having holes of diameter identical as optics tested laser and optics of aiming imager. They are used to prevent laser light reflected at internal collimator parts to go out of collimator creating danger for human operator.

PC set is basically a typical desktop PC.

BOR/LMET are computer programs that support measurement of HEL parameters.

## 5 Safety issues

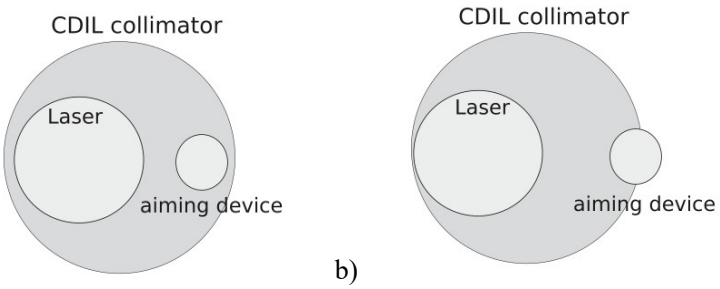
LAHEL system does not emit its own radiation but can reflects a small fraction of light emitted by tested HEL. Even this small fraction can be dangerous for operators of LAHEL test systems. It is obligatory for test team to wear safety laser glasses to follow typical safety rules for operation of high power lasers. A perfect solution is when humans are not present in test room (both tested HEL and LAHEL system are remotely operated.

## 6 Limit of boresight capabilities

Typical LAHEL is optimized for testing HEL laser systems in situation when aperture of CDIL collimator (see Table 7):

1. fully overlaps optics of HEL laser
2. at least partially (over 50%) overlaps optics of aiming device.

Typical LAHEL does not enable boresight of HEL laser systems having aiming device outside aperture of CDIL collimator. However, such HEL laser systems can be tested using optional customized LAHEL systems (see Option section).




a) b)

Fig. 2. Aperture of CDIL collimator relative to optics of tested laser/aiming device:a) collimator aperture fully overlaps optics of both laser and optics of aiming device, b) collimator aperture overlaps optics of laser and partially optics of aiming device

## 7 Technical specifications

| Parameter | LAHEL140 | LAHEL240 |
|---|---|---|
| Performance parameters | | |
| Maximal aperture of tested HEL system | 140mm | 240mm (optional: 300mm) |
| Range of measured optical power | 0.1kW to 10kW | 0.1kW to 10kW (option up to 30kW) |
| Range of measured divergence angle | 0.5mrad to 10mrad (circle) | 0.4mrad to 12mrad (circle) |
| Range of measured boresight errors | Up to 10mrad (option 30mrad) | Up to 12mrad (option 42mrad) |
| CDIL collimator | | |
| aperture | 140mm | 240mm |
| Focal length | 1200mm | 2000mm |
| Spectral band | At least 700nm – 1700nm | At least 700nm – 1700nm |
| Collimator resolution | 90 lp/mrad | 140 lp/mrad |
| Laser irradiation damage threshold | At least 300kW/cm² (input plane) | At least 300kW/cm² (input plane) |
| LAIP imaging meter | | |
| Spectral range | 1) 700 –1100nm<br>2) 950 –1600nm<br>3) 700 –1700nm | 1) 700 –1100nm<br>2) 950 –1600nm<br>3) 700 –1700nm |
| Image resolution | 1200 x 800px | 1200 x 800px |
| Linear FOV | At least 12 x 12 mm | At least 24 x 24 mm |
| Angular FOV | 10x10mrad | 12x12mrad |
| Dynamic of light intensity of tested laser beams | 1000 | 1000 |
| Range of measured optical power (combined with CDIL collimator attenuators) | At least 10W to 10000W | At least 10W to 10000W |
| Resolution of measured optical power | Not worse 1W | Not worse 1W |
| Accuracy of measurement of optical power | 3% | 3% |
| Resolution of measurement of divergence angle | 0.04mrad | 0.04mrad |
| Accuracy of measurement of divergence | 5% or 0.1mrad | 5% or 0.1mrad |

| | | |
|---|---|---|
| angle | | |
| PC Control | USB 2.0 | USB 2.0 |
| Environmental parameters | | |
| Work temperature range | +10ºC to +32ºC | +10ºC to +32ºC |
| Humidity range | Up to 95% (non condensing) | Up to 95% (non condensing) |
| Storage temperature range | –10ºC to +55ºC | –10ºC to +55ºC |

## 8 Versions

LAHEL can be delivered in form of different versions of different design, test capabilities and price. Special code that uses one number and four letters is used to describe these versions.

The number describes aperture of collimator used by test system. Two CDIL collimators are typically offered (Table 1). Collimators of bigger aperture can be optionally delivered.

*Table 1. Collimator code of versions of LAHEL systems*

| Collimator code | Collimator aperture | Collimator focal length |
|---|---|---|
| 140 | 140mm | 1200mm |
| 240 | 240mm | 2000mm |

Attention:

- Collimator aperture should be preferable at least partially overlap system total aperture (diameter of circle that can overlap both laser optics and optics of aiming imager)
- Collimator aperture must be bigger (at least 10%) over aperture of optics of tested laser.

System test capabilities are described by four letter code (Table 2):

*Table 2. Four letter code of versions of LAHEL systems*

| Code | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Test capabilities | Measured power of tested HEL | Wavelength of tested HEL | Boresight capabilities |
| A | Measurement of spatial intensity distribution (divergence angle) | 0.1to 1 kW | In band: 700-1100nm | No |
| B | Measurement of optical power | 0.1to 3 kW | In band: 950-1600nm | Projection of aim target to be seen by VIS imager |
| C | Both divergence angle and mean power | 0.1to 10 kW (option up to 30kW) | In band: 700-1700nm | Projection of aim target to be seen by thermal imager |
| D | | | | Both VIS and TI |

Example: Code LAHEL240 CBAB means system built using collimator of optical aperture 240mm, capable to measure both divergence angle and mean power of tested HEL of power up to 3kW of wavelength in band: 700-1100nm. System project image of aiming target seen in visible band by VIS imager (typical part of HEL system).

## 9 Options

### *9.1 Laser system of ultra large total aperture*

Typical LAHEL is optimized for boresight HEL laser systems of total aperture ( circle that overlaps both laser and aiming device) smaller or approximately equal to aperture of CDIL collimator. However, Inframet can deliver special LAHEL system capable to boresight HEL laser systems of total aperture up to 1000mm.
Attention: This is a solution customized for specific laser system. Customer is expected to deliver detail drawings showing diameter and location of optics of both laser and aiming channel.

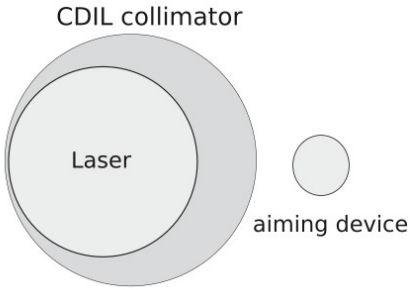



Fig. 3. Case of tested laser system of ultra large total aperture over aperture of CDIL collimator

## 10 Summary

1. There is presently huge interest in HEL laser systems.
2. Testing HELs is a metrological challenge.
3. LAHEL is the first commercially available system for testing HEL systems.

Version 2.2

CONTACT: Tel: +48 22 6668780 Fax: +48 22 3987244 Email: info@inframet.com