Risk Assessment

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NIST - Boulder, CO

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Rockwell Laser Industries

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Bioptica Laser Safety

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Dynamic Laser Solutions
Risk Assessment
Dear Committee Members:

This brief letter is a request for consideration by Z136 ADCOM for the establishment of a Technical Sub-Committee to formulate, address and provide guidelines regarding risk assessment as an informative appendix to ANSI Z136 for the Safe Use of Lasers.

Part of the premise for this suggestion and request for consideration is that a common thread for safety in the workplace is the concept of hazard and risk management. Such concepts encompass the understanding of hazards and appropriate safety control
One working example of where this informative section would be helpful, could be taken from the Province of Ontario, Canada, which has the legislated requirement for a Pre-Start Health and Safety Review documentation requirement before commissioning industrial equipment. This essentially ensures that due diligence has been conducted by the owner and provider of the new equipment for compliance with all appropriate regulations and associated risks in its operation are brought to an acceptable level (ideally mitigated or negated).

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Guidelines for Pre-Start Health and Safety Reviews:
How to Apply Section 7 of the Regulation for Industrial Establishments

April 2001

Health and Safety Guidelines
The Importance of Risk Assessment

The management of workplace hazards must be based on the conclusions of a risk assessment.

The likelihood of harm occurring

The severity of the harm caused

Risk = Likelihood x Severity
The Importance of Risk Assessment

• **Risk Assessment:**
  The process by which the intended use (and reasonably foreseeable misuse) of the machine, the tasks and hazards, and the level of risk are determined

• *Risk assessment generates an informed hazard evaluation to effect (if necessary) risk reduction measures*

• **Risk Reduction:**
  The application of protective measures to reduce the risk to a tolerable level (where the residual risk is as low as reasonably practicable or acceptable)
Safety Measures Must be Based on a Risk Assessment

Risk is the *likelihood* that someone may be injured by the laser, taking into account -

• all the potential hazards,

• the harm that could be caused,

• all reasonably foreseeable circumstances of use, misuse and equipment failure.
The Safety Objective

To reduce risk to:
As Low as Reasonably Acceptable (ALARA)
a.k.a.
As Low As Reasonably Practicable (ALARP)
“This machine is perfectly safe... As long as you never press this button.”
AUTOMATIC HIGH-VOLUME "WHOAA" FLIP-DOWN SUNGLASSES
SAFETY ROPE WHEN OTHER SYSTEMS FAIL
BIRD CAGE MASK & SAFETY GOGGLES
180° REAR VIEW MIRROR
HEAD LIGHTS
PRESCRIPTION SAFETY GOGGLES TO INSURE HORSE'S GOOD VISION
GRAB RAIL
SAFETY SWITCHES & HOTLINE TO INSURANCE COMPANY
STEEL TOED STIRRUPS
SAFETY NET ALL AROUND

4 WHEELS TO KEEP HORSE UPRIGHT IN CASE HE SLIPS - HENCE NOT ENDANGERING RIDER

ROLL BAR
HARD HAT WITH WIDE BRIM & EAR PROTECTORS
PADDED BACK SEAT & HEAD RESTRAINT
TAIL & DIRECTIONAL LIGHTS
BACK UP LIGHTS
SHOULDER HARNESS
AUTOMATIC, AIR FILLED CHEST PROTECTOR
MAPS IF YOU GET LOST & CHECKLIST BEFORE RIDING
BLUE TAIL FLY REPELLENT
SEAT BELT
SELF STARTER (ACCESSORY)
KNEE PADS (JUST IN CASE) & QUILTED PANTS
DUAL CINCH
E.P.A. EMissions CONTROL SYSTEMS
NON-SKID SPARK SUPPRESSORS

COWBOY AFTER O.S.H.A.
Accidental Laser Exposure

Accidental exposure to laser emission can arise from:

1. Misdirection or misalignment of a laser beam
2. Inadvertently moving into a laser beam
3. Reflection of a laser beam
Accidental Laser Exposure

This can be the result of:

1. Lack of adequate control of the laser environment.

2. Failure to follow correct procedures.

3. Malfunction of the equipment (particularly of protective features, e.g. interlocks).
General Safety Principles

• Laser radiation should be enclosed as far as possible, and access to it limited to the extent that is reasonably practicable.

• Levels of accessible radiation should be no greater than necessary.

• The existence of accessible laser hazards should be justifiable.
Summary of Laser Classes

Classes 1, 2 & 3R  No hazard (unless misused).
Classes 1M & 2M  No hazard to the unaided eye. Eye hazard with magnifying aids.

Class 3B  Eye hazard.
Class 4  Eye & skin hazard. Fume hazard. Risk of fire.

(Also, in service mode, if power levels equivalent to Class 3B or 4 are accessible.)
But:

The laser class identifies, in broad terms the **potential hazard** of the *accessible* laser radiation.

It does not define the **actual risk** of using the laser equipment.
Risk Assessment

1. What harm can be caused?
2. Under what circumstances can this happen?
3. How likely is this to occur?
Risk assessment: A Scoring Approach

Severity:
1 = Insignificant: Might see harmless diffuse laser reflections
2 = Minor: Temporarily affects vision but no permanent damage
3 = Severe: Permanent damage or loss of vision quality
4 = Major: Permanent and major loss of sight or vision quality.

Probability:
1 = Improbable: Possible to occur, but only in unlikely circumstances or very unreasonable use.
2 = Remote: Unlikely, but possible to occur at some time during expected lifetime of product
3 = Occasional: Might occur at some time during expected lifetime of product
4 = Probable: Reasonably expected to occur at some time during life of product
5 = Frequent: To be expected on every use of product although not necessarily occurring.
## Risk Assessment: A Scoring Approach

<table>
<thead>
<tr>
<th>Probability/Likelihood</th>
<th>Insignificant (1)</th>
<th>Minor (2)</th>
<th>Severe (3)</th>
<th>Major (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improbable (1)</td>
<td>Low Risk (1)</td>
<td>Low Risk (2)</td>
<td>Low Risk (3)</td>
<td>Low Risk (4)</td>
</tr>
<tr>
<td>Remote (2)</td>
<td>Low Risk (2)</td>
<td>Low Risk (4)</td>
<td>Medium Risk (6)</td>
<td>Medium Risk (8)</td>
</tr>
<tr>
<td>Occasional (3)</td>
<td>Low Risk (3)</td>
<td>Medium Risk (6)</td>
<td>Medium Risk (9)</td>
<td>High Risk (12)</td>
</tr>
<tr>
<td>Probable (4)</td>
<td>Low Risk (4)</td>
<td>Medium Risk (8)</td>
<td>High Risk (12)</td>
<td>High Risk (16)</td>
</tr>
<tr>
<td>Frequent (5)</td>
<td>Low Risk (5)</td>
<td>Medium Risk (10)</td>
<td>High Risk (15)</td>
<td>High Risk (20)</td>
</tr>
</tbody>
</table>
## Protective Control Measures

<table>
<thead>
<tr>
<th>CLASS</th>
<th>These should be implemented unless a risk assessment justifying the adoption of alternative protective control measures has been undertaken.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No protective control measures are necessary under conditions of normal operation. (This may not be the case under conditions of maintenance or service.) In the case of embedded laser products containing a laser of higher power, follow instructions given on the warning labels and supplied by the manufacturer. Special precautions may be needed for on-site servicing of embedded laser products.</td>
</tr>
<tr>
<td>1M</td>
<td>Do not direct the beam into areas where other people unconnected with the laser work may be present, unless they are known to be beyond the hazard distance of the laser. Prevent direct viewing of the laser source through magnifying viewing instruments (such as binoculars, telescopes, microscopes, optical sights or magnifying lenses, unless these incorporate adequate optical attenuation) within the area in which the laser is being used. (Note: the type of viewing aid that could be hazardous may be indicated on the warning label or in the user information supplied by the manufacturer. Prevent the use of any external optics that could decrease the beam divergence.</td>
</tr>
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</table>
# Protective Control Measures

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</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Do not stare into the beam. Do not direct the beam at other people or into areas where other people unconnected with the laser work might be present, unless they are known to be beyond the hazard distance of the laser.</td>
</tr>
<tr>
<td>2M</td>
<td>Do not stare into the beam. Do not direct the beam at other people or into areas where other people unconnected with the laser work might be present, unless they are known to be beyond the hazard distance of the laser. Ensure the beam is always terminated at a suitable non-specular (i.e. non mirror-like) surface. Prevent direct viewing of the laser source through magnifying viewing instruments (such as binoculars, telescopes, microscopes, optical sights or magnifying lenses, unless these incorporate adequate optical attenuation) within the area in which the laser is being used. (Note: the type of viewing aid that could be hazardous may be indicated on the warning label or in the user information supplied by the manufacturer.) Prevent the use of any external optics that could decrease the beam divergence.</td>
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</thead>
<tbody>
<tr>
<td>3R</td>
<td>Prevent direct eye exposure to the beam. \nEnsure the beam is always terminated at a suitable non-specular (i.e. non mirror-like) surface. \nDo not direct the beam at other people or into areas where other people unconnected with the laser work might be present, unless they are known to be beyond the hazard distance of the laser.</td>
</tr>
<tr>
<td>3B and 4</td>
<td>Class 3B and 4 laser products should not be used without first carrying out a risk assessment to determine the protective control measures necessary to ensure safe operation. \nWhere reasonably practicable, use engineering means, as specified in IEC 60825-1, to reduce the Class of the laser to below Class 3B. (This will normally mean completely enclosing the laser radiation to ensure Class 1 operation.)</td>
</tr>
</tbody>
</table>
Risk Assessment

- **What** harm can be caused by the laser equipment?
- **How** is the laser procedure carried out?
- **Where** is the laser being used?
- **Who** are the people at risk?
What? The Laser Equipment

The class of the laser - how hazardous is it?
The emission wavelength - what harm can it cause?
What other hazards are there (e.g. gas, fire, etc.)?
How?  The Treatment or Process

How is the laser procedure carried out?

What other hazards might the laser process introduce (e.g. fume, fire, gas, etc.)?

Under what conditions can these hazards occur?
Where? The Environment

Where is the laser being used?

How is this area laid out? (Consider doors, windows, furniture & other equipment.)

What sort of access is there into the laser area?
Who? The People

- Who is involved in the laser procedure?
- How aware are they of the hazards?
- How likely are they to follow required procedures?
- Who else might enter the laser area or be at risk of harm?
- How well are all personnel protected?
<table>
<thead>
<tr>
<th>Workplace</th>
<th>Fire</th>
<th>Other (list below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slips and trips</td>
<td>Services</td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>Working space</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Edge protection</td>
<td></td>
</tr>
<tr>
<td>Access and egress</td>
<td>Traffic routes</td>
<td></td>
</tr>
<tr>
<td>Obstructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>Electrical equipment</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Lifting equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workplace transport</td>
<td>Display screen equipment</td>
<td></td>
</tr>
<tr>
<td>Machinery</td>
<td>Pressure vessels</td>
<td></td>
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<tr>
<td>Hand tools</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>Repetitive work</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Noise</td>
<td>Electricity</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substances</td>
<td>Asbestos</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>---------------------</td>
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<td>--------------------</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Asbestos</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Dusts</td>
<td>Legionella</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Fumes</td>
<td>Biological</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Flammables</td>
<td>Body fluids</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
<td>Other (list below)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Processes</th>
<th>Other (list below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work at heights</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Confined spaces</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Outdoors</td>
<td>Other (list below)</td>
</tr>
<tr>
<td>Hot works</td>
<td>Other (list below)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Work Organisation</th>
<th>Other (list below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lone working</td>
<td>Workload</td>
</tr>
<tr>
<td>Violence and aggression</td>
<td>Stress</td>
</tr>
<tr>
<td>Driving</td>
<td>Working hours</td>
</tr>
<tr>
<td>Contractors</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>Other (list below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuts/burns</td>
<td>Other (list below)</td>
</tr>
</tbody>
</table>
1. The beam delivery-system

   *How is the beam delivered to its point of use?*

2. The possibility of errant beams

   *Could the beam deviate from its intended path, or be reflected from its point of use?*
A misdirected beam can cause injury, and set fire to things (and even cause explosions).
Levels of Risk -

- **High risk**: Unacceptable risk. Additional controls essential.
- **Medium risk**: Consider further controls, unless these are impractical or not cost effective.
- **Low risk**: Acceptable risk, unless further risk reduction can easily be achieved.
# Basic “Laser” Risk Assessment

The risk assessment may need to be supported by a written hazard evaluation or by other more detailed arguments.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>People at risk</th>
<th>Existing controls</th>
<th>Level of risk</th>
<th>Further action required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks inherent in the laser equipment (other than emission of laser radiation) –</td>
<td>Gas, chemical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of exposure to emitted laser radiation -</td>
<td>Eye and skin exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other risks associated with the laser process –</td>
<td>Fume, fire, plasma radiation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks arising from equipment malfunction –</td>
<td>Unexpected laser emission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks arising during beam adjustment or equipment servicing –</td>
<td>Misdirected beams Electric shock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risk reduction can be an iterative process to achieve safety.

Generic Example of Common Safety Hazard Analysis and Risk Assessment
Consider Finally:

What could go wrong
Supplemental Resources and Information

Can draw upon national and international consensus standards, including, but not limited to the following:

• **2006/42/EC** – European Machinery Directive
• **ISO/IEC 31010:2009** - Risk management -- Risk assessment techniques
• **ISO 12100:2010** – Safety of machinery – General principles for design – Risk assessment and risk reduction
• **ISO 13849-1:2006** – Safety of machinery – Safety-related parts of control systems – Part 1: General principles of design
• **IEC/ISO 60825-14** - Safety of laser products – Part 14: A user's guide
• **ISO 13849-1** - Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design
• **ANSI B11.0-2010** – Safety of Machinery – General Requirements and Risk Assessment
• **ANSI/RIA R15.06-1999 (R2009)** – For Industrial Robots and Robot Systems – Safety Requirements
Supplemental Resources and Information

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- **ANSI/RIA R15.06-1999 (R2009)** – For Industrial Robots and Robot Systems – Safety Requirements
- **NFPA 79-2012** – Electrical Standard for Industrial Machinery
- **ANSI/PMMI B155.1-2011** – Standard for Packaging Machinery and Packaging-Related Converting Machinery – Safety Requirements for Construction, Care, and Use
- **SEMI S10-0307** – Safety Guideline for Risk Assessment and Risk Evaluation Process
- **NOM-004-STPS-1999** – Protection Systems and Safety Devices for Machinery and Equipment Used in the Workplace