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Title:

Hazard Control Plan CST1-006
LIBS and Laser Ablation Dynamic Studies

Author(s):

Scott R.. Greenfield

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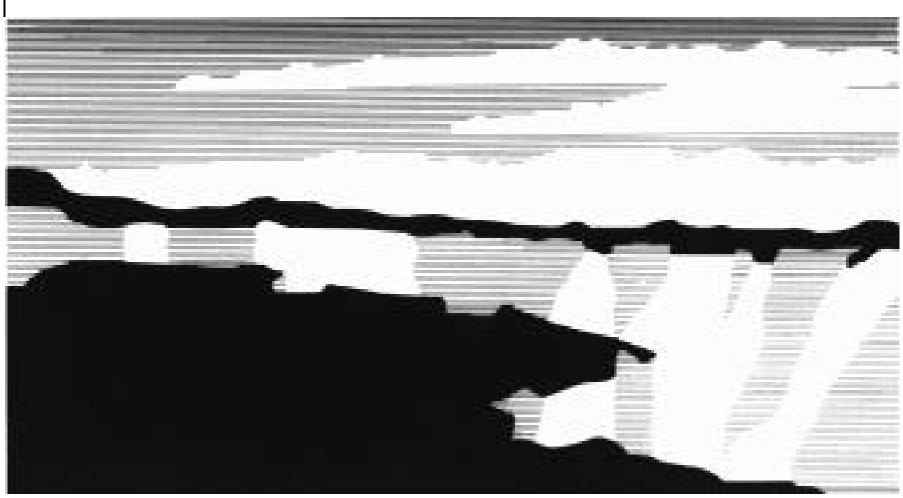

Los Alamos
NATIONAL LABORATORY

HAZARD CONTROL PLAN

Chemical Science & Technology Division

Title of Work

LIBS and Laser ablation dynamics studies

Activity/Task Identification Number(s)

Statement of Work

The work consists of laser ablation studies of various samples, including metals, polymers, and geological materials. LIBS experiments involve spectroscopically resolving the plasma emission from the ablated material. Laser ablation dynamics studies involve measurements of surface morphology changes after the ablation pulse but before or just following material ejection. Some samples require wet chemical preparation, others can be used as is. Modification of the experimental setup (optical and/or electronic) is periodically necessary, as is equipment repair.

Principal Author of the Plan

Scott R. Greenfield	JRO Postdoctoral Fellow	______________	________
Name	Title	Signature	Date

Names of Individuals Who Performed the Hazard Analysis (including Subject Matter Experts and independent peers)

Hazard Analysis performed by**:** Aaron Koskelo, Scott Greenfield, Joanna Casson, and Nancy Scherbarth
Subject Matter Experts: Cy Jakubowski
Independent peers:

Initial Risk Estimate ○ Minimal ○ Low ○ Moderate ● High

List of Work Permits Required to Perform Work

Residual Risk Estimate ○ Minimal ● Low ○ Moderate

Work Authorization

______________	______________	______________	________
Name	Title	Signature	Date

Authorization Expiration Date

Hazard Control Plan

1. Work Definition

A. Summary statement of work

The work comprises of optical experiments that involve laser ablation of materials.

B. Definition of tasks ***(List specific activities, sequence, duration, etc.)***

Due to the nature of the research, it is impossible to give the sequence and duration of any tasks, as these vary daily. Instead, tasks will be classified as frequent or infrequent.

<u>Frequent tasks:</u>

- Sample preparation: may include adding inert material (e.g., clay) and small quantities of hazardous analytes to acidic aqueous solution; drying samples; pressing samples
- Minor alignment of experiment: day-to-day beam alignment to optimize experiment
- Data acquisition
- Data analysis

<u>Infrequent tasks:</u>

- Major alignment of experiment: modifications to the optical setup
- Software development
- Electronics development
- Equipment repair/modification

C. Flowchart ***(Optional)***

D. Instrumentation/equipment used to execute the work

Lasers (commercial and home-built), monochromators, diode array, CCD, computers, power/energy meters, photodiodes, oscilloscopes, motorized translation stages, optics, high voltage power supplies, delay generators, hydraulic press, optical tables

E. Location of work ***(Technical Area(s), Building(s), Room(s), FMU(s))***

TA-46: Bldg 31, Rm 151A, and Bldg 41, Rm 110

F. Personnel performing the work

Aaron Koskelo, Scott Greenfield, Joanna Casson, and Nancy Scherbarth

G. Constraints of the facility and/or location in which the work will be performed

The work will be performed in the locations shown above, where the engineering controls given in section 3Bii are in place.

H. Effects on the environment, facility, and people in the vicinity

The work will be confined to the laboratories shown above, and will result in negligible emissions to the environment. Any generated hazardous wastes will be dealt with as per LIR404-00-03.0 (http://iosun.lanl.gov:1800/pdfs/ops/lir/LIR4040003.pdf) and other applicable laboratory policies.

I. Legacy issues associated with work ***(Consequences on human health and the environment resulting from the work)***

None

2. Identification of Hazards

A. Hazards checklist (***See attached; check all that are applicable***)

B. Discussion of initial risk (***High, medium, low, minimal; see matrix in Section 8.0, "Risk Determination," of LIR 300-00-01.0***)

Tables 1 and 2 summarize the work that was defined, the hazards that were identified, and the initial risks that were determined. The assessment of severity was determined from the worst possible consequence, the likelihood was assessed as the probability of occurrence in the absence of any controls or hazard mitigation and the assignment of risk was then made according to LIR 300-00-01.0. The initial overall risk estimate of "high" is due to the existence of one or more individual hazards of high risk.

3. Hazard Assessment and Controls

A. Methodology (***Describe which hazard screening technique (What-if, HAZOP, or FMEA) will be employed. Identify ES&H subject matter experts and/or independent peer(s) as required in Section 7.3 of LIR300-00-01.0***)

- The "What-if" hazard screening technique was employed on August 11 and 12 by the individuals listed on the first page.
- ES&H subject matter experts: Cyril Wm. Jakubowski, CSP
- Independent peers:

B. Controls (***List hierarchy of controls and discuss all controls necessary to mitigate the hazards***)

i. Elimination/substitution
ii. Engineering controls (***Fume hoods, interlocks, shielding, etc.***)
iii. Administrative controls (***Procedures, work permits, training requirements, etc.***)
iv. Personal protective equipment (***Gloves, face mask, etc.***)

Part of the work done in Rm 110, Bldg. 41 involves sample preparation, and falls under the LANL Chemical Hygiene Plan (LS106-01.0, http://iosun.lanl.gov:1800/pdfs/ops/ls/ls106010.pdf). As such, the controls for the chemical hazards in that lab are covered by this plan. The Chemical Hygiene Plan does not apply to the work in Rm 151A, Bldg 31, which falls under the scope of HazCom (29 CFR 1910.1200). As per the HazCom standards, a chemical inventory for that lab exists and is included as Attachment 1.

i. Elimination/substitution

- None of the hazards are mitigated by elimination/substitution

ii. Engineering controls

- <u>Access control</u>:
  For both labs, room access has been restricted at all doors. In Rm 151A, Bldg 31, both doors have a combo lock. In Rm 110, Bldg 41, there is a combo lock on the door to the hallway; the door to the adjacent lab (Rm 106) does not, but access to Rm 106 from the hallway is restricted by a combo lock. This prevents unauthorized and untrained personnel from entering either lab, mitigating many of the hazards.
- <u>Laser Interlocks</u>
  All doors are interlocked to the power supply of the main lasers. When the shutter of any of the YAG lasers is open, Class 4 laser radiation is present in the room and “red” operation is mandatory. Operation on “yellow” will be restricted to power-on for the main lasers, but with the internal shutter closed so that no laser radiation is emitted. If any door is opened under “red” operation, the laser power supply is completely shut off, and all Class 3b and 4 laser radiation is terminated. (A third door in Bldg 31, Rm 151A has been removed from service with slide bolts on both sides.) Thus, no one can enter the room while hazardous laser radiation exits.
- <u>Hood</u>
  A certified hood will be the location for all sample preparation involving volatile hazardous chemicals and/or particulate. This will greatly reduce the inhalation risks associated with working with these materials.
- <u>Sample enclosure</u>
  A vented enclosure will be the location of the sample for all ablation experiments that can produce hazardous particulate.
- <u>Flammable cabinet</u>
  An appropriate flammable cabinet is present for the storage of all inflammable chemicals, reducing the risk of fire.
- <u>Vented oven</u>
  The oven is vented to the hood, reducing the risks due to any vapors produced by the heating of items put in the oven
- <u>Hydraulic press blast shield</u>
  A blast shield is attached to the hydraulic press, reducing the risks due to press failure while under pressure

- HEPA vacuum
  An ES&H-certified HEPA vacuum exists for periodically cleaning up the ablated particulate in the sample enclosure, reducing the risks due to those particulate. A damp rag may also be used in conjunction with the HEPA vacuum for cleaning the sample enclosure.
- Satellite storage facility
  A satellite storage facility exists outside of Rm 110 in Bldg. 41. Use thereof is the first step in the safe disposal of hazardous waste.
- Secondary containment
  Proper secondary containment exists for the storage of all pertinent chemicals, and for the transport (by foot) of chemicals within the site, thus reducing the risks due to spills.
- Gas cylinder accessories
  Proper wall holders and carts are used for the storage and moving, respectively, of compressed gas cylinders, reducing the risk of the explosive release of cylinder pressure.
- GFI outlets
  All 120V outlets in Rm 151A, Bldg 31 are GFI, virtually eliminating the risks due to electrical hazards (resulting from ground faults) for equipment plugged into those outlets.

iii. Administrative controls

- Training: see Sections 5A&B below
- Protocol for entering laser lab during red operation
  Entry into labs while hazardous laser radiation is present is prevented by engineering controls (*vide supra*). If entry is desired under these conditions, the operator must close the laser shutter (eliminating any laser radiation) and switch from “red” to “yellow”. At this point, authorized personnel may enter by using the door lock code, or the operator may let anyone in. “Red” operation will not resume until the operator has verified that all personnel are using the appropriate PPE (*vide infra*), and that unauthorized personnel have sufficient training to be present.
- Protocol for major laser alignment
  Major laser alignment is defined as the addition or subtraction of optical elements (e.g., lens, mirror, etc), or the adjustment of any optical elements that causes the beam to deviate from its original path. The guidelines are:
  1. There will be as few personnel in the lab as necessary.
  2. The laser system will be operated at as low power as possible to accomplish alignment.
  3. Whenever new components have been added, or old components moved, a careful check will be made to locate and block all stray reflections.

4. As much as possible, alignment will be performed in sections, with down beam sections blocked completely.

- Protocol with respect to security badge while working with laser

  The security band hanging at chest-level poses a nontrivial risk of eye damage, as it can easily dangle in front of the beam if the worker is leaning over the table. Since the badge and its pouch are fairly reflective, they pose a eye-damage hazard. Therefore, before leaning over a table with a beam, the worker must safely stow the badge (e.g., put in shirt pocket, put under shirt, or remove).
- Protocol for use of IR card

  IR cards are purposely put in front of IR beams. They are fairly reflective, and therefore constitute an eye hazard. Workers must place the card in the beam in such a fashion as to avoid allowing the reflection to hit anyone in the room.
- Protocol for optical system design

  Whenever possible:
  - All laser beams will remain in the horizontal plane at roughly waist level.
  - Polarizers with escape window(s) will be installed so that the beam(s) leaving said windows remain in the horizontal plane. The orientation of such polarizers will be fixed, with any polarization adjustment done with a waveplate or a polarizer without escape windows.
  - All stray reflections and others unwanted beams will be blocked by appropriate beam dumps.

  These will reduce the likelihood eye damage by reducing the likelihood of a beam reaching eye level, or of leaving the table top.
- Protocol for electronic work
  - All electrical devices that are plugged into 120V outlets in Rm 151A, Bldg 31 are GFI–protected and fall under Table 2.1 of LIG402-600-01.0. As such they can be worked on in any state by a lone qualified person.
  - Rm 110, Bldg 41 is not GFI-protected, and all electrical work on systems with access to >50V will fall under Table 2.2. If at all possible, the equipment will be moved to Rm 151A, Bldg 31 for non-de-energized work, where it can be plugged into a GFI outlet.
  - The laser power supply in Rm 151A, Bldg 31 (Coherent Antares) falls under Table 2.2, and requires two people and an SOP or SEWP for diagnostics and testing work.
- Protocol for reducing tripping hazards

  Power cords for equipment on or under the laser table will be plugged into outlets on or under the table to avoid stringing them across aisles. Free-standing equipment (e.g., oscilloscopes on carts) will generally also be plugged into table outlets, unless the tripping hazard would be lessened by plugging into wall outlets. Cables and tubing that must be laid across aisles (e.g., the Antares' umbilical cord) should be covered by appropriate and clearly marked cable bridges and should be placed in areas of minimal traffic. The lab floor will remain uncluttered.

- Labeling
  All chemicals and hazardous waste will be properly labeled, reducing a multitude of risks that these items pose to personnel and the environment. Items removed from the oven will be labeled as hot whenever the opportunity exists for another worker to accidentally touch said items.
- Food and drink
  No food or drink is allowed in either lab, reducing the risk of chemical ingestion.
- Protocol for use of carbon disulfide (CS_2)
  CS_2 is a Category I Chemical (known human reproductive toxin). It is used in Rm 151A, Bldg 31 to set t=0 for the laser experiment. A few milliliters are put in a sealed spectrophometric cuvette, which is then placed at the crossing point of the IR and visible laser beams. The CS2 is stored in a flammable cabinet, and the transfer into the sample cell is done in a hood. Proper PPE are used while working with CS2 (gloves, glasses, and lab coat).

iv. Personal protective equipment

- Appropriate Laser protective eye wear
  To be worn whenever conditions call for "red" operation. Will protect workers from laser beam if engineering and administrative controls fail.
- Safety glasses
  To be worn when working with chemicals, hand tools that pose an eye hazard (e.g., drilling, wire cutters), compressed gases, when handling laser (arc or flash) lamps, and when doing soldering.
- Hearing protection
  Hearing protection is to be worn in Rm 110, Bldg 41 when performing ablation experiments. A measurement of the noise level by the CST-25 ES&H Team should be done to determine if hearing protection is necessary.
- Chemical gloves and labcoat
  A labcoat or apron and appropriate gloves are to be worn when handling chemicals to reduce to risk of skin exposure.
- Thermal gloves and tongs
  Thermal gloves and tongs are to be used when putting items in or removing items from the oven to reduce the risk of burns.

General lab and division policy for appropriate lab attire (no shorts, no open shoes) will be followed.

C. Support dependencies (e.g., external support needed to ensure conformance to ES&H requirements, security, material control and accountability, etc.)

Regular maintenance of utilities and other support services necessary to maintain controlled access and adequate ventilation is provided by CST-25, the facilities management group for TA-46. Waste management is conducted by communication of staff with CST-25 waste coordinator for scheduling waste disposal and guidance in proper management of waste and waste profile forms.

D. Residual Risk Determination

i. Summary of risk analysis

In all cases, the residual risk is decreased to low or minimal using the controls described above.

ii. Discussion of residual risk (***High, medium, low, minimal; see matrix in Section 8.0, "Risk Determination," of LIR 300-00-01.0***)

The residual risk as well as the residual severity and likelihood are also listed in Tables 1 and 2 for each hazard.

4. Supporting Documentation for Performing Work

A. List of applicable facility documents (***E.g., Facility's checklist, Safety Analysis Reports, etc***.)

Believed to be none valid for CST

B. List of applicable Laboratory policies (***E.g., Laboratory Implementation Requirements (LIRs), Administrative Requirements (Ars), etc***.)

- AR 1-3 Safe Operating Procedures and Special Work Permits
- AR 1-8 Working Alone
- AR 1-9 Hazard Communication
- AR 6-2 Workplace Monitoring for Chemical, Physical, and Biological Hazards
- AR 10-8 Waste Minimization
- AR 11-2 Fire Protection
- AR 12-1 Personal Protective Equipment
- AR 14-1 Pressure Systems Including Compressed Gas Systems
- LIR402-400-01.0 Lasers
- LIR402-600-01.0 Electrical Safety
- LIG402-600-01.0 Electrical Safety Implementation Guide
- LIR404-00-03.0 Hazardous and Mixed Waste Requirements for Generators
- LP106-01.2 Lockout/Tagout for Control of Hazardous Energy Sources for Personnel Safety (Red Lock Procedure)
- LP106-02.1 Lockout/Tagout for Control Equipment and System Status (Blue Lock Procedure)
- LS106-01.0 Chemical Hygiene Plan
- TB 1101 Fire Extinguishers
- TB 1201 Eye and Face Protection
- TB 1402 Compressed Gases

C. List document numbers of applicable Special Work (SWPs) and Radiation Work permits

None

D. List document numbers of applicable Standard Operating Procedures (SOPs)

CST-SOP-330 (Bldg 31, Rm 151A) and CST-SOP-193 (Bldg 41, Rm 110)

E. Other supporting documentation (Optional)

5. Supporting Documentation for Workers

A. Formal training requirements (***List of training required to enable worker authorization***)

All persons must have the following training:

- Laser Safety Orientation (course #670, every 3 years thereafter Laser Safety Update, course #3565)
- Waste Generation Overview (course #8477, suggested every 2 years thereafter)
- Hazard Communication Introduction (course #2398)
- CST Chemical Hygiene Plan Training: video "Keys to Laboratory Safety" (contact Alice Rodriguez at 5-8311), and LS106-01.0 (http://iosun.lanl.gov:1800/pdfs/ops/ls/ls106010.pdf)

Those persons doing work on electrical components involving voltages of >50V must have the following training:

- CPR-Adult (course #3583, every 12 months)
- Electrical Safety in the R&D Laboratory (course #11627, every 3 years)
- Lock Out/Tag Out (was course #6713, now course #13337, every 2 years)

Those persons doing work with compressed gasses must have the following training:

- Gas Cylinder Safety (course #9518)
- Pressure Safety Orientation (course #769)
- All persons who work with pressures >150 PSIA shall take the Intermediate and High Pressure Safety Course (course #11459)

In addition, all persons must be registered as a laser user with ESH Div. (LANL form 1556, Registration for Laser Area Personnel)

B. On-the-job training requirements (***List of on-the-job training required to enable worker authorization***)

All persons must:

- read and understand this HCP
- discuss specific operations, hazards and questions with the supervisor

- sign the HCP Awareness signature sheet (Attachment 2)
- keep a current copy of this HCP in the laboratory where it will be used
- be familiar with the locations and procedure for using the nearest eye wash station, safety shower, and location of the nearest spill control kit; review the MSDSs for the chemicals used in these procedures; be familiar with Laboratory policy for proper disposal of hazardous waste.

C. Qualifications of subject matter experts (***Optional***)

D. Training documents and records (***Can be located on Laboratory EDS or CST ISM database***)

6. Change Control

Change triggers are changes that warrant review of the Hazard Control Plan. If significant changes are made in any of the following, then reevaluation and appropriate modification of the Hazard Control Plan must be performed before work can continue.

i. Introduction of new hazards
ii. Changes to engineering controls
iii. Changes to administrative controls

7. Work Authorization

A. Summary (***Brief, executive summary of Hazard Control Plan by level of management determined by matrix in Section 7.3.3, "Authorization of Work," of LIR 300-00-01.0***)

B. Authorization signature (***On Hazard Control Plan cover page***)

9. Worker Authorization

A list of authorized workers and managers providing authorization will be maintained on the CST ISM database. Reauthorization as needed, but at least annually.

<u>Attachment 1</u>: Chemical Inventory for the Laser Ablation Dynamics Laboratory (TA-46, Bldg 31, Rm 151A)

Chemical	**Quantity**
Methanol	1000 ml
Acetone	25 ml
Glycerol	10 ml
Carbon disulfide	25 ml
Polydimethylsiloxane	40 lbs
N_2 (gas)	standard cylinder

Product	**Quantity**
Antifreeze	1 gallon
Tetrafluoroethane (Vari-air)	2 can (8 oz ea)
Corona dope	2 oz
Pre-cote 33	1 spray can
FC-104 index matching fluid	150 ml
FC-43 index matching fluid	50 ml
Silicone heat sink compound	1 oz
5-minute epoxy	25 ml
superglue	2 g
Swak	150 ml
Snoop	8 oz
Spray paint (enamel)	12.5 oz
Spray paint (high temp.)	12.2 oz
3-in-1 oil	3 oz
Spindle oil	6 oz
Aerokroil oil	10 oz
Loctite	10 ml
Lubiplate	14 oz
Epoxy (Huntington)	8 oz
Epoxy (Devcon Al)	6.8 oz
Epoxy (Armstrong)	ca. 10 oz
Krytox	8 oz
Epoxy-patch	ca. 8 oz
Silicone II (sealant)	2.8 oz
Drierite	2 lbs
Vacuum grease	150 g
732 RTV	8 oz