LABORATORY SAFETY

IESL-FORTH

P. Samartzis

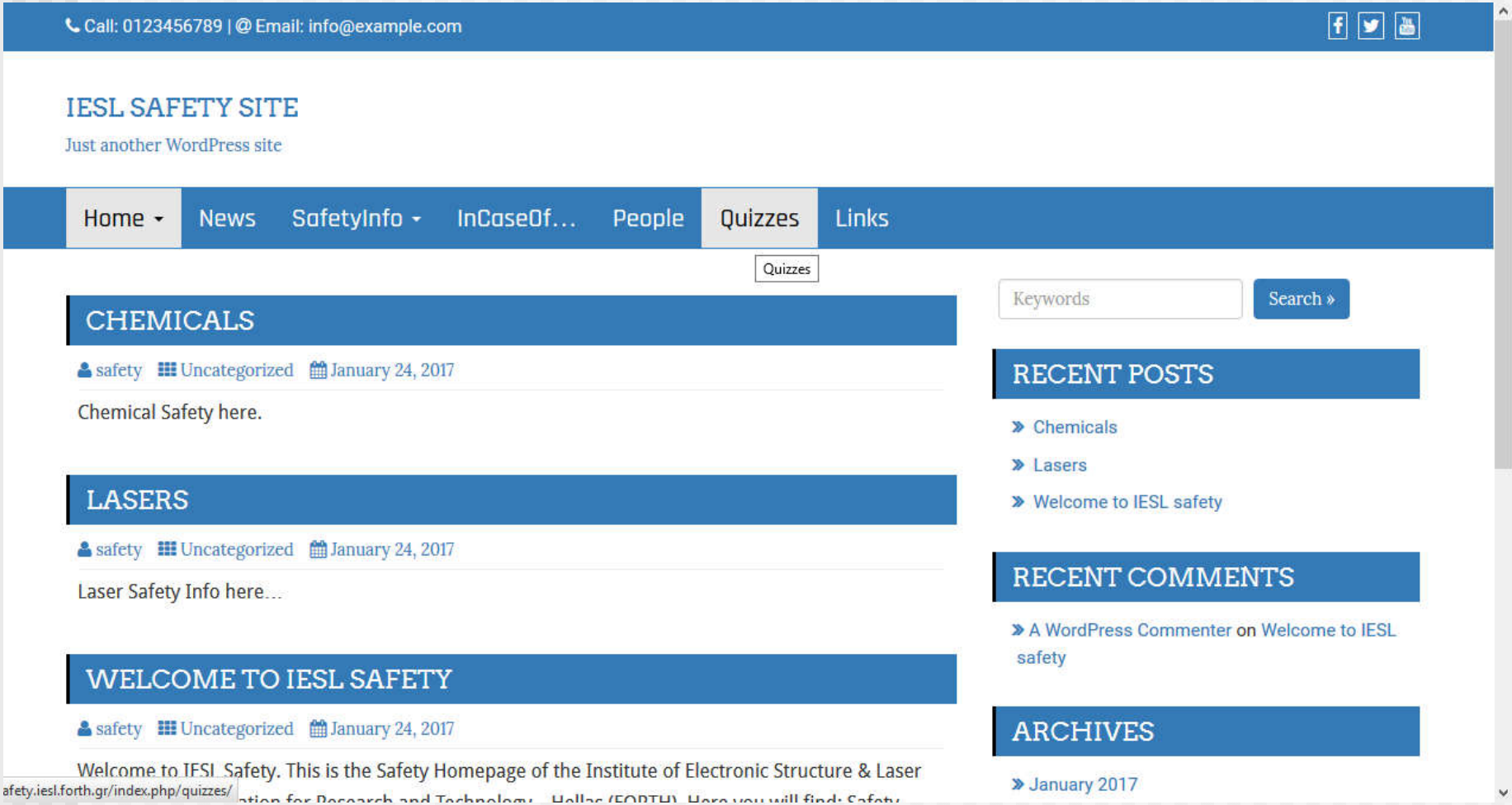
05/04/2017

LABORATORY SAFETY

- GENERAL LAB SAFETY
- LASER SAFETY
- CHEMICALS & WASTE HANDLING
- ELECTRICAL SAFETY
- PRESSURE SAFETY (HIGH & VACUUM)
- CRYOGENICS SAFETY
- FIRE SAFETY

http://safety.iesl.forth.gr

IESL safety site: needs content & style



http://safety.iesl.forth.gr

LABORATORY SAFETY

GENERAL LAB SAFETY

RULE NUMBER ONE:

SAFETY

IS OUR FIRST

PRIORITY

GENERAL RULES

- You are responsible for your safety
- Safety training mandatory before working in the lab
  - Lab-specific safety training
- Use of appropriate safety equipment is mandatory in the laboratories: get familiar with them
- Consider SAFETY when designing an experiment
  - Safeguard continuously working equipment
  - Avoid working alone in the lab
- Keep labs clean and tidy
- No access of un-authorized personnel in the laboratory (especially kids)
- No food & drinks in the lab
- Use common sense
- If in doubt, ASK!

SAFETY CONTACTS

- Group/Activity Safety Officer
  - Principal Investigator
- Division Safety Officer
  - Lasers: Petros Samartzis (x1467)
  - Materials: Benoit Loppinet (x1465)
  - Microelectronics: Ilias Aperathitis (x4123)
  - Comp. Center: Vassilis Kirkinis (x1815)
- IESL Safety Officer: Petros Samartzis
  - Office: Γ260 – Phone: x1467
  - Lab: B217 – Phone: x1333
  - Email: sama@iesl.forth.gr

In Case of an Incident

- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel
- File an accident report

- **<u>USE COMMON SENSE</u>**

http://safety.iesl.forth.gr

LABORATORY CARD

ΕΡΓΑΣΤΗΡΙΟ : Β-207

ΥΠΕΥΘΥΝΟΣ ΕΡΓΑΣΤΗΡΙΟΥ : Α. Εγγλέζης
Τηλέφωνο : -1327(γρ), 2810-318765(σπ),

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ : Δ. Αγγλος (D. Anglos)
Τηλέφωνο : -1154 (γρ), 2810-235392 (σπ), 693 7748630 (κιν)

Τηλέφωνα άμεσης ανάγκης – Call for Emergency

Τεχνική Υπηρεσία	-1094, -1095	Building service
Πύλη ΙΤΕ (Φύλάκας)	-1111	FORTH gate
Πυροσβεστική	199*	Fire Department
Αστυνομία	100*, 2810-282316*	Police
ΕΚΑΒ	166*	
ΠΕΠΑΓΝΗ	2810-392111*	University Hospital
Βενιζέλειο	2810-237502*	Venizelio Hospital

* Για εξωτερική γραμμή πρώτα το 9 (Dial 9 to get an outside line)

INCIDENT REPORT

Ονομα – Επώνυμο	**:**
Ιδιότητα (Ερευνητής, φοιτητής)	**:**
Ημερομηνία	**:**
Εργαστήριο	**:**
Επιστημονικός Υπεύθυνος	**:**
Είδος ατυχήματος :	Τραυματισμός Υλικές ζημιές Φωτιά
Πηγή ατυχήματος :	Λέιζερ Ηλεκτρική τροφοδοσία Χημικά Τροφοδοσία νερού
Περιγραφή ατυχήματος:	**…**

http://safety.iesl.forth.gr

A message from Technical Service

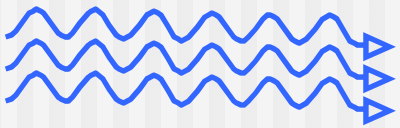
Don’t abuse building facilities

LABORATORY SAFETY

LASER SAFETY

IESL LASER SOURCES

- Solid state (Nd:YAG: 1064/532/355/266 nm, TiSapph: 800 nm)
- Gas lasers (HeNe: 632.8 nm)
- Excimer (KrF:248 nm, ArF:193 nm, XeCl:308 nm)
- Dye lasers (220-800 nm)
- Diode lasers (e.g. femto lasers pump units)



Coherence,
Monochromaticity,
Directionality

LASER PARAMETERS I

- Emission wavelength (UV, Visible, IR)
- Output power/energy (mW-W, nJ-kJ)
- Pulse duration (cw, ns, ps, fs)

Band		Wavelength
Ultraviolet (UV)	**UV-C**	**200 – 280 nm**
	UV-B	**280 – 315 nm**
	UV-A	**315 – 400 nm**
Visible (VIS)		**400 – 700 nm**
Infrared (IR)	**IR-A**	**700 – 1400 nm**
	IR-B	**1400 – 3000 nm**
	IR-C	**3000 – 1 mm**

LASER PARAMETERS II

- Radiant Power: P (W)
- Laser pulse energy : $E = \int P(t)dt$ (J)
- Laser pulse peak power : $P = E/\Delta\tau$ (W)

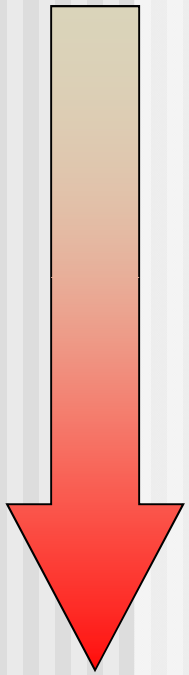
  $\Delta\tau$: temporal pulse width (FWHM)
- Irradiance, Power density: $I = P/A$ (W/m^2)
- Energy density (flux) : $F = E/A$ (J/m^2)

  A : irradiated area
- Brightness : $\beta_v = P(v) /A\ \Delta\Omega\ \Delta v$ (W/cm^2srHz)

  Sun (580 nm; 5800 K) ≈ $1,5x10^{-12}$ W/cm^2srHz

  He-Ne laser (1 mW, 632,8 nm) ≈ 25 W/cm^2 sr Hz
- Intensity : $I(v) = P(v) /A\ \Delta v$ (W/cm^2Hz)

LASER CLASSES

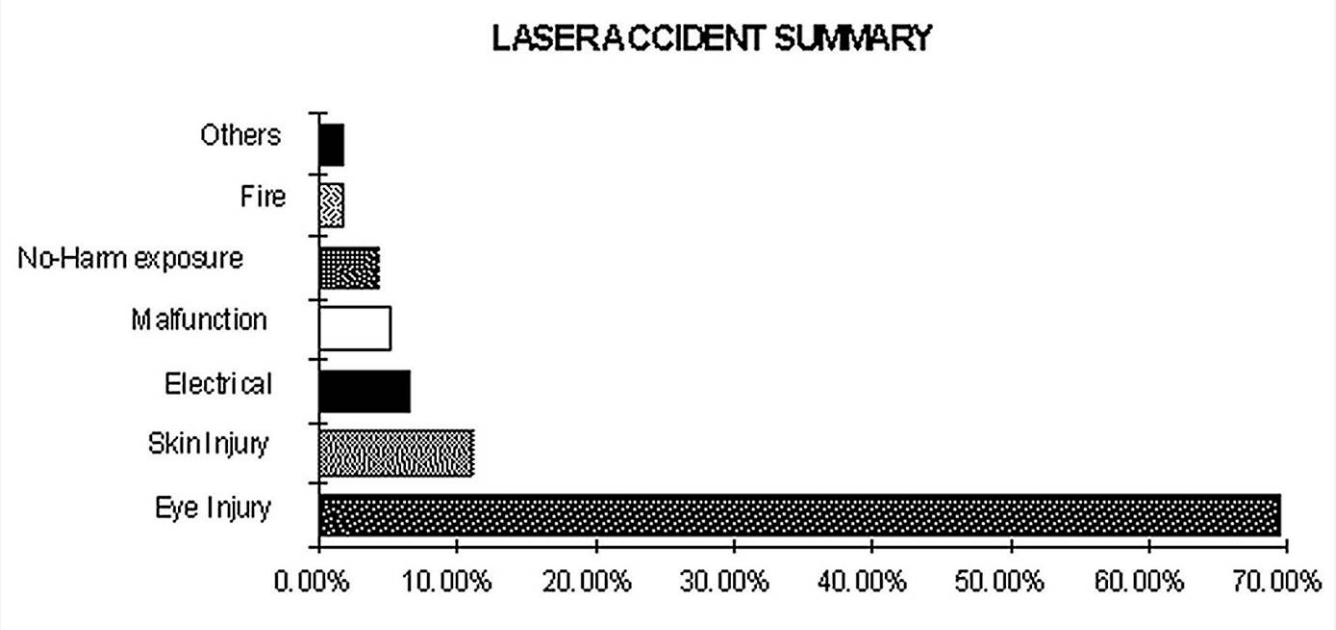


- **CLASS 1** harmless
- **CLASS 2** visible radiation
  momentary exposure (0.25s)
- **CLASS 3** 3a (1 – 5 mW)
  3b (5- 500 mW)
  no direct exposure
- **CLASS 4** Pulse or cw (>500 mW)
  Extremely hazardous

ALL lasers in IESL labs are CLASS 4

LASER ACCIDENTS

Laser accidents (USA, 1964-1992)



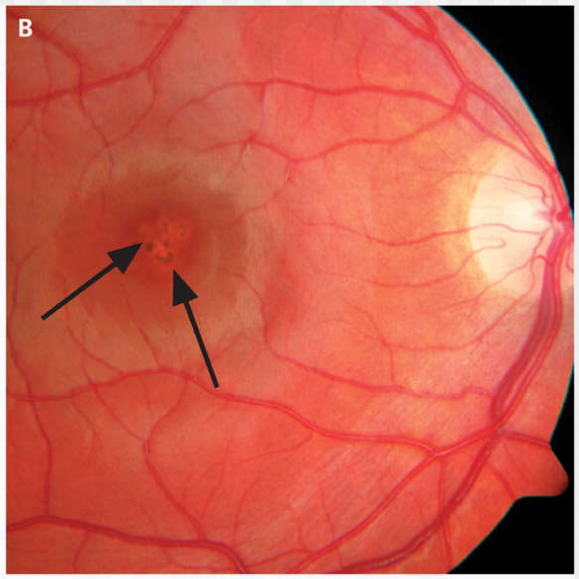
Most accidents involve eye injuries

http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html

LASER RADIATION DAMAGE

- **EYES**

150 mW
green laser pointer
(532 nm)



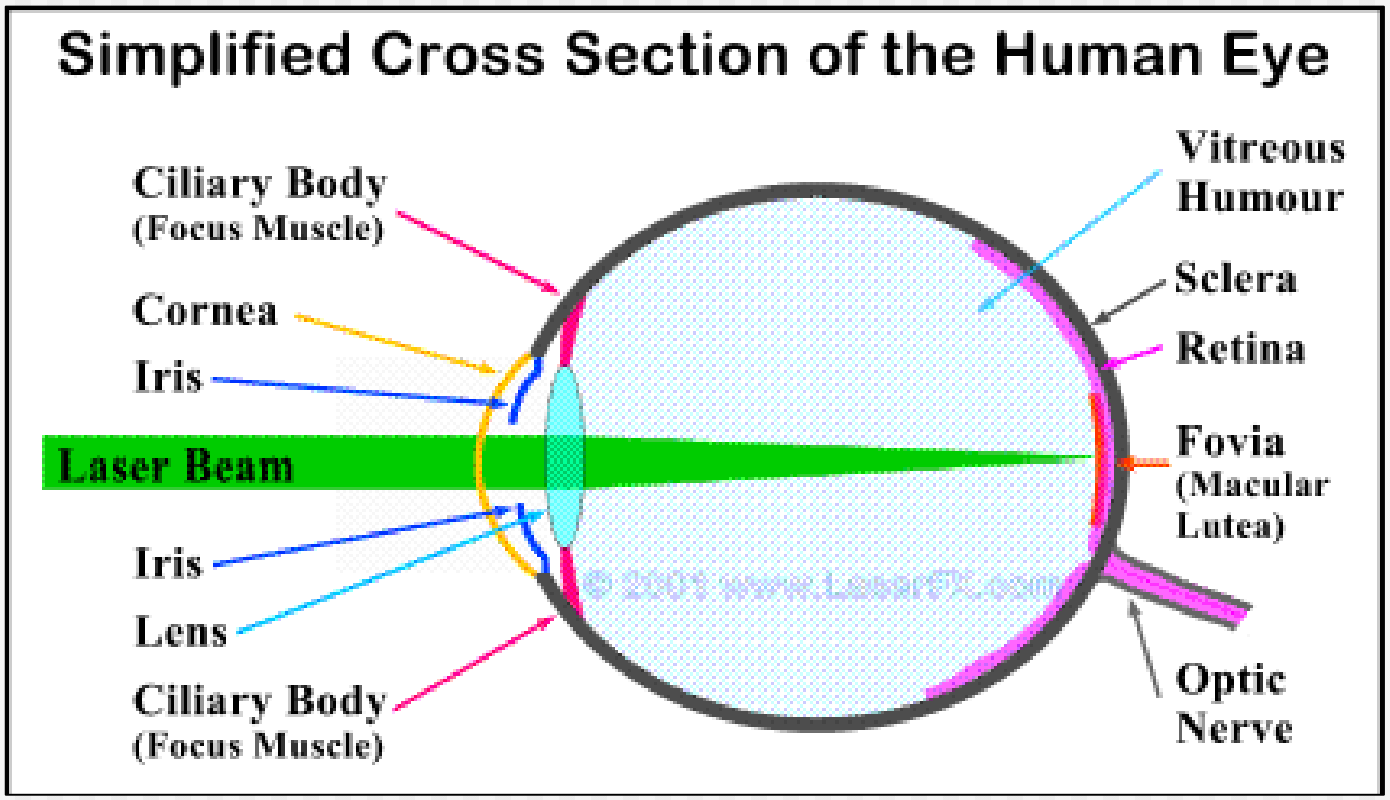
http://www.nejm.org/doi/full/10.1056/NEJMc1005818#t=article

- **SKIN**

5W/cm^2 for 1 sec
CO_2 laser
(10,6 μm)

http://www2.lbl.gov/ehs/safety/lasers/bioeffects.shtml

LASER vs HUMAN EYE



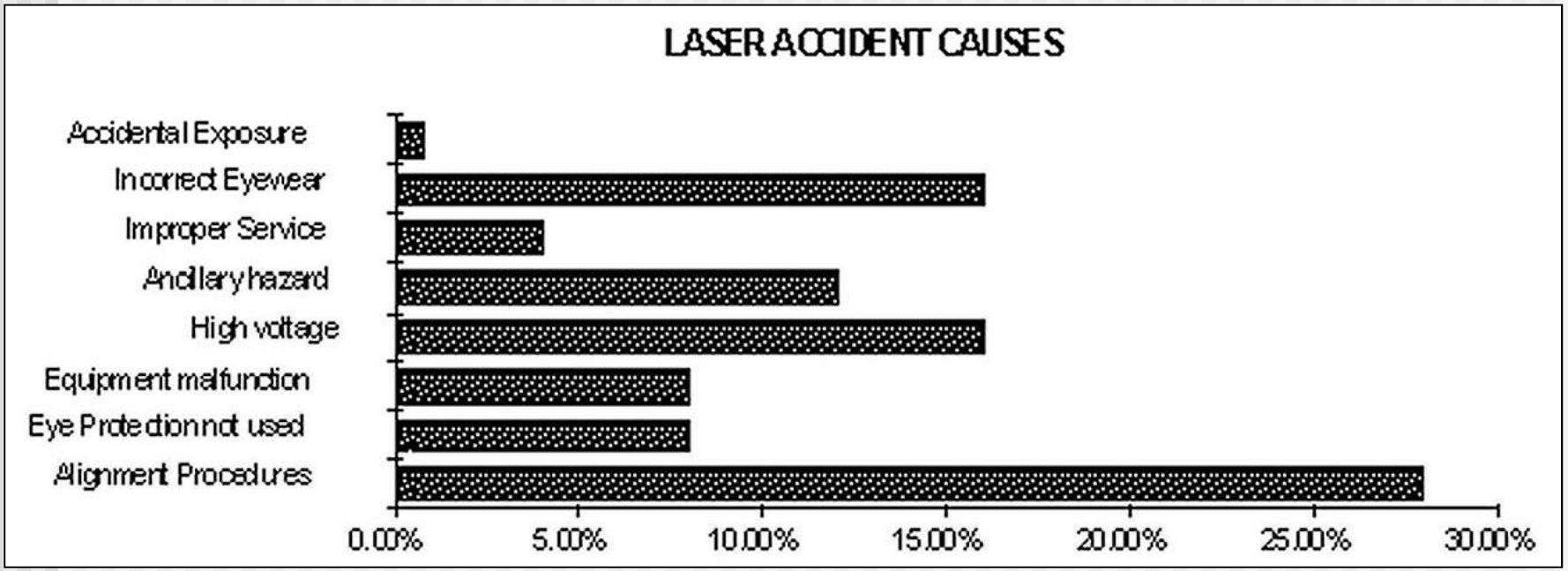
Cornea (κερατοειδής) : 1400 nm – 1mm & 180 nm – 315 nm

Lens (Φακός): 315 nm – 390 nm & 700 nm – 3000 nm (sel.)

Retina (αμφιβληστροειδής): 400 nm – 1400 nm

LASER ACCIDENT CAUSES

Cause of Laser accidents (НПА, 1964-1992)



Most accidents take place during beam alignment or/and because no proper eyeware was used

http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html

1st TAKE

Incident ALERT Message from Performance Surety

FOR DETAILS:

- **Occurrence Report:** ALO-LA-LANL-CHEMLASER-2004-0001
- **PS-7 Occurrence Investigators:** Matt Hardy, 667-6335; Rita Henins, 665-6981

An additional alert about this event will follow if the investigation reveals details that indicate an unknown hazard exists for other employees involved in this type of activity. For more information about "1st Take," please call LANL PS-7 at 665-0033.

August 18, 2004
LANL CHEMLASER 2004-0010

Student sustains laser eye injury

On July 14, 2004, an undergraduate student employed by another government agency was injured while performing work with a Class IV neodymium (Nd:) YAG laser at Los Alamos National Laboratory. The student came to the Laboratory to work with a LANL scientist investigating the potential use of lasers in studying the composition of comets.

The scientist and student had set up a laser experiment designed to suspend and then analyze particles inside a vacuum target chamber using an unusual configuration that was neither described nor analyzed in work control documents. The experiment used a Particle Generating (PG) laser to suspend the particles and the (Nd:YAG) Laser Induced Breakdown Spectroscopy (LIBS) laser to vaporize the suspended particles. The PG laser was aligned vertically to allow the beam to enter through the top of the target chamber; the LIBS laser was aligned horizontally to allow the beam to enter through a side window. The scientist energized both laser power supplies and was operating the LIBS laser with the Q switch trigger cable disconnected (a mode the scientist believed did not allow the LIBS laser to produce a laser beam). With the Q switch disabled and the LIBS laser's flashlamps operating, the scientist believed that only white light exited the laser's optical tube and traveled down the laser beam path. The scientist wanted to demonstrate that the PG laser could suspend particles from the sample and intended to use the light from the LIBS laser to illuminate the suspended particles and make them visible inside the target chamber.

The scientist fired and secured the PG laser and then observed the suspended particles illuminated by the LIBS laser inside the target chamber. He told the student he could see suspended particles and invited the student to take a look. As the student bent down to look into the chamber, she saw a flash and subsequently noted a reddish brown substance floating in her left eye. Neither the scientist nor the student were wearing laser eye protection. The student was taken to LANL's occupational health facility (HSR-2) and was referred to several eye specialists. Laser eye damage was confirmed. The student continues to experience loss of central vision in her left eye.

Laser operations were suspended and the LANL Director assembled a team to investigate the accident, determine the causal factors, and make recommendations.

Experimental setup showing the target chamber and the LIBS laser

Re-creation of target viewing position

Initial Analysis

The investigation is nearing completion and formal findings will be made available in a few weeks after corrective actions are developed and incorporated. Lines of inquiry have included the use of personal protective equipment, the mentoring and supervision of students, management oversight and control of work/workers, and the reporting and notification process for abnormal events. Laboratory measurements were made to characterize the conditions and configuration believed to have existed when the accident occurred. Measurements indicated that the student could not have received a laser eye injury under these conditions because the LIBS laser did not emit a beam in this configuration. Consequently, the team is evaluating if other configurations could have resulted in the accident.

Initial Recommendations

Management Level: Managers should:

- Ensure that required safety practices are implemented in the workplace;
- Ensure training requirements are completed before authorizing work;
- Ensure that personal protective equipment is used;
- Ensure laser personnel complete a baseline eye examination;
- Ensure changes to work and associated changes in work configuration are authorized, and that these changes are addressed in work control documents; and
- Provide LANL employees with this "1st Take," either through Nested Safety meetings or required reading programs.

Worker Level: Workers should:

- Know the hazards of their experiment;
- Wear specified laser eye protection as required;
- Challenge unsafe or questionable behavior, and if you're not sure, *ask*;
- Use interlocks as designed; and
- Prevent eye exposure to direct or scattered radiation from a Class IV laser.

More information will be provided to employees in the "Final Take" alert message from Performance Surety.

GUIDANCE: Resources at hand

For more information related to laser safety you can refer to:

- Lasers LIR 402-400-01.3
- Laser Safety: Class 3b or 4 Self Study Course No. 17817
- American National Standards Institute Z136.1 (Safe Use of Lasers)
- Lessons Learned: Operational Experience Summaries, 2nd Quarter - 2004 (http://www.eh.doe.gov/paa)
- Occurrence Report: ALO-LA-LANL-CHEMLASER-2004-001
- Occurrence Report: OAK-LBL-MSD-2003-0001
- Occurrence Report: ALO-LA-LANL-FIRNGHELAB-1999-0002
- Occurrence Report: ALO-LA-LANL-FIRNGHELAB-1998-0002

Experimental setup showing the target chamber and the LIBS laser

Re-creation of target viewing position

REFLECT ON THIS

Small fraction (4%) of pulsed laser beam, diameter 2 mm, with energy of 2.5 mJ/pulse, reflected from a piece of optic has energy density of :

$$(0.04 \times 2.5\ \text{mJ})/(\pi \times (0.1)^2\ \text{cm}^2) = 3.2\ 10^{-3}\ \text{J}/\text{cm}^2$$

This exceeds the damage threshold of the cornea ($\sim 10^{-7}$ J/cm^2) by a factor of $3.2\ 10^4$.

Protection for this level of exposure requires the use of appropriate laser eye-ware with optical density at the laser wavelength :

$$(\text{OD}) = \log(3.2\ 10^4) = 4.5$$

LASER SAFETY PRACTICE

- **USE APPROPRIATE LASER PROTECTION EQUIPMENT**
  - **GOGGLES**
  - **LAB COATS**
- **NEVER look directly at the laser beam**
- **Beware of & minimize/block REFLECTIONS**
- **Always know where your beam (and reflection) is**
- **Keep experiment WAY BELOW eye level**
- **Protect others around you**
  - **Laser light ON**
  - **Use protective panels**

In Case of a Laser Incident

- Remain calm!
- Assess the situation
- Call for help
  - Turn laser source off to protect others
- Seek medical attention
- Contact safety personnel
- File an accident report

http://safety.iesl.forth.gr

LABORATORY SAFETY

CHEMICAL SAFETY & WASTE HANDLING

LAB CHEMICALS

- **Flammable**: e.g. organic solvents, H_2
- **Explosive**: e.g. acetylene, azides
- **Pyrophoric**: e.g. phosphor
- **Toxic**: e.g. chlorine, methyl iodide
- **Corrosive**: e.g. strong acids & bases
- **Carcinogenic**: e.g. benzene

Material Safety Data Sheets (MSDS)

SIGMA-ALDRICH
A Part of MilliporeSigma

200,000+ PRODUCTS | 500+ SERVICES | Featured INDUSTRIES | Hello. Sign in. ACCOUNT | 24/7 SUPPORT | 0 Items ORDER

USA Home › 289566 - Iodomethane

289566 SIGMA-ALDRICH

Iodomethane

contains copper as stabilizer, *ReagentPlus*®, 99.5%

Synonym: **Methyl iodide**

SDS | SIMILAR PRODUCTS

CAS Number 74-88-4 | Empirical Formula (Hill Notation) CH_3I | Molecular Weight 141.94

Beilstein Registry Number 969135 | EC Number 200-819-5 | MDL number MFCD00001073

PubChem Substance ID 24857202

POPULAR DOCUMENTS: SPECIFICATION SHEET (PDF)

ICH_3

Purchase | Safety & Documentation | Peer-Reviewed Papers 81 | Related Products 1

Properties

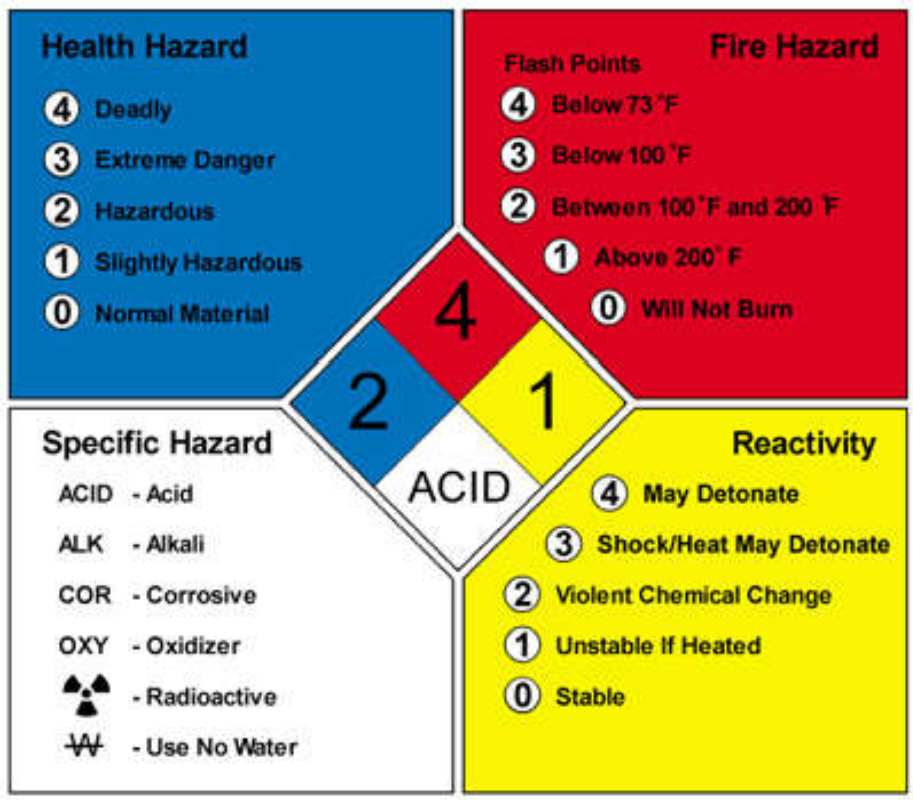
grade | *ReagentPlus*®

Price and Availability

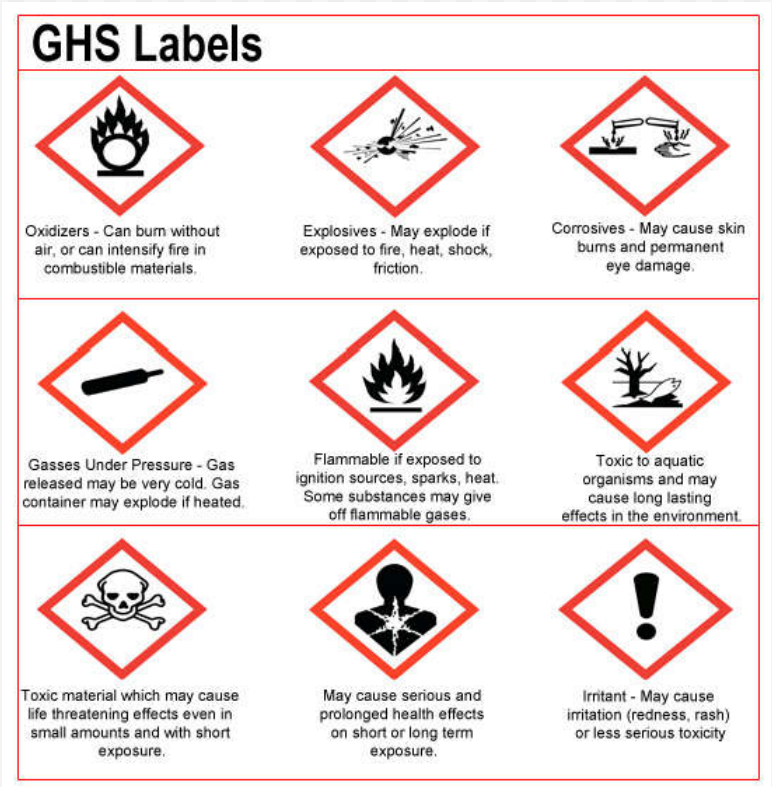
Price

All manufacturers are required to provide MSDS

Different labeling systems



www.nfpa.org



https://www.osha.gov/dsg/hazcom/pictograms/index.html

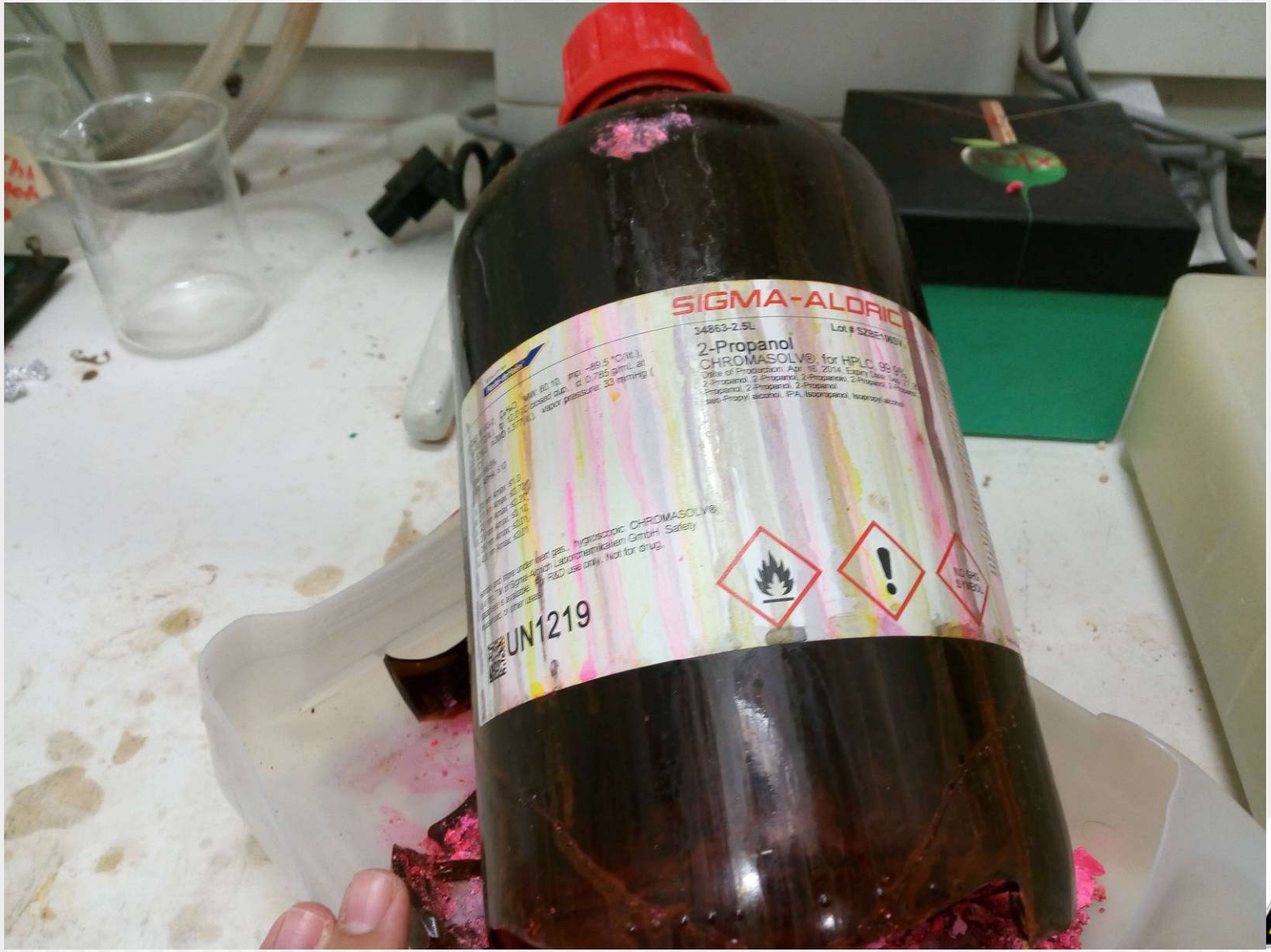
CHEMICAL SAFETY PRACTICE

- Design your experiment carefully
- **Study Material Safety Data Sheets**
- Use smallest quantities allowed
- Use **APPROPRIATE** protective equipment
  - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,…
- **LABEL** everything appropriately
  - Chemical name/formula, owner/lab, date, quantity
- Dispose of chemicals **SAFELY** after use

BASIC WASTE HANDLING

- Follow **MSDS** instructions for disposal
- Follow/establish **lab rules** related to waste
- Label your waste containers
- Some salts, acids & bases can be disposed in the sink if NEUTRALIZED and DILUTED with plenty of water
- Organic chemicals WITHOUT F, Cl, Br, I go to "**Non-halogenated Organic Waste**"
- Organic chemicals WITH F, Cl, Br, I go to "**Halogenated Organic Waste**"
- Pump oil to "**Mechanical pump oil**"
- Sharps/solid waste go to "**Solid Waste**"
- **If in doubt, ASK!!!**

CHEMICALS


SIGMA-ALDRICH
34863-2.5L
2-Propanol
CHROMASOLV® for HPLC
UN1219

CHEMICALS

CHEMICALS

In Case of a Chemical Incident

- **Accident examples**
  - Spill, glassware breaking, explosion, fire,…
- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel

- **USE COMMON SENSE**

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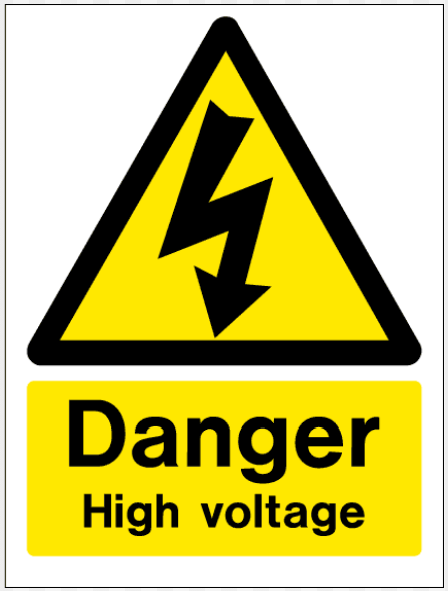
LABORATORY SAFETY

ELECTRICAL SAFETY

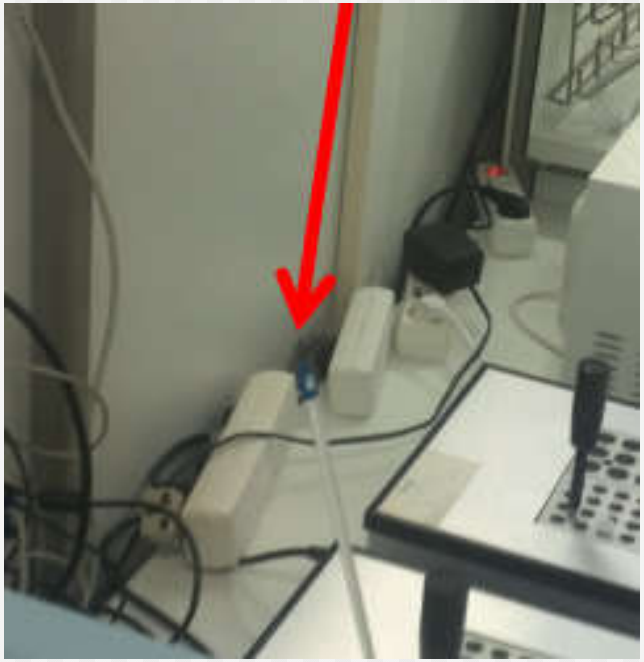
ELECTRICAL HAZARDS

- Sources
  - High voltage power supplies
  - Equipment (e.g lasers, vacuum pumps, computers)
  - Regular electrical lines and outlets
  - UPS electrical lines and outlets (red OR labeled “UPS”)
- Hazards
  - Electrocution
  - Electrical Fires



ELECTRICAL SAFETY PRACTICE

- **Keep cables OFF the floor**
- Keep water away from electrical equipment
  - Water low – electricity high
- Turn OFF power supply before touching "hot" parts
- Ground appropriately
- **DON'T** try to repair equipment
- Beware of BARE cables
- Follow specifications
- **Do NOT use back to back power strips**



In Case of an Electrical Incident

- **Remain calm!**
- **Assess the situation**
- **No water** on electrical fires
- Cut off power supply
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

http://safety.iesl.forth.gr

LABORATORY SAFETY

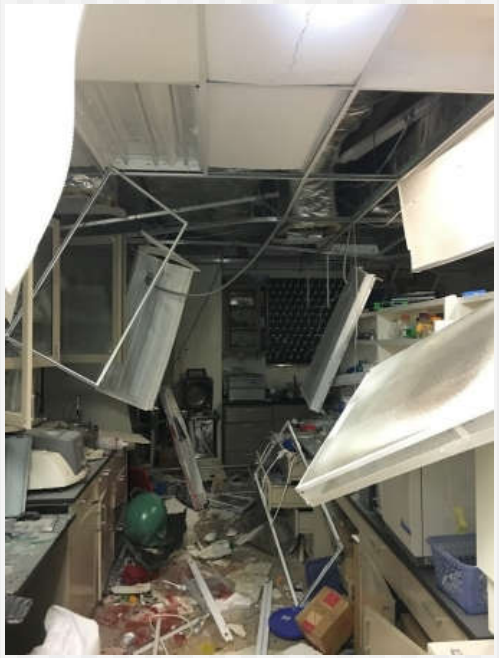
HIGH PRESSURE & VACUUM SAFETY

HIGH/LOW PRESSURE HAZARDS

Spark from pressure gauge caused University of Hawai explosion, fire department says

Latest News
Web Date: April 19, 2016

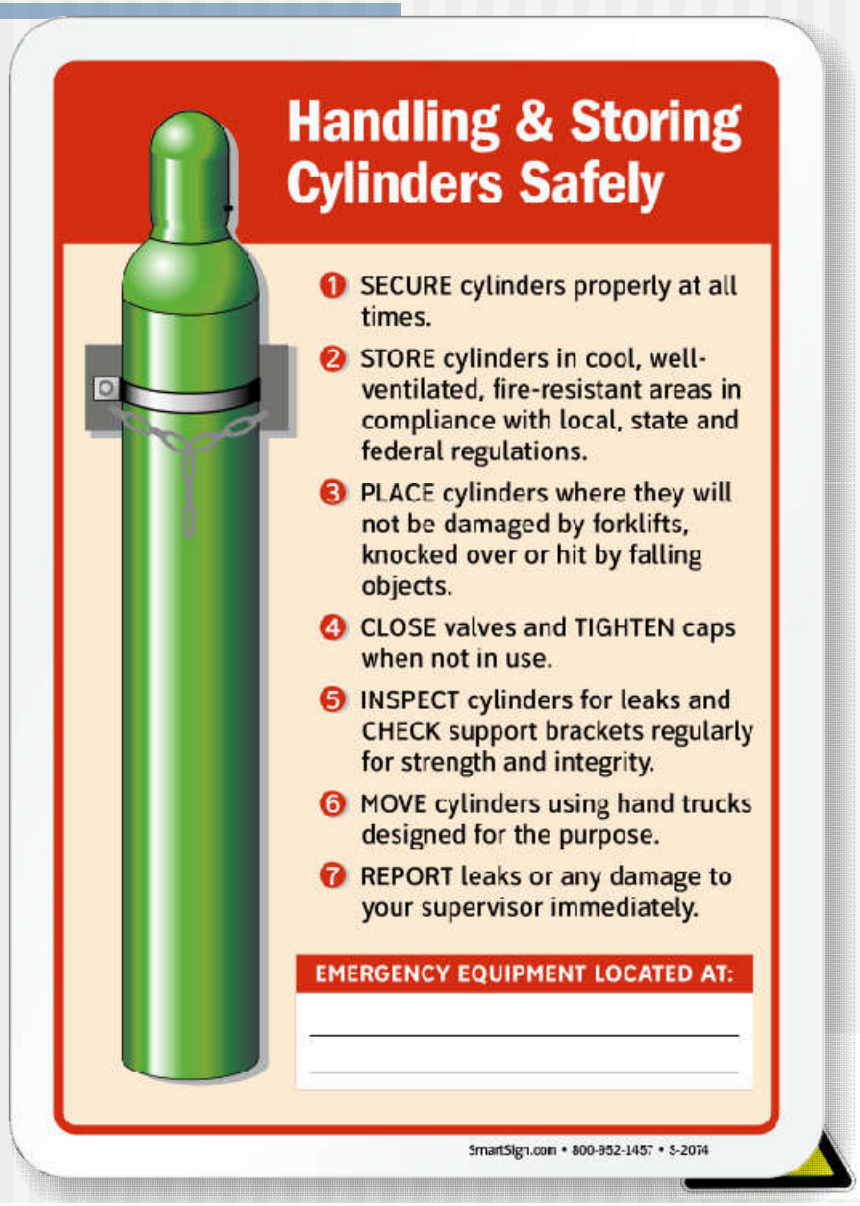
Postdoc Thea Ekins-Coward, who lost an arm in the incident, was using a gauge not specified for work with flammable gases



http://cen.acs.org/articles/94/web/2016/04/Spark-pressure-gauge-caused-University.html

PRESSURE SAFETY PRACTICE

- **Keep gas cylinders <u>bound</u>** on wall/heavy tables **<u>correctly</u>**
- **<u>Do NOT</u>** use gas cylinders without appropriate regulator
- Learn to:
  - Move gas cylinders safely
  - Leak-check gas/vacuum lines/chambers safely
- Beware of pressurized cooling water network
  - Water low – electricity high
- Report any problems you notice



In Case of a Pressure Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

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LABORATORY SAFETY

CRYOGENICS SAFETY

CRYO HAZARDS

- Explosion
- Frostbites
- Asphyxiation
- Burns

http://ehs.ucsf.edu/cryogenic-liquids

CRYO SAFETY PRACTICE

- **Use appropriate handling equipment**
  - Gloves, apron, mask
- **DO NOT TOUCH** cold containers with bare hands
- Vent containers appropriately
- Do not play with cryo-liquids
- Learn how to use cryo-equipment (valves, dewars, hoses) safely

In Case of a Cryogenics Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

http://safety.iesl.forth.gr

LABORATORY SAFETY

FIRE SAFETY

In Case of a Fire

ΦΩΤΙΑ!!!

- Ενεργοποιήστε άμεσα συναγερμό – Καλέστε την Π.Υ.
- Ελέγξτε άμεσα αν υπάρχουν θύματα – Αναφέρετέ το.
- Επιχειρήστε διάσωση αν δεν κινδυνεύετε οι ίδιοι – Αλλιώς εγκαταλείψτε αμέσως.
- Μην ανοίγετε πόρτες, παράθυρα – Διακόψτε τον αερισμό.
- Διακόψτε την τάση αν δεν υπάρχει πρόβλημα σκότους στο χώρο.
- Μη ψεκάζετε με νερό υπέρθερμα μέταλλα, οθόνες Η/Υ, υγρά καύσιμα.
- Μπορείτε να ψεκάσετε με γλυκό νερό υπό χαμηλη τάση από απόσταση άνω των 5m.

OHS M4.2 - 15 -

ΠΡΟΣΟΧΗ ΌΤΑΝ:

- ✓ Ο καπνός της φωτιάς βγαίνει παλμικά.
- ✓ Οι φλόγες έχουν χρώμα μπλε.
- ✓ Ακούγονται περίεργοι ήχοι όπως σφυρίγματα.
- ✓ Τα παράθυρα έχουν μαύρες κηλίδες σαν λάδια.

ΑΠΟΜΑΚΡΥΝΘΕΙΤΕ ΑΜΕΣΩΣ ΚΑΙ ΜΗΝ ΑΝΟΙΓΕΤΕ ΠΟΡΤΕΣ-ΠΑΡΑΘΥΡΑ

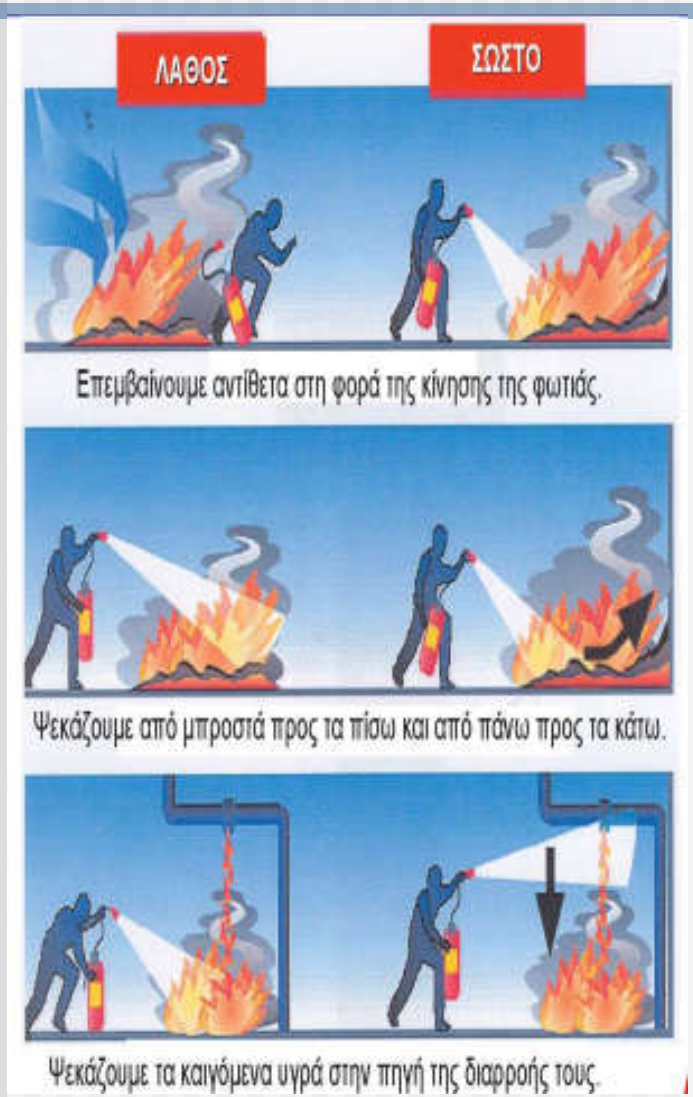
Πιθανό να ακολουθήσει απότομη υπερδιόγκωση της φωτιάς ή και έκρηξη (flashover / backdraft)

14.2 - 16 -

Τυπική εικόνα flashover

http://www.forth.gr/ty/

How to fight a fire



http://www.forth.gr/ty/

LABORATORY SAFETY

ANY QUESTIONS?

http://safety.iesl.forth.gr