Laboratory Safety Rules and Procedures

Department of Aerospace Engineering at KAIST

Effective from Sep. 01, 2016

This code provides clear guidelines for all aspects of laboratory conduct at the department of aerospace engineering at KAIST. The code aims to communicate with you some of prevailing work customs to increase safety awareness. An exhaustive list of things that someone must be careful of is not included herein. Do not replace the formal training package that you have received or will receive from the university with this handout. You are welcome to discuss any of the points raised in this handout with your laboratory instructor and/or advisor.

- REMEMBER -

You should not trust the existing wisdom blindly and the same applies to health and safety when doing laboratory work. If you think that you are doing something seems not right, wrong or dangerous, then STOP what you are doing and tell someone next to you immediately followed by discussion with your lab instructor and/or advisor!

A. Generality

1. **Safety first** => Never compromise safety for speed or performance. No matter what the source of pressure to you (e.g., to meet the deadline for a paper, to provide data for a sponsor, and/or for a meeting with your advisor), you should never perform laboratory work unless you feel confident that you know all the possible risks associated with your work and that you have minimized them. Working under stress is a recipe for disaster. Relax and concentrate fully before conducting experiments. BE PATIENT, CAREFUL, AND THINK TWICE.

2. **Rules** => Sometimes, it may be considered smart to “bend the rules” and indeed, we have all felt at times that some rules may be exaggerated. Nevertheless, we have prevailing rules in the laboratory and we must follow them all. Eventually, you will realize reasons for them and their usefulness.

3. **Competency** => You are not expected to know everything. In case you feel that you have been asked to perform work for which you have not received adequate training or guidance, refuse to do it and discuss your reluctance with your advisor or colleague. There is a lot of “learning by mistake” in research, but it is better to take small careful steps rather than big strides, especially in the beginning of your work. To our understanding, professionalize basic necessary practical skills in combustion and fluid mechanics laboratory for example, can take months or even years, so you should never overestimate your capability. IT IS NOT SHAMEFUL AT ALL TO ASK HOW TO DO THINGS.

4. **You are not alone** => You are responsible not only for your own safety, but also for the safety of others because any dangerous action from your part may have an impact on the others. All other colleagues in the laboratory are there to help you. More experienced students and instructors can give you invaluable advice, recommendation, practical help, and/or training. WE ARE ALL LIVING IN THE COMMUNITY.

B. Safety rules and procedures

SR: Strict Rule (must be followed); **CS**: Common Sense

1. **Qualification for Experiments** => You must attend *dept. safety training* to be qualified to perform any experimental works related to "combustions, aerodynamics, and high speed/pressure" **(SR)**. The *dept. safety training* is held at the beginning of every semester; the detail rules and regulations are explained and safety-related experiences are shared among the participants. Particularly, only those who have attended the dept. safety meeting are allowed to go into *the dept.-controlled lab** during the corresponding semester. When a non-qualified person such as a visitor or an undergraduate student needs to go into *the dept.-controlled lab*, they should be accompanied by a faculty/staff member or other approved nominee **(SR).**
(As of Sep. 01, 2016, *the dept.-controlled lab* includes all the areas of W10, N7-2 Rm#1308-1, Rm#1308-2, Rm#1308-5, N5 Rm#2307 and the 1st floor experimental area of N7-5).

2. **Working time** => Any experiment related to combustions, aerodynamics, and high speed/pressure is to be performed during normal working hr. (weekday 9-6). In exceptional cases only, discuss with your advisor about possible extension to the evening or during the weekend. The exception should not become the norm but should be considered individual. Outside the office hours, you can perform other jobs such as data processing and/or reading etc. Person wishes to work outside the office hours need to provide a work plan that clearly defines the proposed task and limitations on that task outside the hours. Work by undergraduate students can only be performed when directly supervised by a staff member or approved nominee **(SR)**.

3. **Working alone** => At all times, someone else must know that you are conducting experiment. Any heavy/dangerous test must not be performed by one person. Never work behind closed doors alone **(SR)**. Tell your colleagues what you are doing – explain to them your experiment and let them teach you theirs, even if you are not formally involved. Take a walk through the laboratory before leaving in the evening to check everything is fine. There is an increased risk in laboratory work after-hours and working alone in a building or far removed from other people. All areas should have an after-hours procedure for any hazardous and/or isolated work including means of communication and security **(CS)**.

4. **Keep records** => Get a logbook (research notebook) and write all your activities. Keep records of your ideas, fears, conclusions, results, practical problems, instrumentation problems, etc. Write down things that you have done right or wrong. Develop the habit of going back to your records for consultation. You would be surprised by how many things from the first year of your PhD have forgotten by the time you write-up thesis **(CS)**.

5. **Planning and risk assessment** => Discuss your results from the laboratory work with your advisor. Plan well ahead and get advice regarding specifications of tubing, fittings, materials etc. **(SR)** Think carefully about all eventualities such as "what would happen if this tube leak?", "what would happen if this pressure read-out fail?", "Is there a possibility of flame flashback?", and "What should I do if I spill fuel on the floor?" Assess the magnitude of such risks: are they highly likely or unlikely? Would you and others escape unhurt? Do you know what needs to be done in such circumstance?

6. **Fire-exits and emergency procedures** => Familiarize yourself with the laboratory's fire-exit **(SR).** Develop a quick shut-down procedure for your experiment that you should follow in case of emergency evacuation.

7. **Housekeeping** => Keep floors tidy and dry. Keep benches free from chemicals and apparatus that are not being used. When leaving the laboratory, turn off all equipment in use **(CS)**.

8. **Gas handling** => Moving high-pressure bottles; installing and operating pressure regulators; installing pipe systems and checking them for leaks; selecting the right tube, fitting and connector for the particular gas, pressure and temperature; these are examples of common activities in the laboratory. Make sure that you know the specifications of each component and examine its suitability for your rig. Seek advice and keep records of the specifications of every product you purchase **(CS)**. Before performing any of the above actions, make sure that you have either taken the university's safety course **(SR)**.

9. **Chemicals and hazardous substances** => This is an area of ongoing concern in the laboratory because we usually keep many unnecessary chemicals and hazardous substances. If you need to work with a dangerous material, ensure you familiarize yourself with any risk involved. Are the materials you are ordering unhealthy, poisonous, or carcinogens? How should you handle them? Should you let others handle them? Order the minimum amount necessary and discuss the details of what you purchase with your advisor. Do not allow flammable materials to accumulate in the laboratory. Hazardous substances must be disposed of in accordance with the university policy and statutory requirements **(SR)**.

10. **Source of risks** => Spills; pipes bursting; burns; equipment and burners not secured in place; dirty fittings on gas bottles; wrong specifications; too hot gases for the tubes provided; not adequate ventilation; unburned fuel and partial oxidation products released in the laboratory; vapors; sparks from mains plugs and light switches; sparks from static electricity on ourselves; non-earthed metal frames; breathing fine dusts; tripping over cables and tubes on floor; live wires; long electrical cables on the floor; the list is endless. Read about experiments similar to yours, think hard, discuss with other students and advisors. Look around the laboratory for good and bad examples. There is always something you have not thought about **(CS)**.

11. **Ventilation** => Extracting all the fumes we may produce is essential and you should never perform experiments without adequate ventilation in your area **(SR).** Having a powerful exhaust in a combustion experiment is needless to say imperative because any carbon monoxide produced can kill you.

12. **Personal protection** => Approved safety spectacles, goggles or safety shields must be worn in all areas where tools or substances such as chemicals, liquids, lasers or radiation may cause eye injury. Appropriate protective clothing (for example gowns, overalls, closed laboratory

coats, flame resistant clothing, etc.) shall be worn where required. Hearing protection must be worn if noise can damage or impair hearing **(CS)**.

13. **Laser** => Lasers are particular hazards and special training is necessary. You are not allowed to go into rooms when the laser warning lights are on. Laser rooms can be accessed only by particular persons, the so-called registered users **(SR)**.
14. **Electrical equipment and fire prevention** => No smoking in laboratories or in any university buildings. Open flames should not be left unattended and no open flames should be used near flammable solvents. Before starting work, all staff and students are to become familiar with the fire procedures and location and use of fire-fighting equipment within the laboratory **(CS)**.
15. **Standard operating procedure forms** => Once you have absorbed and acted on the above points, then you are in position to start your experiment. The final, and very important step is to put all your thoughts concerning the safe design and operation of your experiment, and all your "what if" scenarios concerning possible eventualities, in an organized document. This is the "Standard Operating Procedure" which must be completed by you, with the assistance of your advisor. This document should be treated as a dynamic record of possible things that can go wrong and should be updated every time you change something or you come up with a new idea of what could be wrong **(CS)**.

- Common sense tips for safety -

1. Be aware of emergency procedures and emergency evacuation assembly locations.
2. Closed-in footwear at all times. Bare feet, thongs and sandals are prohibited.
3. It is prohibited to eat, drink and apply cosmetics in laboratories.
4. Mobile phones should be used only for emergency contact during laboratory work.
5. Do not store food and/or drink in laboratory refrigerators or laboratory storage units.
6. Check whether first aid boxes are equipped.
7. Wash skin immediately with plenty of water if contaminated with acids and alkalis.
8. Avoid lifting heavy objects. Use lifting devices and trolleys where appropriate. Where lifting is unavoidable, seek assistance if required.
9. Do not use any machines, equipment or laboratory apparatus without prior instruction/training by the supervisor or technical staff on safe work procedures and practices.
10. OBSERVE SAFETY SIGNS AT ALL TIMES!

Standard Operating Procedure (SOP)

for Equipment, Rig, Process, System or Test Name & Location

Equipment name:
Prepared by:

Approved by:

Point of contact:
Location:
Date:
Expiration Date:

I. Emergency Shutdown Procedures

Add **photos** for all Emergency stop (E-stop) locations and make sure all E-stops are properly identified	Step 1. Step 2. Step 3… Suggestions: brief, clear description of steps to follow. Use color coding or labeling on equipment to facilitate identification of critical valves/switches. Ensure critical valves/switches are accessible without interference from the hazard.

II. Equipment (Rig) Description and Test Scope

Describe the purposes of your experiment. Include description of equipment, processes, system or test set-up. Add picture and label components of your test setup if possible. If equipment is purchased from manufacturer, include vendor name, part number, and serial number. Include detailed operating conditions, i.e., pressure, temperature, flow rate, voltage, ampere, etc.

III. Specific Safety and Health Hazards/Precautions

Identify specific hazards associated with your equipment, process, system or test conditions. Proper trainings and knowledge must be obtained if there exist any hazards that apply to your experimental setup.

Hazard checklist (this is an example, not exhaustive)

Hazard name	**Extra attention required**
Hazardous chemicals	Label chemicals
Electrical hazard	>50 V
Excessive noise	>85 dB
Laser	Class 2 or higher
Radiation	Any
Falling objects hazard	Any
Biosafety	Any
Pressure/vacuum vessel rating	>2 atm, < 1 atm
Confined space	Any
Magnetic field	Any
Air quality/Respiratory hazard	Any
Chemical waste	Ensure proper disposal procedure
Temperature	>60 °C touch protection
Ergonomics	
…	…

IV. Personal Protection Equipment (PPE) Required

Identify all PPE that must be worn with particular attention to those items that are different from or additional to those that are normally required in the lab. Examples: safety glasses with side shields, goggles, face shields, heat resistant gloves or chemical gloves. Note that MSDS and equipment manufacturer's instructions may be sources for PPE information.

V. Specialized Training Required

Identify all specialized trainings that must be completed prior to operating or maintaining your equipment, process, system, or test. Examples: high-power lasers, high-pressure compressors/pressure vessels, electrical safety, radiation safety, highly reactive catalyst, combustion, etc.

VI. Normal System Startup/Operation/Shutdown

Describe in detail how to start your test rig, how to operate it at steady-state conditions, and how to shut down your equipment and test rig. Low and high speed data acquisition systems need to be discussed as well. If valves are used in your system, all valves must be labeled. Include Piping and Instrumentation Diagram (P&ID) as part of your SOP.

VII. Power/Facilities Service Failure

Identify special procedures to be followed during and after a power/facilities service failure, if such interruption could cause a hazardous condition. Ensure all devices are fail-safe in the event of power loss and that equipment does not restart when power is restored.

VIII. Pollution Control and Waste Disposal Procedures

Identify all pollution control and waste disposal requirements.

IX. Schedule Safety Review

Schedule safety review with your advisor(s).