C4DFED SAFETY MANUAL

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Centre for Design & Fabrication of Electronic Devices

Indian Institute of Technology Mandi

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1. EMERGENCY — WHAT TO DO

Emergency	Do this
Chemical on skin	Get to nearest shower, pull the handle, **stay under water 15 minutes**. Remove contaminated clothing while under water. Shout for help — do not leave to find it.
HF on skin	Shower **5 minutes**, then apply calcium gluconate gel with clean gloves and keep massaging it in. **Seek medical help immediately, even if it does not hurt yet.** Send the chemical data sheet (DS) with the patient.
Chemical in eyes	Eyewash, hold eyelids open, **15 minutes**. **Never put calcium gluconate in the eyes** — water only.
Chemical inhaled	Move to fresh air. Seek medical attention. Do not re-enter.
Fire	Pull the alarm. Evacuate. Alert others as you go. Assemble at *Ground*.
Gas alarm	Evacuate immediately by the nearest exit. Do not investigate. Do not re-enter until cleared by staff. Assemble at *Ground*.
Spill	Stop work. Warn others. Evacuate the bench area. Call staff. **Do not clean up a spill you are not trained for.**
Injury / unconscious person	Do not move them unless they are in further danger. Call for help. If they are chemically contaminated, protect yourself before touching them.
Power or exhaust failure	Stop all wet chemistry immediately. Bring instruments to their safe state if you can do so safely. Leave.

Emergency numbers

IIT Mandi emergency / security	*01905-267126*
Institute medical centre / ambulance	*01905-267209*
Centre Office	*01905-267841*
Technical staff on call	*+91-7018590918*
Fire	*01905-267024*

After any incident, however minor: report to the TA or C4DFED Office or within 30 minutes, before leaving. **Honest reporting carries no penalty. Concealment is a six-month ban.**

3. EMERGENCY EQUIPMENT

Know where these are **before** you need them. Locations are verified monthly by technical staff and marked on the floor plan posted at the entrance.

Equipment	Where	For
Emergency shower	*Technology Lab 3*	Whole-body chemical contamination

Equipment	Where	For
Eyewash station	*Technology Lab 3*	Eye contamination
Calcium gluconate gel	*Technology Lab 3 inside First Aid Box*	HF exposure only. Check the expiry date before you start work.
Fire extinguishers	*Outside C4DFED Office*	Know which type is where
Fire alarm pull points	At exit doors	
First-aid kit	*Inside First Aid Box, Outside C4DFED Office & Technology Lab 3*	Minor Medical Treatments

Every laboratory has exits. Locate both on your first visit.

4. ENTRY, GOWNING AND ATTIRE

4.1 Before you enter

- Leave bags, backpacks, jackets and outer garments in the Cabinet at the entrance. **Nothing personal passes the gowning boundary except your phone and notebook.**
- No food, drink, chewing gum, earphones or Bluetooth devices inside.
- **Closed shoes always.** No sandals, no open toes, no shorts, no skirts.
- **No contact lenses.** Chemical vapour trapped behind a lens can cause serious eye injury.
- **No cosmetics.** Makeup is a major particulate source and can react with chemicals.
- Long hair fully covered. Remove rings, bangles and watches — **gold rubs off jewellery and is a semiconductor poison**, and jewellery traps chemicals against skin.
- If you are unwell — coughing, sneezing, fever — do not enter. You are the largest contamination source in the room.

4.2 Gowning

Follow the posted gowning sequence for your laboratory. Full gowning is hood or cap, gown, shoe covers or booties, mask where required, gloves, and safety eyewear.

- Keep all hair and ears covered.
- **Never unzip or open your gown inside a laboratory.**
- Change gloves whenever they are contaminated, torn, or before touching a clean surface.
- De-gown in the reverse order in the designated area. Do not walk out gowned.

4.3 Why these matters?

The human body is the main source of contamination in a cleanroom: shedding skin and hair, saliva while talking, oils and sweat. **Sodium and potassium from body fluids are semiconductor poisons** which in tiny amounts alter the conductivity of doped silicon. Gowning protects the work as much as it protects you.

5. PERSONAL PROTECTIVE EQUIPMENT

Work	Minimum PPE
General laboratory presence	Gown, shoe covers, hair cover, safety glasses
Any chemical handling	Add chemical apron, chemical-resistant gloves rated for that chemical, face shield
HF, BOE and fluoride etchants	Chemical apron, **double gloves**, full face shield **and** safety glasses, work behind the sash
Piranha and hot acid	As HF, plus keep the sash as low as possible; never lean over the bath
Solvents	Solvent-resistant gloves, work in the exhausted bench
Furnace and hot-plate work	Heat-resistant gloves, face shield when loading or unloading hot
Vacuum system maintenance	Staff only

Check gloves for the right material and for pinholes before every use. Nitrile is not adequate for all chemicals. If you do not know which glove, ask before you start — not after.

6. CHEMICAL SAFETY

6.1 General rules

1. Use chemicals **only at the designated bench, only inside the exhausted area, only if you are cleared for wet processing.**
2. Read the SDS before first use of any chemical.
3. **Always add acid to water, never water to acid.**
4. Label every container: contents, concentration, your name, date.
5. **Do not leave chemicals unattended for more than 15 minutes.** If you must step away, label the container with contents, your name and the time.
6. Never return used chemical to the stock bottle.
7. Never mix chemicals unless the SOP tells you to. Acids and bases react violently. Solvents and oxidisers react violently.
8. **Never attempt to clean up a spill you are not trained for.**
9. Chemicals are issued from Secured Storage in working quantities only, against the Issue Register. Bulk containers do not leave storage.
10. Clean your glassware and your bench when you finish.

6.2 Hydrofluoric acid — the one that kills

HF is not like other acids. It is a weak acid chemically but the danger is not the acid burn: the fluoride ion passes straight through skin and attacks deep tissue and bone, stripping calcium. **A serious exposure may**

not hurt at first. Dilute HF can cause delayed injury hours later, by which time damage is done. Systemic fluoride poisoning from a large exposure can stop the heart.

HF is a **clear, colourless liquid that looks exactly like water.**

Rules — all absolute:

- **Never work with HF alone.** A second HF-cleared person must be physically present and must have *agreed* to be your buddy.
- **Verify calcium gluconate gel is present, in date and within reach before you start.** No gel, no work.
- Both of you must know the exposure procedure before starting.
- Work behind the sash, in the fully exhausted area. Avoid the fumes — inhalation is as dangerous as skin contact.
- Every container clearly labelled. Never in glass.
- **No HF work outside standard working hours, ever.**
- HF and fluoride-containing waste — including BOE and ammonium fluoride — goes into the designated HF waste container only, never into a general acid drain or carboy.

If HF touches you — or you think it might have:

- Get under the shower and flush **5 minutes**.
- Remove contaminated clothing while under the water.
- Apply calcium gluconate gel with clean gloves; keep massaging it in.
- **Go for medical attention immediately, even with no pain and no visible mark.** Take the SDS.
- Eyes: water only, 15 minutes. **Never put the gel in eyes.**
- Tell staff. Cordon off the area so nobody else is exposed.

6.3 Piranha (sulphuric acid + hydrogen peroxide)

- **Self-heats violently on mixing** and destroys organic material instantly — photoresist, wipes, gloves, skin.
- Vapour is extremely caustic. Exhausted bench only.
- **Never add water to piranha** — sulphuric acid is water-reactive; it will heat, not cool, and can explode.
- Never mix with solvents, flammables or bases.
- Boiling piranha spatters. Never lean over it. Full face shield.
- **Never seal a piranha waste container** — it continues to evolve gas and will burst. Use the designated open-vented piranha waste route only.
- Mix only the volume you need, and only when you are ready to use it.

6.4 Other hazards

Acids (HCl, HNO_3, H_2SO_4, H_3PO_4, acetic) — corrosive to skin, eyes and airway. Exhausted bench, apron, face shield. Segregate waste from HF and from bases.

Bases and developers (NaOH, KOH, NH_4OH, TMAH) — as corrosive as acids and often underestimated. **TMAH is additionally a systemic poison absorbed through skin; a large skin exposure can be fatal.** Treat every TMAH developer with the respect given to an acid. Note that Na and K compounds are semiconductor poisons — check they are permitted on your tool.

Solvents (acetone, IPA, methanol, NMP) — flammable and readily inhaled. Keep away from hot plates. **An acetone spill near a hotplate can ignite, and vapour drawn into the exhaust can have serious consequences.** Never leave a hotplate on when you finish.

Hydrogen peroxide — a strong oxidiser; reacts violently with organics and with many metals.

Chlorinated solvents — toxic, and some are carcinogenic. Approved use only.

6.5 Process gases

Users never handle gas cylinders. Staff and vendor only.

- **Silane is pyrophoric** — it ignites spontaneously in air. Cylinders live in ventilated cabinets with flow-restricting orifices and flow-limit valves.
- **Chlorine and other halogen gases** are severely corrosive; chlorine forms hydrochloric acid in the lungs and the effects may not appear for days. **Any suspected exposure needs immediate medical attention even if you feel fine.**
- **Toxic gas alarm: evacuate immediately.** Do not investigate, do not collect your samples, do not return until staff clear the area.

7. OTHER PHYSICAL HAZARDS

Hazard	Where	Rule
High voltage	Sputtering, RIE, PECVD, probe stations, e-beam	Never open an enclosure or defeat a lid interlock. Assume it is live.
Vacuum / implosion	All vacuum systems, glass desiccators	Never vent a hot chamber. Inspect glassware for cracks before pulling vacuum.
High temperature	Furnaces, RTP, hotplates	Heat gloves and face shield. Nothing flammable near a hotplate. **Always switch the hotplate off.**
UV	Mask aligner, UV ozone, some cures	Never look at the source. Keep shields in place.
Lasers	Cutting, ellipsometry, some metrology	Never defeat a beam enclosure. Eyewear rated for that wavelength.
Moving parts	Dicing saw, spin coaters, robotic handlers	Lids closed while running. Never reach into a spinning coater.
Cryogens	LN_2	Cryo gloves and face shield. Never in a sealed container. Asphyxiation risk in confined space.
Compressed air / N_2	Everywhere	Never point at yourself or another person. Never use to clean clothing or skin.

8. WASTE

11. Segregate at the point of use into the designated labelled containers. **Nothing goes into any sink or drain, ever.**
12. Separate streams: **HF and fluorides · acids · bases and developers · piranha · solvents · metal etches** — never combined.
13. Every waste container: contents, your name, date. Metal etch waste in a separately labelled rinsed bottle.
14. **Never overfill and never seal a container that evolves gas.**
15. Solid waste — used wipes, gloves, contaminated substrates — into the designated bin, not the general bin.
16. Staff coordinate collection and disposal. If a container is full, tell staff; do not improvise a new one.

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9. THE BUDDY RULE

Required for all extended-hours and out-of-hours work, and for all wet chemistry at any hour.

- A buddy is a **qualified user who has agreed** to be your buddy. Someone who happens to be in the room is **not** your buddy.
- Your buddy must be physically present, know what you are doing, and be able to help — walk you to the shower, rinse your gloves, call for help.
- **Check in with each other at least every 15 minutes.**
- **If your buddy leaves, stop all hazardous work** until they return or someone else agrees.
- Agree before you start who is buddying whom, and for how long.

Working alone in breach of this rule is treated as a Cardinal Rule violation where HF is involved, and a 30-point violation otherwise.

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11. REPORTING

Report **within 30 minutes, and before leaving the facility**, to the C4DFED office:

- any injury, however minor
- any chemical contact, even if you feel fine
- any spill
- any equipment fault, alarm or unexpected behaviour
- any near miss — something that could have gone badly but did not

Then tag the instrument RED and file the Incident Report within 24 hours.

> **A near miss reported today is an injury that does not happen next month.** There is no penalty for reporting, and there is no such thing as a report that was too minor to make.