General Protocols and Safety training Polymer Processing laboratory & Photovoltaic Lab

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Hint for the test

- Reds are definite questions!
- Does not mean there are no questions from other colours!

General Rules

- Please note that strict action will be taken against the violator of safety rules.
- Do not start when in doubt.
- Keep good house keeping habits.
- DO NOT WORK ALONE, or when stressed or not well.
- Working hours of the lab:24×7
- Please contact any of the Facility Technologist or Technology Manager (Mr. Dwarakanathan), if you have any suggestions or want to give feedback.

Access

1. **Download the authorization form**
2. **Fill, sign and submit it.**
3. **Read the contamination protocols and safety documents.**
4. **Take the test.**
5. **PASS IT, you are in!**

- **Authority to enter does not mean authority to operate the instruments.**

Equipment usage

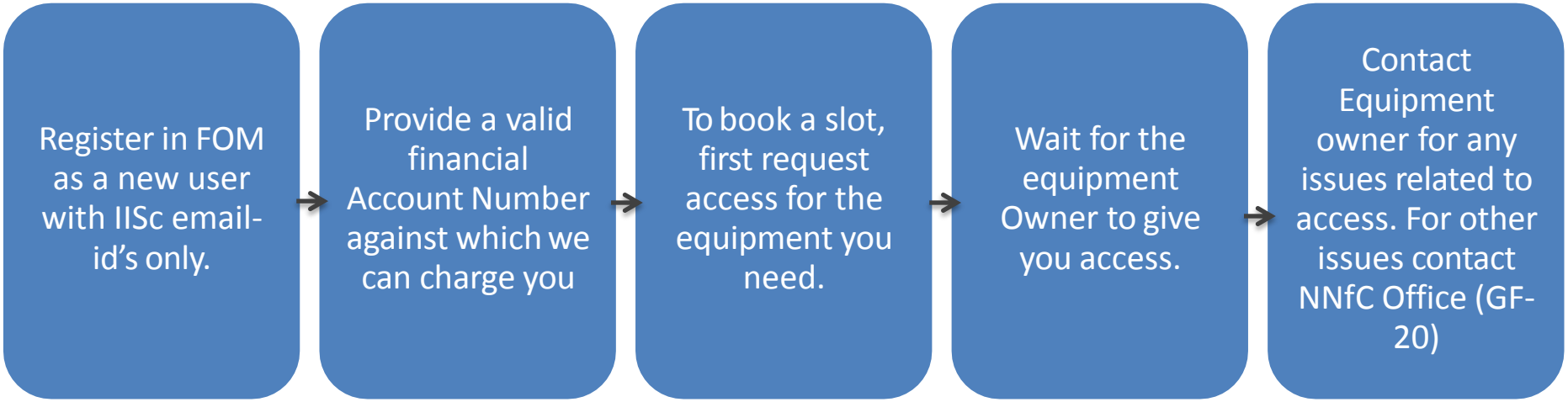
- **Types of users: Dependent/ Independent**
- **Dependent authorized users: Only day time access (10.00am-5.30pm) / process done by Facility Technologist, please book the Slot at least one day in advance and inform the same to FT as the FT will be handling multiple tools during the Day.**
- **Independent users: Anytime access, after proper training and practice session.**

New Materials Entry

- Need special permission for non-standard Chemicals/photoresists/wafers/targets etc.
  - No exceptions…
- Procedure to seek permission for bringing in the new material is,
  - Email Technology Manager Mr R. Dwarakanathan (dwarakanath@iisc.ac.in) and Facility Technologist Ms.Shilpa Chander (cshilpa@iisc.ac.in)
  - with
    - ✓ Prior process
    - ✓ Post process
    - ✓ MSDS of the material
    - ✓ Why the material need to be used in the polymer processing lab

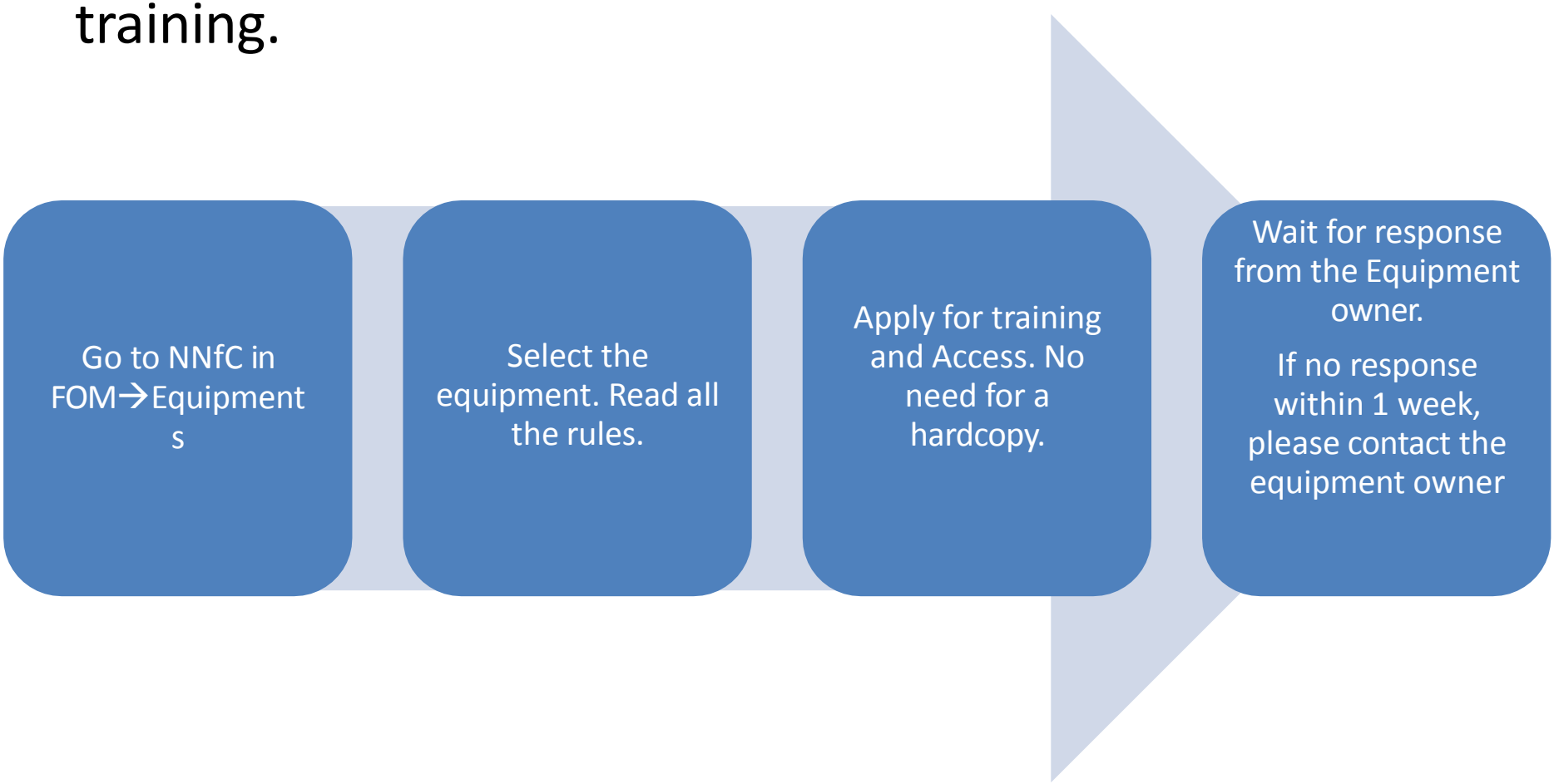
Procedure for booking the Slot in FOM

- Only those who have biometric- access can register in the FOM



Procedure For Getting Trained on an Equipment

- Only those who have biometric-access can register for training.



Loss of access

- Six months of no activity automatically removes biometric access
  - Take safety test and ask for biometric access again
- Three months of no tool use will remove independent access
  - Ask for retraining
  - Retraining might consist of just practice slots or full training depending on the tool
  - Talk to the concerned FT
  - Plan in advance: FOM alert will be sent

Slot Booking

- Slots need to booked by using FOM software, before starting the tool.
- If you book, but do not turn up penalty points may be levied as per the norms
  - Also, the slot will be charged

04/09 04/16 04/23 04/30 05/07 05/14 05/21 05/28

Mon 06/04	Tue 06/05
09:00 - 10:00	09:00 - 10:00
10:00 - 11:00	10:00 - 11:00
11:00 - 12:00	11:00 - 12:00
12:00 - 13:00	12:00 - 13:00
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23:00 - 00:00	23:00 - 00:00

Slot cancellation on FOM

- Slots booked on FOM will not be honoured if
  - Slots booked by dependent users using express logon
  - Slots booked by dependent users after official working hours
  - **Slots booked without relevant information**
    - **Process conditions**
    - **Materials information (different layers, pre process)**
  - Slots booked by users who are under suspension

In case of tool break down

- Send ‘Instrument problem report’ to the instrument managers using FOM
  - Log off and press the “something wrong” button
- Inform the concerned facility technologist (phone numbers available on the FOM page)
  - Call from outside the lab in case of network problem
- If unable to contact FT’s, please put the tool down notice and send an email to the FT and technology manager

- DO NOT TRY TO REPAIR THE TOOL BY YOURSELF

Buddy System:
One rule not to be forgotten

Buddy system **need to be followed strictly at all times**

- **Someone needs to know where you are and what your process is**
- ***This is for your safety and safety of Lab***

Communications from the Lab

- FOM sends a notice to all users
  - Make sure your registration email is your official IISc email id
  - Notices will not be sent to other emails like gmail, yahoo mail etc
- General email to all CeNSE users
- Broadcast emails sent to IISc
- Notice on FOM page of the tool.

Responsibility of the user

- Proper and professional conduct
- Not cause disturbance or disrupt the procedures of other users
- Report any violation noticed immediately to the FT/Lab Manager
- It is the responsibility of the user to maintain the lab in optimum level
- Independent user is responsible for the tool during Non office Hours
- Knows emergency protocols thoroughly
- Has enough presence of mind to save lives and the facility
- Must wear all the PPE when you are using the Tool.

User agreement

All are expected to sign USER Agreement before becoming Authorised USER

- Violations of protocol and procedures will lead to
  - Penalty points
  - Restricted access and privileges

Violation of Rules

- Depending on the extent of violation
  - –You *may* get just a warning
  - –You may get your booking cancelled
  - –You may loose your registration for a short while

  Or

  You may loose your registration all together!

REMEMBER, monitoring cameras are everywhere !!!!

Rules apply 24X7

Penalty point chart

Cumulative penalty points	Disciplinary action
>30 points	One week suspension
>60 points	Two week suspension from Lab
>90 points	3 week suspension from Lab, no cleanroom access
>100 points	Barred from access to the Lab, case to go to Cleanroom committee

Emergency: Call 115

- Stop the process by pressing the emergency stop buttons of the equipment's (if known)
- Immediately alert the staff concerned (phone numbers are near the door) or call BMS : “115”
- Evacuate the area by the nearest exit if ordered evacuation by the Building management system (announcement will be made)
- Do not wait to remove PPE’s (aprons, sleeves, mask etc) for evacuation

CENSE Alarm Response

- Common Alarms: Fire and Smoke
  - Evacuate through the nearest exit
  - Follow signs in the corridor

Chemical Safety training, Polymer Processing laboratory

Chemical Safety

- To ensure a safe environment for learning and research
- To prevent fatal Injuries and accidents
- To make sure that lab specific protocols are understood

HF/BHF burns

Fume hoods are the only safe places for chemicals

PPE protocol for working in the Acid Hood

- While working with chemicals, it is mandatory to
  - Wear lab **shoes**

  - Wear **Lab coat ,Aprons**

  - Wear safety **glasses, Sleeves & face shield**

  - Wear appropriate **gloves (Acid resistant)**

  - Make sure exhaust is functioning
  - No Phone usage at wet bench

  - After every acid process, the user has to pour the hood with lots of DI water and wipe it clean with the Plastic wiper.
  - Contact lenses not allowed
  - Intern has to work only along with the mentor in Acid Hood

PPE protocol for work in the Solvent Hood

- While working with chemicals, it is mandatory to
  - Wear lab **shoes, Lab coat**

  - Wear appropriate **Head Cover, Face mask & Gloves**

  - Wear safety **glasses & face shield**

  - No Phone usage at wet bench

  - Make sure exhaust is functioning
  - Contact lenses not allowed
  - Intern has to work only along with the mentor

PPE protocol for work in Litho Room (PV Lab)

- While working with chemicals, it is mandatory to
  - Wear lab shoes 
  - Wear Face masks, Gloves, Head cover 
  - Wear safety **glasses** 
  - Make sure exhaust is functioning
  - Contact lenses not allowed

Use of gloves

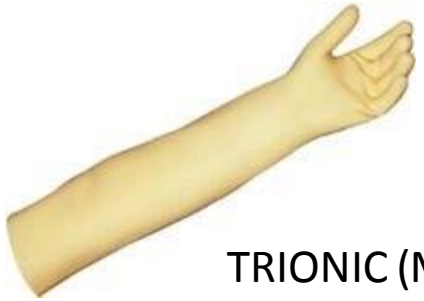
- PVC
  - Are used protect wafers from particles generated by humans
  - ***No resistance to chemicals***

- NITRILE
  - Thin chemical resistant gloves
  - Strong material : used for installation and maintenance of the tools

Use of gloves

- TRIONIC (MAPA)
  - Thick chemical resistant gloves : used for cleaning up leaks
  - Nevertheless don't put your hands in liquid chemicals!

F-telon gloves (Teflon incorporated)



TRIONIC (MAPA

Chemical spill pads

Chemical spill pillows

PPE Sequence

- Facemask
- Hair net
- Aprons
- Sleeves
- Goggles
- Face-shield
- Nitrile gloves
- MAPA (if needed)

While wearing PPE

Do not touch with your contaminated gloves

- Face shield/Apron/sleeves
- Your clothes
- Mobile
- Taps
- Phone
- Computer Keyboard (Example, for extension of the slots)

Removing PPE

- **Removal in the order**
  - Contaminated gloves, wash and keep in its place
  - Sleeves, fold and keep
  - Face shield
  - Goggles
  - Apron

- ACCESS TO THE LABORATORY WILL BE DENIED IF PPE RULES ARE VIOLATED !!!!

Hazard Symbols

Carcinogen
Mutageniciy
Reproductive Toxicity
Respiratory Sensitizer
Target Organ Toxicity
Aspiration Toxicity

Flammables
Pyrophorics
Self-Heating
Emits Flammable Gas
Self-Reactives
Organic Peroxides

Irritant (skin and eye)
Skin Sensitizer
Acute Toxicity
Narcotic Effects
Respiratory Tract Irritant
Hazardous to Ozone Layer

Skin Corrosion/Burns
Eye Damage
Corrosive to Metals

Explosives
Self-Reactives
Organic Peroxides

Gases Under Pressure

Oxidizers

Acute Toxicity (fatal or toxic)

Aquatic Toxicity

Explanations

Chemical Handling

- Chemicals should be used only in the fume hoods
- All chemicals in the Lab need to be labelled
  - Solutions left for cooling/later use need to be identified using identification chit
- Do not randomly mix chemicals since this may result in an explosion / evolution of hazardous gases
- Please consult the facility technologist if you are unfamiliar or unsure about a process
- Please enter your process in the log book

MSDS/AAA Principle

- All chemicals in the fab are hazardous. **Ensure that you have read the MSDS of the chemicals before use.**

- **What is an Material Safety Data Sheet**
  - **–Tells what chemicals are in the product,**
  - **–What the hazards of the chemicals are**
  - **–How to protect yourself from the hazards.**
- **Where to get M.S.D.S**
  - **–Manufacturer websites, or**
  - **–Google search "MSDS + name of chemical product" MUST READ !!**
- The label on the bottle also will contain some relevant information

- ***AAA principle: Always Add Acid toWater***

- Transferring of bulk chemicals allowed only with full PPE

- **THE USER WORKING AFTER YOU IN A LAB, HAS TO TRUST EVERYTHING IS SAFE AND CLEAN !!!!**

Use of glassware

- Fluoride solutions to be used only in Plastic Beakers/Petridishes/Measuring Cylinders
  - Fluoride etches glass!
- Other acids to be used only in the glass beakers

Plastic

Glass

Disposal Of Chemicals

- Aqueous waste solutions of Alkali's and Acids to be disposed into their respective bottles after cooling (<50 deg C)!
- Aqueous heavy metal waste (including Pb) to be disposed into the designated plastic bottle
- **HF and BHF solutions to be disposed in a designated plastic can as well**
- Organic solvents in a separate bottle, separate bench provided, **SHOULD NOT BE POURED INTO ACID WASTE CANS**
- **Lead wastes, lead contaminated gloves, wipes and other things to separately in dedicated bin.**
- ***Si wafer pieces to be discarded in the designated bin at the wet etch***
- ***Needles and other sharps (glass pieces) to be disposed to the red bin***
- *Waste bins/bottles are only for PP Lab waste, should not discard outside waste inside the PP lab waste bin*

Why is disposal procedure important?

- Improper disposal can cause major accidents
- Severe accidents can result from mixing of incompatible chemicals, for example:
  - Nitric acid with acetone/ ethanol/ acetic acid
    - Results in fire and explosion
  - Hydrogen peroxide with organic solvents
    - Results in fire and explosion

What is the most dangerous acid known to man?

- **Hydrogen fluoride gas is an acute poison that may immediately and permanently damage lungs and the corneas of the eyes. Aqueous hydrofluoric acid is a contact-poison with the potential for deep, initially painless burns and ensuing tissue death.**

Hazards from Fluoride solutions

- Hydrofluoric acid and Buffered HF solution
  - Equally hazardous
  - Highly dangerous due to the internal tissue and bone damage (Decalcification) caused by contact with the **colour less liquid!**

Symptoms HF injury: HF 50%

- *Almost immediate deep throbbing pain, burning feeling,(especially at hands and finger tips)*
- Red discoloration with whitish blister, tissue under skin starts dying off, bone de- mineralises
- Need only 1% body surface area to be exposed
- Systemic fluoride intoxication
- **Painful treatment in hospital (death possible)**

Symptoms of HF injury: Diluted HF solution < 20%

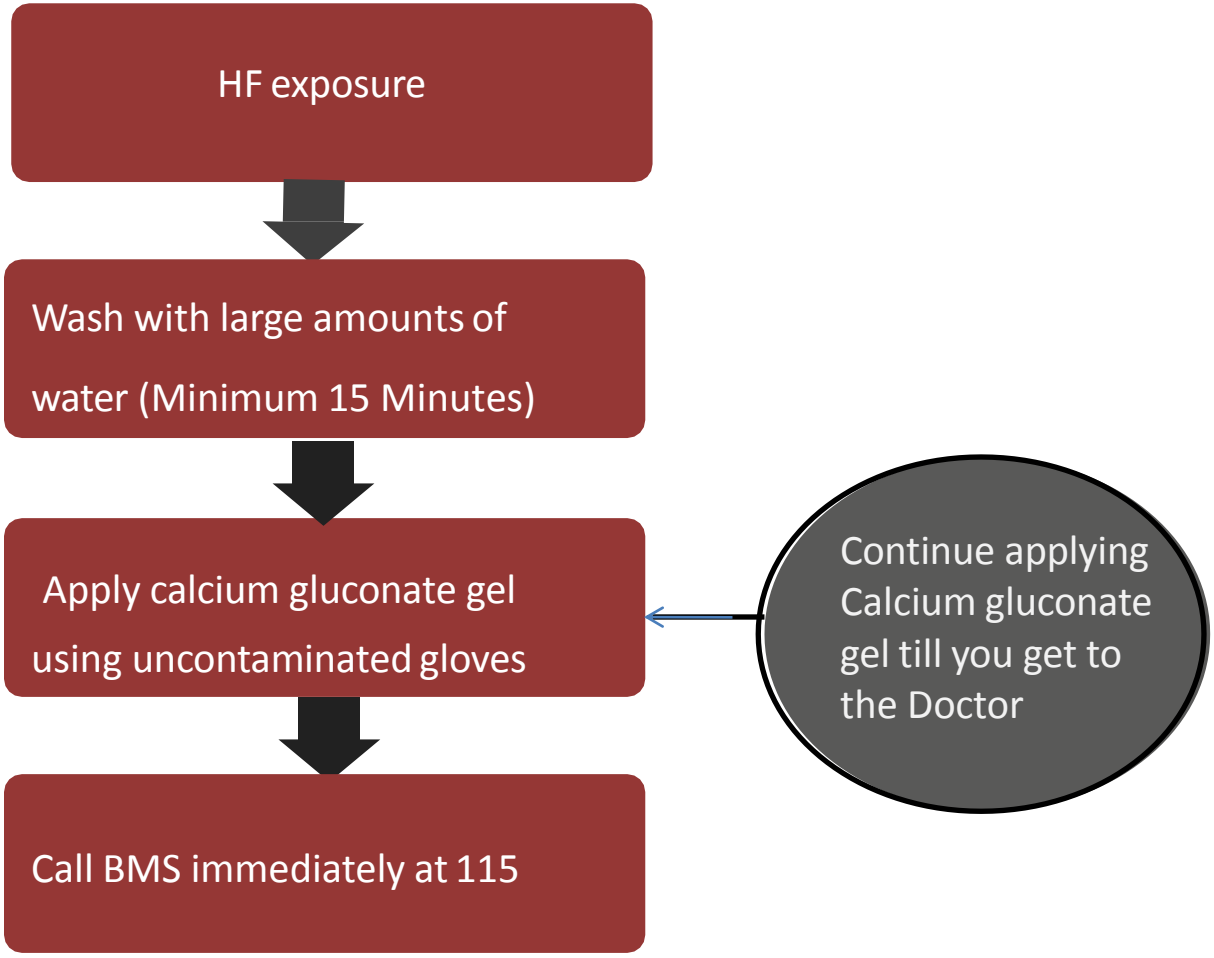
- Sometimes it can take up to 24 hours before symptoms appear (pain, rash)
- Might result in deeper penetration and more painful burn (especially at hands and finger tips)
- The surface symptoms are minimal or may be absent
- Can cause white discoloured skin, blisters seldom form
- HF solution >20%<49%:
- Symptoms sometimes just noticeable after a few hours!
- Treat all unlabelled, water-like solutions as HF solutions

First Aid

- Wash with large amounts of water (Minimum 15 mins)
- Rub in Calcium gluconate gel (make sure your hand is not contaminated)and cover the burn with plastic foil
- Seek medical attention
- Calcium Gluconate Gel is in the First aid box

Most of the harm from HF exposure can be minimized if washed within minutes

Exposed to HF?



Other Acids and Bases

- Strong acids:
  - Sulfuric, Nitric, Hydrochloric etc
- Weak acid
  - Acetic acid
- Bases
  - Potassium hydroxide, NaOH

Sulphuric acid is unique because it not only causes chemical burns, but also secondary thermal burns as a result of dehydration.

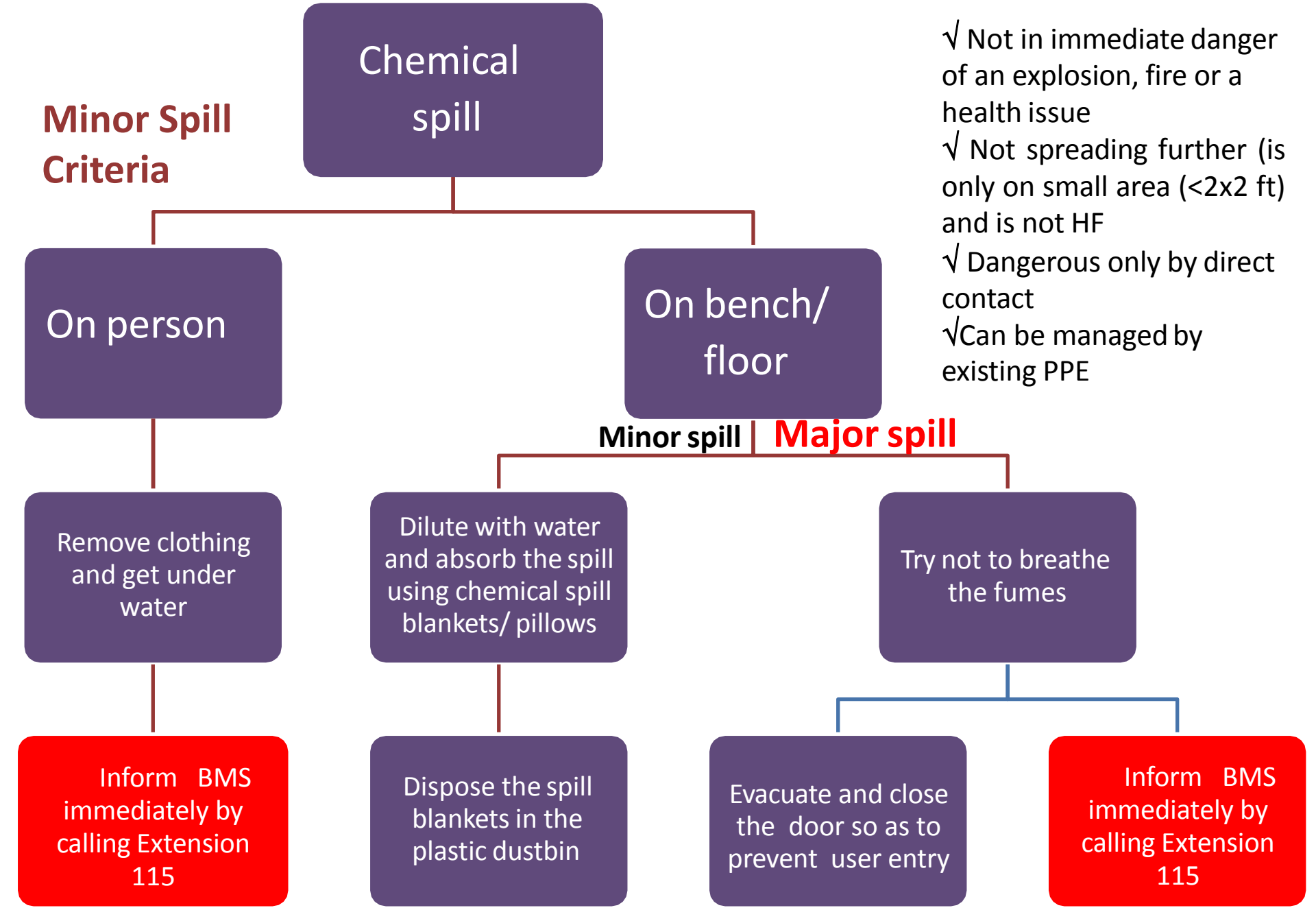
- The strong acids & bases are poisonous, corrosive, and will cause severe burns to body tissue.
  - Long term exposure will cause lung and tooth damage.
  - The weak acids will cause eye, skin and mucous membrane irritation and burns.
  - Some are even carcinogenic or teratogenic.
  - TMAH and KOH causes severe eye damage and blindness
  - Exposure to 25% TMAH might cause respiratory failure

How to treat a Chemical burn

http://medicalart.johnshopkins.edu/portfolio-item/first-aid-how-to-treat-a-chemical-burn/

Chemical Spill on the bench/floor

- On the floor,
  - **Small**
    - Contain the spill using chemical spill pillows
    - Dilute the spill with water and put spill blankets
    - Discard spill blankets and pillows in the plastic dustbin after use
  - **Big**
    - Come out and close the door to the lab
    - Inform BMS immediately
    - Take precautions not to breathe in the fumes


Minor Spill Criteria
Chemical spill
√ Not in immediate danger of an explosion, fire or a health issue
√ Not spreading further (is only on small area (<2x2 ft) and is not HF
√ Dangerous only by direct contact
√Can be managed by existing PPE
On person
On bench/ floor
Minor spill | Major spill
Remove clothing and get under water
Dilute with water and absorb the spill using chemical spill blankets/ pillows
Try not to breathe the fumes
Inform BMS immediately by calling Extension 115
Dispose the spill blankets in the plastic dustbin
Evacuate and close the door so as to prevent user entry
Inform BMS immediately by calling Extension 115

Hazards from organic solvents

- Halocarbons like Chlorobenzene are irritants and toxic to kidneys, lungs, the nervous system, liver, mucous membrane etc
- Exposure to organic acetates may cause irritation of the eyes, nose, & throat. Severe overexposure may cause weakness, drowsiness, & unconsciousness
- Acetone, Isopropyl Alcohol (IPA) and Methanol:
  - All solvents may cause skin and eye irritation..
- Most of the organic solvents are colorless & combustible, PLEASE OBTAIN PRIOR PERMISSION BEFORE HEATING. Solvent vapour's are toxic, use only in ventilated hoods

Emergency Eye Wash & First Aid Kit(PP Lab)

Emergency Eye Wash available near the Sink

First Aid Kit is available near the Entrance

High Temperature Tubular Furnace

CeNSE

CAUTION

Please take out Watch, Ring & Bangles before using the Glove Box

Must wear Gloves before using the Glove Box

Gas Cylinders Safety training, Polymer Processing laboratory / Photovoltaic Lab

CAUTION

KEEP ALL CYLINDERS CHAINED

GAS CYLINDER SAFETY

- Certain specific properties of compressed gases make them highly useful in various research activities. These gases, however, can be dangerous if not handled in an appropriate manner. Many of the odourless and colourless gases are highly toxic and flammable and this calls for utmost care while handling them.

Types of gases

- Flammable gas burns or explodes if it is mixed with air, oxygen or other oxidant, in the presence of a source of ignition.
- Please note that flammable and inflammable are synonyms & non-inflammable is their antonym.
- Inert gas is resistant to chemical action under normal temperature and pressure conditions.

Types of gases

- Oxidising gas supports combustion.
- Pyrophoric gas spontaneously ignites upon exposure to air.
- Corrosive gas can burn and destroy body tissues on contact. Corrosive gases can also attack and corrode metals.
- Poisonous (Toxic) gas is harmful to humans when it exceeds the maximum allowable concentration in air.

Gases Info

Inert gases - Argon, Helium, Neon and Nitrogen

Flammable gases- Hydrogen, Methane, Ethylene, Ethane,Propylene, Acetylene, Isobutylene, LPG and Deuterium

Toxic gases- Carbon monoxide, Sulphur dioxide, Phosgene, Boron trichloride, Germane, Diborane, Chlorine and Ammonia

Pyrophoric gases - Silane and Phosphine

Oxidisers - Oxygen and Nitrous oxide

Hazards in gas cylinder usage

- Oxygen deficient atmosphere resulting in asphyxiation.
- Formation of flammable gas air mixtures in case of
- leakage of flammable gas.
- Oxygen enriched atmosphere in case of leakage of oxygen gas.
- Injury caused by fall of gas cylinders during handling.
- Exposure to high concentrations of toxic or corrosive gases in case of leakage.
- Gas cylinders can explode when exposed to high temperatures, e.g., in case of fire.
- If the valve breaks, the sudden release of compressed gas can turn it into a lethal projectile.
- Leakage of any gas (except oxygen) inside a confined/enclosed space can cause displacement of oxygen resulting in an oxygen deficient atmosphere.
- Entry into a workspace with oxygen level below 19.5% is unsafe and not permitted

Storage of gas cylinders

- Flammable gas cylinders must be separated from oxygen cylinders by a distance of 6m or by a wall of 30 minutes fire resistance.
- Empty cylinders must be marked /tagged and stored separately.
- Only gas cylinders for immediate use must be stored inside the laboratory
- Materials must not be stored in front or on top of the gas cylinders.
- All cylinders in the laboratories must be clearly labelled.
- Gas cylinders must not be stored near exits and passages.
- Gas cylinders must be stored away from heat sources.
- Cylinders must always be kept chained
- NEVER roll them along the ground

Safe use of gas cylinders

- Refer the Material Safety Data Sheet(MSDS) for the gas before usage, to know about the hazards and precautions to be taken.
- Do not tamper with the cylinder valves.
- Always use the correct regulator for the cylinder.
- Inspect the regulator for damage before use.
- Never use damaged regulators, piping, etc. After the regulator is attached, the cylinder valve must be opened just enough to indicate pressure on the regulator gauge and all connections must be checked with a
- Do not stand in front of the regulator gauge or the valve outlet side, while opening the valve.
- Use safety glasses while working with gas cylinders. compatible solution for leaks.
- Ensure proper ventilation in the area where gas cylinders are stored.
- Spindle key must always be placed at an easily accessible location, for closing the valve in case of emergency.
- Close cylinder valve whenever work is finished /cylinder is empty

Hydrogen Gas Safety

Introduction

- Hydrogen (H2) is an extremely flammable, colorless, odorless compressed gas that is used in many research laboratories. It has virtually no toxic effects on the human body, but it can displace air causing asphyxiation if enough is released in an enclosed room. The biggest danger when dealing with hydrogen is that is has a wide explosive/flammability range (4%-74% in air). This means that even a small leak can cause a hazardous fire. Hydrogen is very light and quickly rises if released, and also has the unique characteristic of making certain metals brittle after prolonged use. So, use caution when working with metal tools and devices.

Fire Hazards

- When hydrogen is in air it can ignite with extremely low energy input. For instance, hydrogen only needs 10% of the energy (0.02 millijoules) required to ignite a gasoline air mixture. Even a static spark from a person or clothing can ignite hydrogen gas. Hydrogen needs only a minimum of 10% oxygen or a maximum of 41% of oxygen in air to ignite. Also, because the flame is almost invisible in daylight, finding and fighting a hydrogen fire can be difficult.

Protective Measures

- There should be no open flames or smoking in areas where hydrogen is used.
- Work in an area with plenty of ventilation. If possible, work in a fume hood or use a canopy hood as fugitive vapors, if not captured, may collect near the ceiling.
- Ground all equipment and piping used with hydrogen, and make sure that you are properly grounded before working with hydrogen. Rubber soled shoes prevent you from being grounded, so you should touch a grounded object to discharge built up static electricity before beginning work.
- Wear appropriate lab safety gear for the work being performed: safety glasses/ goggles, lab coat, gloves and preferably a face shield. Use metal piping with hydrogen.
- Do not use non-conductive or plastic tubing. Be sure to dissipate static charge when flowing hydrogen gas by electrically bonding and grounding the cylinder, metal piping and apparatus being used.
- NEVER USE ADAPTERS.

Hydrogen Gas Safety

- All electronic equipment used near hydrogen gas must be grounded.
- Check that the pressurized system does not leak hydrogen with leak detection solution or pressure sensing.
- Close the cylinder valve when not in use. Do not leave the piping pressurized if not in use.

<u>Hydrogen is incompatible with many materials and situations (check your MSDS for list of incompatibles):</u>

- It ignites easily with oxygen, could explode when heated.
- It reacts violently or explosively or forms heat- and/or-shock sensitive explosive mixtures with oxidizers, halogens, halogen compounds, acetylene, bromine pentafluoride, chlorine oxides, fluorine perchloride, oxides of nitrogen (check MSDS for list of incompatibles).
- Mixtures with chlorine may explode on exposure to light.
- Mixtures with oxygen may explode in presence of platinum catalyst.
- It is incompatible with copper (II) oxide, difluorodiazene, iodine heptafluoride, lead trifluoride, liquid nitrogen, lithium perchlorate trihydrate, metals, nitrogen trifluoride, nitryl fluoride, palladium (II) oxide, palladium trifluoride, polycarbon monofluoride, potassium tetrafluorohydrazine, xenon hexafluoride.
- It forms hydrides when heated with alkalis, alkaline earth, and some other elements.

Hydrogen Gas Safety- In Emergency

- Contact in Emergency – BMS: 115

If a leak is detected:

o Evacuate the immediate area of all non-essential personnel

o Immediately shut off the hydrogen source and increase indoor ventilation

o Notify BMS immediately

o To detect a small local hydrogen fire (the flame is nearly invisible), use a piece of tissue paper on a stick, the paper will readily ignite upon contact with the flame.

In case of fire:

o Shut off the hydrogen source if safe to do so

o Let the fire burn itself out (If the flame is snuffed out, it may reignite and cause greater damage).

o You may use a water fire extinguisher if you have been trained and if it is safe to do so. You may also use water spray to thermally protect people and equipment if necessary. Note that a venting hydrogen flame cannot be extinguished with water.

o Execute the emergency plan immediately; this includes calling 115, notifying the Lab In charge and other required emergency contacts.

Oxygen Gas

- Odourless
- Generally considered non-toxic at atmospheric pressure
- Will not burn, but supports and accelerates combustion
- Materials not normally considered combustible may be ignited by sparks in oxygen rich atmospheres
- Greasy and oily materials must never be used on oxygen cylinders or fittings as it can cause explosion.
- Regulators for oxygen service must never be used with flammable gases. Cross contamination of internal parts may result in rapid oxidation and fire.
- High pressure oxygen will react violently with oils and grease and cause a violent explosion or localised ignition leading to injury of the user and damage to equipment.
- Oxygen supports and can greatly accelerate combustion of flammable materials. Oxygen, as a liquid or gas, may cause severe frostbite to the skin or eyes. Do not touch frosted pipes or valves.

Nitrogen Gas Safety

- Odourless
- At high concentrations almost instant unconsciousness may occur, followed by death
- No warning signs before unconsciousness occurs
- Cold Nitrogen is heavier than air
- Does not burn
- Largely Inert

Asphyxiation is the main hazard associated with inert gases such as helium, argon, and nitrogen. If these gases escape undetected into the atmosphere, they can quickly reduce the oxygen levels below concentrations necessary to support consciousness and life.

Argon Gas

- Odourless
- At high concentrations almost instant unconsciousness may occur, followed by death
- No warning signs before unconsciousness occurs
- Argon is heavier than air
- Does not burn
- Inert
- Asphyxiation from non-toxic, non-flammable gases by displacement of oxygen (e.g. nitrogen, carbon dioxide or argon)

Penalty points
(2x times for second violation)

- Using without booking slots: 15 points
- Not wearing proper PPE (gloves/ goggles): 15 points
- Leaving solutions without identification chit: 15 points
- Leaving bench unclean: 30 points
- Using BHF/HF/ Vaporizer carelessly: 100 points (immediate suspension of access)
- Bringing external chemicals without permission:100 Points

Thank you