20. Personal Safety

COVER PAGE

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INTRODUCTION

An ASU is a complex plant producing gas (N2, O2, AR...) and associated cryogenic liquids, these products being either at extremely high or low temperature as well as extremely high pressure.

All personal including subcontractors working in the plant shall receive the safety information included in this document and understand it.

When several firms are used as subcontractors to perform at the same time one operation or several operations that might interfere, a meeting aiming to work out the prevention safety measures related to the concerned operation must be organized.

The common industrial hazards are mainly linked to:

- Personal safety equipment
- Usual hazardous works

The hazards on cryogenic air separation unit are mainly linked to:

- Processed gas
- Cold
- Work in confined space
- Hydrocarbons in the air (Developed in the Process Safety section)
- Restrictive area

Operators are strongly requested to take the here below mentioned recommendations into consideration, since the hazards that are here evoked may lead, if the necessary precautions are not taken, to serious damages to the plants and also to injuries and even fatalities to people.

Complementary information are given in Volume B section « SAFETY/ ENVIRONMENT »

1 COMMON INDUSTRIAL HAZARDS PREVENTION

1.1 The Working Permit

As a rule, the **work permit procedure** must be widely implemented for any work in the plant:

WORK PERMIT N°

JOB DESCRIPTION

CONCERNED EQUIPMENT : ---------- ZONE : ----------

CONFINED AREA : ☐ Yes ☐ No If answer is YES a[illegible] Pre-Entry Permit

JOB : ----------

PERSON in CHARGE of the JOB : Name : ---------- Company : ----------

WORK PERMIT VALIDITY : From (day / time) : ---------- To (day / time) ----------

POTENTIAL HAZARDS

A. - NEARBY COACTIVITIES (example : welders above, Painters below, Traffic ...) - DESCRIBE :

B. - FLUIDS : ☐ Gas ☐ Liquid ☐ Others Which ones : ----------

Related Hazards : ☐ Anoxia ☐ Toxicity ☐ Overoxygenation ☐ Inflammation ☐ Hot Work
☐ Heat ☐ Cold ☐ Pressure ☐ Flames / sparks (A)
☐ Electricity ☐ Corrosive ☐ Others

C. - JOB'S SPECIFIC HAZARD : ☐ Height ☐ Digging ☐ Lifting ☐ Fire ☐ Flames / sparks
☐ Noise ☐ Electricity ☐ Rotating / moving parts ☐ Others

D. - OTHERS : ----------

(A) Apply Fire Permit

PREVENTION

☐ Drain ☐ Depressurization ☐ Locking out (B) ☐ Nitrogen blowing ☐ Steam blowing ☐ Analysis
☐ Air ventilation ☐ Deriming ☐ Signposting ☐ Barricades ☐ Cordoning ☐ Protective screen
☐ Scaffolds ☐ Watchman ☐ Signalman ☐ Extinguisher ☐ Fire Hose ☐ Nets

OTHERS : ----------

PERSON in CHARGE of the IMPLEMENTATION of PRECAUTION MEANS : ----------

(B) apply Lock out procedure

P.P.E.

☐ Hard hat ☐ Goggles ☐ Safety boots ☐ Hearing protection ☐ Harness
☐ Breathing apparatus ☐ anti-dust mask ☐ gloves ☐ Analyzer

OTHERS : ----------

SIGNATURES

	NAME	COMPANY	Prior to work Date / time	Work achieved Date / time
Person in charge of the job				
AL/DI Site Manager				
Site Safety Manager				

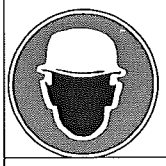
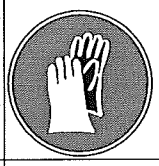
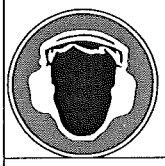
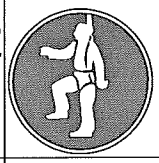
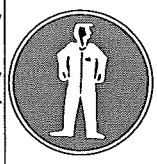
ADDITIONAL PROCEDURES to be APPLIED :

☐ Detailed Work procedure ☐ Lockout procedure ☐ Fire permit ☐ Pre-entry permit
☐ Others :

Contacts in case of accidents : NAME : Phone nr :
NAME : Phone nr :

1.2 Personal safety equipment

The workers must be fitted with the necessary personal safety equipment. Any safety equipment, whether collective or personal, must comply with existing standard and country regulation.

	**Hard hats** for head protection.		**Safety shoes**
	**Safety glasses** for eyes protection and adequate face shields for specific hazards such as: chipping, acid work, welding, molten metal, other risks of the same kind.		**Safety mitten or gloves** for hand protection.
	**Personnel when exposed to any hazard to ears must wear ear protective devices.**		**Safety belt or harness** complying with existing standard or (and) country regulation.
	**Protective masks** with suitable filter when exposed to any hazard to the lungs caused by: harmful fumes and gases, spray painting, excess dust, other risks of the same kind.		**Clean work clothes**; fire-retardant clothes are recommended when working in area where hazard of oxygen enriched atmosphere or presence of flammable product exist. Other adequate protective clothing will be worn in case of exposure to specific hazards.

1.3 Personal safety recommendations

Work at high level or vessel

For such works specific equipment must be implemented such as scaffoldings, safety harness, life lines and other adequate devices to prevent workers from falling (such devices must comply with the existing standards and (or) country regulations).

Particular precautions must be taken to prevent any piece from falling from elevated locations down to lower levels and to protect people working at lower levels.

It must be reminded that a ladder is not convenient base to perform any work. If ladder is used, it must comply with existing standard and (or) country regulation and be in good condition.

Digging Work

That induce risks of underground networks (pipeline, electrical wires...) break and of fall in the excavation. Piping drawings must be carefully studied before operation in order to locate the underground pipelines or network and care must be taken for digging close to pipes. Shoring is required for deep trenches with vertical walls. Adequate signalling and protection devices must be installed to prevent people from falling in the excavation.

Hoisting and handling equipment

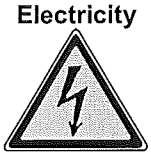
Any operation must be studied in details, particularly when the piece to be handled is heavy or large, in order to make sure that adequate vehicle is used, necessary room for crane is available, and to prevent any damage, especially to people, that could result of the fall of the load. Whether specialist must make sure of the proper condition of the vehicle used, or the evidence of the proper conditions (according to country regulation), as technical visit certificates, must be available.

Only trained, qualified and authorized persons may operate lifting or handling vehicles. Some operation may require the permanent presence of a signalman.

Traffic

Adequate measures must be taken to arrange a circulation schema in the plant site in order to avoid collisions between vehicles. For instance, sign posting may be installed in order to direct, depending on the operation performed, trucks, car, handling vehicles and pedestrians.

Electricity



Employees must be aware of the hazards involved in working with electricity. Only trained, qualified and authorized employees may work on electrical installations.

Appropriate equipment's must be used and must be in good condition (grounded or equipped with double insulation).

If work is to be performed on electrical equipment, work procedures must be applied and special safety equipment must be used. The electrical lock out/tag-out is an essential, obligatory safety procedure. It involves disconnecting the equipment from any possible source of power (electrical, mechanical).

Use adequate sign posting and other means to inform people working on site that work in being performed.

Machines

Since machines include moving parts, any work on them obviously induce a hazard. In addition some of them, as gas compressors, present other risk that are related to high temperature and pressure. The protection devices installed on the machines must be kept in place or replaced when damaged. Any intervention on the machine must be undertaken following the needed procedures that are work permit, electrical and mechanical lockout. Use adequate sign posting and other means to inform people working on site that work in being performed.

Working on piping or vessel

Any work on a pipe must perform following the work permit procedure. The part to be worked at must be properly isolated (double block and bleed, blind flange...) and the means used locked out. In case the part on which the work is performed is used to flow hazardous product, adequate blowing and analysis must be done to ensure the absence of remaining product.

Welsing

Electric arc and oxy-acetylene welding must be performed by qualified and authorized welders only. Welders must wear the adequate equipment. When welding in confined area, particular precautions must be taken (procedure to be followed, analysis to be performed...).

Sources of radioactivity

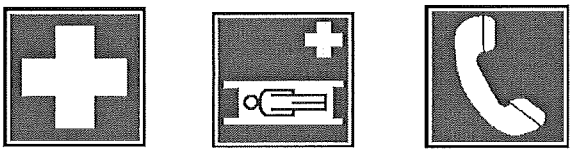
When such a method is used (particularly when verifying the quality of stainless steel welding), a controlled zone must set and properly signalled. A procedure must be worked out to ensure that no one remains inside controlled zone at the time the specialists for radiography work.

Prohibition to smoke on the site and prohibition of open flames

Prohibition of use of cell telephone and Walky Talkies near the electronics components (in particular in control room, near the cupboards systems, in the instrumentation modules....) because of the possible electromagnetic disturbances

1.4 First Aid – Emergency and Evacuation Plan

First Aid



Considering the risks involved in the operation of the plant, appropriate first aid kit should be available and easily accessible at any time by the personal.

Unless a first aid room and a qualified attendant are close at hand and prepared to render first aid to employees on behalf of the employer, the employer shall furnish a first aid kit for the employees. The first aid kit shall include at list all materials necessary to treat hot and cold burns, electrical shocks, and eyewash as well as usual kits.

The contents of the kit should be adapted to the size of the plant, when larger operations or multiple operations are being conducted at the same location, employers should determine the need for additional first aid kits at the site, additional types of first aid equipment and supplies and additional quantities and types of supplies and equipment in the first aid kits.

In a similar fashion, employers who have unique or changing first-aid needs in their workplace may need to enhance their first-aid kits. Consultation from the local Fire/Rescue Department, appropriate medical professional, or local emergency room may be helpful to employers in these circumstances. By assessing the specific needs of their workplace, employers can ensure that reasonably anticipated supplies are available. Employers should assess the specific needs of their site periodically and augment the first aid kit appropriately.

If it is reasonably anticipated employees will be exposed to blood or other potentially infectious materials while using first-aid supplies, employers should provide personal protective equipment (PPE). Appropriate PPE includes gloves, gowns, face shields, masks and eye protection

At least one employee per shift shall be qualified to administer first aid to the injured.

The contents of such kit shall contain a sufficient quantity of at least the following types of items:

- Gauze roller bandages,
- Gauze compresse bandages,
- Adhesive bandages,
- Triangular bandage,
- Antiseptic applicators
- Burn dressing,
- Eye dressing,

1.5 Safety Showers and Eyewash Stations


Safety showers and eyewash stations shall be located within buildings and other process areas where there is a hazard of chemical or cryogenic spillage or splashes. They shall be located as close as practical to the hazards identified. They shall be self contained and supplied with potable water at ambient temperature. They should be tested and maintained periodically.

1.5.1 Emergency Plan

In case of emergency, an adequate emergency plan should be put in place in accordance with local regulation.

1.5.2 Evacuation Plan

An adequate evacuation plan shall be put in place to evacuate all personnel from the facility to a safe location in case of major incident in accordance with local regulation.

2 THE HAZARDS LINKED TO THE GASES

2.1 Toxicity

A gas is toxic when it can cause, even for very low quantities, a poisoning of human body.

Although the main liquids and gases processed in an air separation unit are not toxic, some toxic products may be used for the operation of auxiliary equipment's. Those equipment's are mainly:

- Cooling units using ammonia
- Water treatment station

In case neighbouring factories are possible sources of toxic emissions that might, according to atmospheric conditions and particularly the wind direction, reach the air separation unit site, adequate safety equipment's must be available.

Poisoning effects can be very fast for big quantities breathed causing a fast death or very slow for little quantities. Every little dizzy-turn must be taken into account.

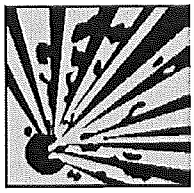
More important the quantity is, more serious the effects are.

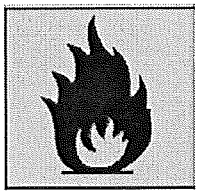
Effects depend on the quality of each gas.

Effects are particularly insidious for gas without color or odor.

It's absolutely imperative to systematically check atmosphere of contaminable zones.

2.2 Explosion or rapid burning





It's very important to keep in mind that explosion is a violent phenomenon causing every time serious damages.

There are two possible causes:

Presence of flammable gas in air

Oxygen enriched atmosphere (More than 21 % of oxygen)

In case of an oxygen enriched atmosphere, the combustive product is in big quantity, certain material normally regarded as being non-flammable in the air become flammable (grease, asphaltic bitumen, oil...).

In this case also, a spark, a flame, a shock, a friction is enough to cause burning. The phenomenon is linked to concentrations ratio of combustible and combustive, and to a fortuitous event which cause ignition.

The explosive regarded zone must be periodically checked.

Tools, clothes, place design will be chosen to prevent any hazard.

Concerned zones or operations on an air separation plant:

The hazard of combustion or explosion exists in any place where, due to accidental or unexpected event or to the performance of an improper operation, atmosphere may be oxygen enriched.

As a rule, specific precautions must be taken when work is undertaken in the vicinity of:

- Liquid oxygen filling station
- Oxygen compressor
- Oxygen expansion valve station
- Oxygen metering station liquid or gaseous oxygen vent

Particular environmental conditions, such as wind direction and strength, may induce oxygen enriched atmosphere on areas which may be considered far enough of the source of hazard.

Flammable products used or stored on site may of course be an other source of combustion, as oil and grease. Lubricants used for oxygen use must comply with Air Liquide recommendations.

Hydrogen is sometimes used for crude argon epuration. The risk due to the presence of this gas is therefore present on the warm argon purification unit and may even spread to the cold argon purification equipment.

Before any work is undertaken on a location where such a risk exists, the work permit procedure must be applied.

2.3 Asphyxiation

Asphyxiation is a lack of oxygen in the body. It occurs when air is replaced by a gas containing not enough oxygen under an assimilable form by the human body:

DANGER BEGINS WHEN O2 CONTENT IS LESS THAN 18 %.

There are two kinds of asphyxiation:

- Sudden asphyxiation:

  For very low oxygen content (less than 6 %), the victim falls down immediately. Death can occur within a few minutes.

- Slow asphyxiation:

  It occurs slowly either by slow decreasing of oxygen content or during the victims presence in a lightly under oxygenated atmosphere.

<u>Concerned zones or operations on an air separation plant:</u>

Any confined area or insufficiently ventilated place where Nitrogen or Argon is likely to be present:

- Inner cold box
- Outer cold box:
- In case any closure device is removed or not tight, nitrogen may flow out, building up an asphyxiant area close to the opening or leakage.
- In the interspace of nitrogen, oxygen and argon storage tanks since there are permanently blown with nitrogen.
- In any room in which equipment operate using inert gases (analysers rooms or cabinets, control room...).
- In any place where air may be replaced by nitrogen or argon (control room, workshop...).
- In trenches or low points (sewers, pits...).
- When using cryogenic liquids (nitrogen, argon...).
- When using by mistake nitrogen instead of air for breathing equipment.
- In rooms where a fixed fire extinction system is installed, when either halon or CO2 is used as an extinguisher agent, since in case of functioning of the system, the oxygen content will decrease down to until hazardous values.
- In the vessels of the purification unit where, even after an air blowing has been performed, nitrogen may desorbe off the adsorbent beds at a later stage.

2.4 Pressure

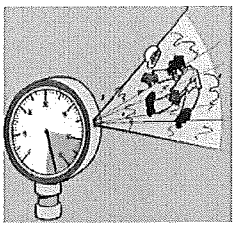
The risk inherent in pressure vessels systems from the quantity of stored energy used to pressurize the fluids contained. **This energy may be considerable!**

In the case of a rupture, this energy will cause a sudden expansion of the fluid:

- Leak and bursting
- Explosion

PRECAUTIONS:

Certain safety measures must be followed to the letter in order to limit the hazards of pressure:



- When systems are being designed, the regulations in effect must be respected. You must comply with the instructions provided in the pressure vessel construction codes. Systems and equipment under pressure must be inspected before the first start-up and then periodically as indicated by law. Equipment under pressure must be checked on a regular basis for strength and leaks.
- Safety devices must be installed for use when normal operation conditions are exceeded (ex: bursting disks, safety valves, buckling rods, cut-off and lock-out devices controlled by temperature or pressure, measurement and regulation devices...).
- The pressure gauges installed on the equipment under pressure are used to measure the internal pressure. The reading on the pressure gauge must always be at 0 before you can start any work on the equipment.
- Operating procedures have been developed to eliminate the hazards of pressure. They must be followed to the letter. One particularly important procedure is the lock-out / tag-out procedure for gases.
- Changes to pressure vessels are prohibited unless done in accordance with the rules: design and construction in accordance with standards, periodic tests.
- Finally, everyone must immediately report any defect or anomaly noted on a device, pipe or safety device to his immediate superior so that measures can immediately be taken to correct the problem. Considering the hazards of pressure, reporting is the duty of each and every one of us.

2.5 Hot temperatures

The risk inherent to hot temperature is that some piping of the plant can reach temperature higher than 150°C or more, causing severe burns. Such high temperature can be reached on the following items:

- the regeneration system including the regeneration heater and the associated piping
- The compressors casing and associated piping
- The vaporisation systems
- The steam piping when existing

PRECAUTIONS:

Certain safety measures must be followed to the letter in order to limit the hazards

of high temperature:

- When systems are being designed, the regulations in effect must be respected.

  You must comply with the instructions provided in the pressure vessel construction codes. Systems and equipment under pressure must be inspected before the first start-up and then periodically as indicated by law. Equipment under pressure must be checked on a regular basis for strength and leaks.
- Safety devices must be installed for use when normal operation conditions are exceeded (ex: bursting disks, safety valves, buckling rods, cut-off and lock-out devices controlled by temperature or pressure, measurement and regulation devices...).
- The pressure gauges installed on the equipment under pressure are used to measure the internal pressure. The reading on the pressure gauge must always be at 0 before you can start any work on the equipment.
- Operating procedures have been developed to eliminate the hazards of pressure. They must be followed to the letter. One particularly important procedure is the lock-out / tag-out procedure for gases.
- Changes to pressure vessels are prohibited unless done in accordance with the rules: design and construction in accordance with standards, periodic tests.
- Finally, everyone must immediately report any defect or anomaly noted on a device, pipe or safety device to his immediate superior so that measures can immediately be taken to correct the problem. Considering the hazards of high temperature, reporting is the duty of each and every one of us.

2.6 Prevention knowledge

Any hazard considered (toxicity, explosion, asphyxiation), the main rule is the knowledge of atmosphere composition where it is necessary to work or to stay.

Measurements can be made:

- Continuously
- Periodically
- Or just when there is a particular danger (with portable analysers)

Neutralization the risk source:

Pipes will be cleaned of their pollutant gas.

For toxic or asphyxiating gas, blowing with air up to safety quantity particular to each gas.

For flammable or combustive gas, blowing with nitrogen up to safety quantities particular to each gas and, afterwards, blowing with air to have a breathable atmosphere (between 18 % and 23 % oxygen).

After these cleanings, atmosphere will be checked as noted above (continuously when performing tasks or periodically after blowing and before any work).

Case of work to be done on only one part of the plant:

This part will be isolated with blind flanges or by pipes disconnected from the polluted part. Nota: An isolating valve or a control valve is not of absolute security.

Adequate safety means supply:

- Safety guards far enough from the dangerous zone but near enough to watch workers.
- Special safety material: special kind of extinguisher for each kind of hazard (Carbon dioxide, water spray...) automatic showers, gas mask adapted to concerned gas, autonomous mask etc.).
- Information and training of people likely to work on polluted areas.
- Use of adequate tools (antiburning lamp, bronze tools (anti-sparks) free of oil and clean).

Generally on a plant:

- Clear signalling of hazardous zones (use barricades, sign posting...),
- Adequate bans (prohibited to smoke, to come in, to make fire),
- Cleanliness (no materials on the ground, no oil pool, no oily rags...),
- Availability of adequate help and safety equipment.

Areas considered as dangerous:

- With difficult access (so, difficult to evacuate) because of small exits (man hole) or exits position (height...).
- With closed area even ventilated because accumulation in corners (analyser panels, caskets, holes, sewers, ground with pit (gas heavier than air), ceilings (gas lighter than air, etc.).
- With cul-de-sac (sewers, pits, gutters, containers...).
- In open air, near a gas source (nitrogen drying outlet...) where atmosphere can be very polluted.
- Places regarded as non dangerous but linked with dangerous places by piping (sewer...).

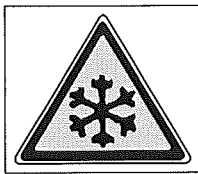
Implementation of procedures for work in vessels, tanks and other confined space:

(See section work in confined space)

Specific Protection Devices:

(See section work in confined space)

3 THE HAZARDS LINKED TO COLD TEMPERATURE



ALWAYS REMEMBER that a liquefied gas concentrates in a small volume big amount of matter.

Therefore, the characteristics and particularly the hazards are amplified in the liquid.

3.1 Causes and effects

Causes	Effects
Causes linked to the cryogenic liquid hazards during plant operation: • Every cryogenic liquid handling, • Container transport, • Work on cryogenic pumps, • Voluntary purges (even with evaporating devices), • Plant cold test without insulation, • Tasks executed in a zone where there are non insulated pipes, • Cryogenic liquids on the ground. Accidental causes: • Cryogenic liquid safety valve opening, • Leak on flanges, valves (packing...), • Not well dried pipes bursting, • Piping collapse due to ice accumulation (during rain or fire fighting).	Every skin touch with liquefied gas or materials at the temperature range of liquefied gas causes serious frostbite, similar to burn. The touch gives a sensation of sticking to the material. • Skin can be damaged by a very cold atmosphere, • Lungs can be damaged by breathing in a very cold atmosphere, • The lower the temperature is, the longer touch or the presence is, the more serious effects are. A serious effect is hypothermia (body temperature decreasing), which can cause death.

3.2 In case of accident

- Remove any cloth embarrassing blood circulation in the frost bitten zone.
- Water the frost bitten part with water at about +20°C **for at least 15mn.**
- Call for emergency or safety brigade in order to make the victim be transferred to the adequate care center (hospital or infirmary).

After cold atmosphere breathing:

- Bring the victim to a warmed room (be careful not to place the victim directly in a hot atmosphere).
- In case of dizzy-turn, bring the victim to a hospital or infirmary (don't forget that hypothermia can cause death).

Frostbites are often painless at the beginning. This may lead to estimate the injury less serious that actually is.

3.3 Prevention

	Gloves (leather...)		Safety shoes
	Safety glasses		Special clothes in case of spray

- **Don't touch** cold material or liable to be cold (vessels, pipes and liquid itself!).
- **Don't stay** in a cold atmosphere (plant cold test, quantity of cryogenic liquid evaporating after fall on the ground...).
- **Don't walk** in a zone where cryogenic liquid has flown on the ground (fog caused by cold hides cryogenic liquid pools).
- **Be careful**, the liquid can freeze and make the zone slippery.
- **Don't purge** voluntarily cryogenic liquids on the ground.
- **Take care of wet clothes**, pockets, shoes (trousers over the boots), gloves which can be filled with liquid spray.

Particular precaution linked to liquid oxygen:

Always remember that purging liquid oxygen aground may lead to immediate explosion if the covering ground matter is combustible.

Be careful with:

- Purge on asphaltic bitumen, on sand etc.,
- Contact with rust, paper,
- Permeation with porous materials (wood, tissues etc.).

Requirements:

- No handling near flammable materials (ground and walls also),
- No storage of volatile materials or flammable materials near oxygen tanks or oxygen vents,
- Provide good ventilation of liquid oxygen storage areas (if possible in open air),
- Proscribe low points (sewers, pits...),
- Install extinguishing devices (sprayed water extinguishers...),
- Requirements for gaseous oxygen hazards and cryogenic liquid handling are also applicable.

4 THE HAZARDS LINKED TO THE CONFINED AREA

4.1 Definition

A closed or open volume, located above or below ground level, in which the natural permutation of the air inside with the atmosphere is diminished.

Open confined spaces (with relatively free and easy access)	Closed confined spaces (relatively tight and difficult access due to the narrowness of the openings)
Trenches, shafts, manholes, tunnels, piping, pipe-lines, sewers, pits, retention basins, air intake for venting inert gases, water/nitrogen towers, ...	Cold boxes, casings: pumps, valves, cold exchangers -reservoirs, tanks, absorbers, cooling towers, heat exchangers, boilers, furnaces, ...

The atmosphere, as one enters in the confined area is unknown and has to be checked.

Generally, any work on an installation, which has already been operating, is hazardous and the surrounding atmosphere always has to be checked, before entering it.

It is hazardous to enter into a confined area because it may contain a dangerous atmosphere (toxic gas or suffocating gas) or an explosive atmosphere.

Inventory of Risks

SUFFOCATION 	Risk of being buried, drowned in perlite, inert gases (argon, nitrogen,...)
POISONING 	Presence of waste or of toxic gases (CO_2, CO, Ammoniac, Chlorine, Phosgene...), Presence of solvents
EXPLOSION-FIRE 	Inflammation of vapours or particles (sparks, hot points)
CHEMICAL 	Presence of chemical substances: burning due to inhalation
ELECTRICAL 	Presence of electrical current, static electricity

RADIOACTIVE 	Presence of radioactive sources
MECHANICAL	Intervention on a piece of equipment in running mode, uninformed personnel (faulty instructions, lack of blind flange, lack of knowledge about pressure variations between different circuits), mechanical weaknesses in the equipment used for the intervention (scaffolding, tunnel,...)
PHYSIOLOGICAL **PHYSICAL**	Medically unfit (claustrophobia, vertigo,...), fatigue, anoxia, physical condition NOTE: The workers' PHYSIOLOGICAL and PHYSICAL FITNESS is a preponderant element to be taken into account when undertaking work.

Example of Accidents

OPERATIONS	CONSEQUENCES
Injection of gaseous nitrogen into a distillation column by a bleed pipe which has defective sealing in the coupling device	Operator feels unwell when working to improve tightness (immediate first-aid)
Check on the penetration of a weld on a pipe of large diameter	A welder and foreman found asphyxiated by argon (death)
A washing tower repainted on the inside	A subcontractor found unconscious in the tower (death)
Removal of molecular sieve from a bottle of a drying unit	Two labourers intoxicated by H2S naturally desorbed of the sieve in the truck the sieve had been poured
Activated carbon filling of a PSA adsorber	High CO content in the bottle when CO naturally desorbed from the activated carbon

4.2 Work in a box insulated with perlite

(Cold box, exchanger box)

Perlite is a hydrated silicate pre-submitted to an expansion by thermal treatment. Perlite is extremely light and fluid. Falling in perlite causes death because one literally drowns and dies of stifling.

It is a highly irritant material, which has to be handled with gloves, protecting glasses and breathing masks or autonomous breathing apparatus.

Work in a perlite box insulated with perlite should be done if the following conditions are fulfilled:

- Scaffolding around the work area.
- All the workers have to be equipped with a security harness linked to a stable point strong enough to carry the worker. The rope shall be short enough to avoid falling in the perlite below the working spot.
- Workers shall be supervised, permanently by other workers, observing the scene from a place out of the dangerous zone.
- Every worker shall wear glasses, gloves and a dust-protecting breathing mask.

Caution:

In the case of a complete removal of the perlite in a box, before entering it, it is compulsory to make sure that no accumulation spot exists.

An old perlite, carrying damp, is more compact and has a more important mass. Perlite could be retained in the upper section by other devices and collapse under a slight action.

Even the devices can be broken by this accumulation, especially when the perlite is old and damped.

4.3 Operating in a box insulated with rock-wool

(Cold tank, exchangers box, pumps casing, turbines casing)

The rock-wool is a highly itching material, which requires to be handled with gloves, glasses and autonomous dust protecting breathing masks.

Caution:

Any work on an installation only accessibly through a tunnel, is highly dangerous, because of the risk of collapsing.

This work is very hazardous and should be avoided. However, if no other possibility exists, it has to be prepared with great care, making sure that all the security instructions are followed.

The tunnel has to be backed-up strongly enough, in order to allow it to support the upper weight.

Of course, the workers operating in it, have to be equipped with a harness, linked to a rope attached somewhere out of the tank and being easily accessible.

The staff entering the dangerous area shall be supervised by people staying out of the tank but near enough to be able to rescue (fainting by lack of air or heat).

The tunnel shall be enough ventilated in order to ensure a sufficient exchange of breathable air.

4.4 Work in an adsorber or close to adsorbing material

Any work performed inside an adsorber is highly dangerous for taking place inside a confined space. All general hazards linked to performing work in such places designated as confined spaces have to be taken into account and the pre-entry procedure must be implemented. There is a further specific hazard associated with the handling and transfer of adsorbing materials, which have the ability such a material to release products that have been previously adsorbed. The desorbed products may include, according to composition of fluid processed through the adsorber, hazardous contaminants, which can seriously injure people by asphyxiation, intoxication or fire.

The main safety measures that should be taken to control these risks are listed here below:

- Material Safety Data Sheet of the material should be looked at and relevant manufacturer recommendations taken into account.
- Hazards during handling and transfer of material should be identified through job safety analysis. This analysis should include the risks described above and include the risk of desorption of hazardous material.
- The pre-entry procedure and work permit should clearly describe the hazards and define the safety measures to be implemented and the protection equipment required prior to any work.
- The hazards and safety measures should be explained to all personnel involved in the work.

4.5 Implementation of the pre-entry procedure

IT IS FORBIDDEN TO ENTER INTO A CONFINED SPACE WITHOUT FIRST HAVING ASCERTAINED THE RISKS AND SET OUT THE PRECAUTIONARY MEASURES TO BE IMPLEMENTED.

The pre-entry procedure must at least stress the following points.

No. : **Date :**

① ACTIVITY

Establishment: Installation: Equipment:

Type of Work:

② RISKS

	yes	no		yes	no		yes	no
- LACK OF OXYGEN	☐	☐	- STATIC ELECTRICITY	☐	☐	- ***GAS POCKET***	☐	☐
- OVER OXYGENATION	☐	☐	- DESORPTION of MATERIAL	☐	☐	- ***LACK OF VENTILATION***	☐	☐
- TOXICITY	☐	☐	- PRESSURE	☐	☐	- ***DEFECTIVE SEALING***	☐	☐
- PRESENCE OF NON BREATHABLE GAS	☐	☐	- TEMPERATURE	☐	☐	- MECANICAL SYSTEM	☐	☐
			- INFLAMMABLE PARTICLES	☐	☐	- SAFETY DEVICE	☐	☐
- PRESENCE OFSOLVENTS	☐	☐	- WORK WITH HOT POINTS	☐	☐	- PHYSIOLOGICALLY FIT	☐	☐
- PRESENCE OF LIQUIDS	☐	☐	- FALLS FROM HEIGHTS	☐	☐	- MEANS OF COMMUNICATION	☐	☐
- DROWNING	☐	☐	- SPARKS	☐	☐	- ...	☐	☐
- BEING BURIED	☐	☐	- PRODUCT INLET	☐	☐	- ...	☐	☐
- EXPLOSION	☐	☐						

③ PREVENTIVE MEASURES

- ***PROCEDURE FOR CONFINED SPACES***	☐	☐	- ***INERTING THE CONTAINER*** (*)	☐	☐	- ***PERMANENT MONITORING***	☐	☐
- ***PROCEDURE FOR LOCKING***	☐	☐	- ELIMINATION OF DANGEROUS MATTER	☐	☐	- *TRAINED SUBCONTRACTORS*	☐	☐
- DRAINING	☐	☐	- OBLIGATORY VENTILATION			- REMOVAL OF SOURCES OF IGNITION	☐	☐
- DEPRESSURIZATION	☐	☐	- BREATHABLE AIR INTRODUCED	☐	☐	- FIRE JET PIPE	☐	☐
- ***ISOLATING FLUID INLETS***	☐	☐	- ***ANALYSIS OF THE ATMOSPHERE***	☐	☐	- *VISUAL* ***INFORMATION***	☐	☐
- ELECTRICAL ISOLATION	☐	☐	***OXYGEN***	☐	☐	- *PHYSICAL FITNESS*	☐	☐
- SAFETY LABELS	☐	☐	INFLAMMABLE SUBSTANCES	☐	☐	- *PHYSIOLOGICAL FITNESS*	☐	☐
- RINSING WITH WATER / SOLVENT	☐	☐	TOXIC SUBSTANCES	☐	☐	- ...	☐	☐
- OBTAINING AN AMBIANT TEMPERATURE	☐	☐	- *CONTINUOUS* ***ANALYSIS***	☐	☐	- ...	☐	☐
			- ZONE CORDONED OFF	☐	☐	(*) see overleaf		
			- WARNING NOTICES	☐	☐			

REMARKS:

④ PROTECTION

☐ BOTTLES OF OXYGEN	☐ SCAFOLDING	☐ FACE MASK
☐ PORTABLE(s) ANALYSER(s)	☐ LIFELINE	☐ SAFETY LIGHTING
☐ FIXED ANALYSER(s)	☐ NACELLE	☐ DIFFERENTIELCIRCUIT BREAKER(30 mA)
☐ EXPLOSIMETER	☐ HELMET	☐ RADIOPHONE (EXPLOSION PROOF)
☐ BREATHING APPARATUS	☐ GLOVES	☐ EXTINGUISHERTYPE : .....
☐ HARNESS	☐ GOGGLES	
☐ ROPE	☐ EAR PROTECTIONS	
☐ LADDER	☐ SPECIAL CLOTHING	

⑤ ANALYSYS

- GAS TO BE ANALYSED	☐ **02**	☐ **H2**	☐ **CO**	☐ **CH4**	☐	☐ .....
- ALARM THRESHHOLD	**19 % - 23 %**	**1 %**	**50 ppm**	**1,25 %**	.....	.....
- ANALYSIS PRIOR TO ENTRY	..... %	..... %	..... ppm	..... %	.....	.....
- ANALYSED EVERY :	..... min.	..... min	..... min	..... min	..... min	..... min

AUTHORIZATION

CAN WORK BEGIN ☐ yes ☐ no

AUTHORISATION DELIVERED BY : ..... POSITION HELD: ..... SIGNATURE :

PERSON IN CHARGE OF THE WORK : ..... SIGNATURE :

PERSON MONITORING THE WORK : ..... SIGNATURE :

PERSON(s) CARRYING OUT THE WORK : ..... SIGNATURE :

AUTHORISED FROM (Date / time) until(date / time)

START OF WORK : END OF WORK :

FINISHED WORK INSPECTED BY : SIGNATURE :

☐ IN CONFORMITY ☐ NON CONFORMITY

4.6 Safety equipment

Consideration shall be given to specifying that the following be worn by men entering the tank:

- Protective clothing
- Eye protection
- Breathing equipment
- Safety harness with line fastened outside of tank

Additional Safety Equipment may include:

- A **ladder** of adequate length, secured if possible at the top and equipped with non-slip feet at the bottom.
- An **air mover** capable of providing adequate and continuous fresh air supply.
- A **portable alarm horn**, possibly compressed gas operated, to summon help by the safety watcher.
- Unless there are persons nearby who are trained to administer artificial respiration, **resuscitation equipment** should be available for emergencies in addition to the self-contained breathing apparatus with which it is mandatory that the safety watcher be provided.
- Where exit from a tank is made vertically through a manhole opening or where vertical ascent is required from a confined space, **a tripod**, block and rope may be needed, particularly for removal of an incapacitated worker.

Breathing apparatus:

Toxic atmospheres:

Use only gas masks with special cartridge adapted to the gas concerned (don't forget to change the cartridge when polluted) or autonomous masks called Self Contained Breathing Apparatus (feed with pure air coming from non polluted area).

Watch out! Paper masks can not stop toxic gases!

- Asphyxiating atmosphere:

  Use only Self Contained Breathing Apparatus (SCBA) with adequate capacity (20 to 45 minutes or more) shall be used.

Watch out! Filtering cartridge of gas masks can not compensate lack of oxygen!

- Flammable atmosphere:

  The protective devices will be included in room design and will be preventive devices.

  The phenomenon is sudden; there is no effective protection for people in case of explosion. It will be necessary to prohibit coming in the polluted zone.

  To prevent clothes fire, use cotton clothes (no synthetic tissues or wool because of the electrostatic phenomenon and rapid burning with sticking to the skin...). After a stay in oxygen enriched atmosphere or after be sprayed with liquid oxygen, it's absolutely necessary to take a shower to prevent electrostatic sparks (synthetic tissues or wool...) and to remove all polluted clothes far away from any heat source (people smoking for example...).

Never use the word «air» when referring to «oxygen»

Fatal mistake have occurred when people who were accustomed to the use of the term «air» when referring to «oxygen» were given oxygen when air was required for ventilation.

5 OTHER HAZARDS LINKED TO AN ASU OPERATION

5.1 Noise

Several equipment in the plant is noisy. This equipment is typically all the rotating machines (compressors, pumps, fans…) but also vents during start-up and shut down. Even if the installation is design to limit the noise impact to regulatory levels, the noise should be taken into consideration during operation.

Noise causes damage which most people are unaware of since it occurs little by little over many years.

This type of damage is irreversible since noise destroys the inner hair cells in the ear. This damage is irreparable since the cells are dead.

Repeated exposure to noise can result in serious deafness

Working with noise can also cause other problems which are every bit as serious (20% more fatigue is enormous!). These other problems can lead to accidents.

The easiest and most effective solution is to have the person who is exposed to noise wear hearing protection. In fact, it is difficult and even impossible to eliminate noise from our facilities, even if we try to decrease the noise level. Hearing protection, even bottom of the line devices, can easily decrease noise levels by 15 decibels.

Noise is dangerous as soon as it reaches 80 decibels. Air Liquide suggests that employees wear hearing protection as soon as noise levels reach 80 decibels and that such protection should be obligatory as of 90 decibels.

5.2 Gas Cylinders handling

Different types of gas cylinders are used in an ASU mainly for gas sampling and calibration of analysers. In addition to the hazard of the gas itself, several safety rules shall be followed with gas cylinders.

Gas cylinders must be:

- Secured in upright position. They must never be stored laying down!
- Stored outdoors and segregated (combustible, oxidizing, neutral and toxic) to avoid any grouping of incompatible gases together.
- Stored away for hot sources and flames.
- Returned empty with the valve closed and the cap secured.
- Filled only by a certified Air Liquide supplier.
- Transported only in a specially fitted and ventilated vehicles.

In addition:

- The local regulation concerning the quantity stored shall be strictly followed.
- Clearly identify the gases (label or tags with composition).
- Never tamper with connectors and distribution networks.

6 RESTRICTIVE AREA

Several areas in the plant should be considered as restricted areas. The restricted areas are not limited to the confined spaces but also to some other dangerous and hazardous area spaces, (often open spaces) because of the significant risks (explosion, burns, asphyxiation…) involved in this area.

These areas are:

- Electrical room
- Instrumentation Cabinets (known as "modins»)
- Compressor's air filter
- Oxygen blockhouses and compressor houses
- Cold box and cold box casings
- Storage tanks retention pits

Electrical room

Due to the electrical hazard, the access to the electrical room shall be restricted to competent electrical personnel trained to electrical hazard. Authorization merely proves that the person has been given specific training in the hazards of electricity, in the procedure to be followed based on his level of authorization, and in the measures to be taken in case of accident.

Such authorization comes from the employer. Authorization is required for any work on electrical facilities.

There are different levels of authorization, based on the hazards present and work performed.

Instrumentation cabinets

Due to the electrical hazard the access to the electrical room shall be restricted to competent electrical personnel. In addition, some Instrumentation cabinets contain gas analyzers. The atmosphere control and alarm system should be strictly checked before access to an Instrumentation cabinet. Access should be strictly forbidden while the red flashing beacon is on.

Air filter house

Due to the hot air and blast hazard in case of surging of the air compressor, the access to the air filter house shall be locked and strictly forbidden during running of the air compressor. Any maintenance in the Air filter house shall be preceded by a work permit procedure.

Oxygen blockhouse and compressor houses

Due to the explosion hazard in the oxygen blockhouse and compressor houses, the access to the blockhouse and compressor house be locked and strictly forbidden during operation of the oxygen piping or equipment. Any maintenance in the Air filter house shall be preceded by a work permit procedure.

Cold Boxes and cold box casings

The Cold boxes and casings contain the equipment needed to separate gases. Due to the cold temperature, the nitrogen, the perlite and the rockwool hazard in the cold box and the associated casings, the access to cold boxes and casing shall be **strictly forbidden during operation of the ASU**.

Confined Space permits shall be put in place before any operation. Cold boxes are constantly ventilated with nitrogen and to enter them in operation means **death**.

Three precautions must be taken before any work is done on a cold box to eliminate any possibility of asphyxiation:

- The nitrogen supply must be locked out and tagged out,
- The oxygen level in the cold box or the adjacent casings must be measured on an ongoing basis,
- If necessary, the area must be ventilated with fresh air.

Some cold boxes are insulated with rock wool and others are insulated with perlite. The perlite-insulated cold boxes are very dangerous because perlite is so fluid that someone falling into it can drown.

It is mandatory to take specific precautions when filling or emptying cold boxes containing perlite:

- A co-worker must be present at all times to supervise the work from outside the hazard zone,
- Oxygen levels must be measured,
- A harness must be worn,
- A dust mask must be worn.
- Wrap-around goggles and gloves must be worn.

WARNING: perlite is very abrasive and is irritating to the eyes and respiratory membranes.

Storage Tank Retention Pits

Access to the storage retention pits shall be strictly forbidden during operation of the LOX, LIN and LAR storages tanks.

Spillage or purging of liquefied gas in the pit can be hazardous: cryogenic fog can form when systems are vented, in the event of leaks, or when there are high concentrations in the atmosphere.

Cryogenic fog can hide several hazards:

- First, as in the case of any fog, you can't see objects which might cause falls or blows if you bump into them,
- Second, puddles of cryogenic liquids can cause serious burns to the feet. As they warm up, these puddles form black ice, which can cause slips and falls.
- Finally, when there is a large concentration of the gas in the air, you will encounter the hazards specific to the gas: an oxygen-rich atmosphere in the case of oxygen, lack of oxygen in the case of nitrogen, etc.

7 SAFETY DATA BASE

7.1 Summary liquid knowledge

Product	Characteristics	Hazards	Precautions for handling	Actions in case of accident
Liquid Oxygen (O2) LOX 	• Dew point at atmospheric press. • 183°C • Density/water of LOX: 1,1(spread aground) Color of LOX :blue light • 1 liter of LOX vaporises into about 800 litters of GOX	*Combustion* • Accelerate vigorously any combustion. • Any contact with combustible (oil, grease..) may induce an explosion. *Frostbite* • Similar to burn. Gravity of frostbite are often undervalued. *Fall* • Due to fog resulting of LOX leakage or vent. *Explosion* • Due to vaporisation of enclosed liquid	DANGER >24%O2 Same as for GOX plus : • Use of adequate gloves, goggles, safety shoes. • Don't stay in cold atmosphere. • Don't walk in cryogenic fog. • Don't purge LOX on ground made with combustible material (i.e. macadam). • Make sure of safety release valve presence on capacity (vessel, pipe) where liquid may be enclosed.	Same as for GOX plus : *In case of skin frostbite* • Water the frost-bitten part for more than 15mn • Don't undress. • Don't touch the frost-bitten part. • Call for medical assistance
Liquid Nitrogen (N2) LIN 	• Dew point at atmospheric press. • 196°C • Density/water of LIN: 0,8 (spread aground) Colorless • 1 liter of LIN vaporises into about 650 litters of GAN	*Breathing* • Asphyxiation *Frostbite* • Similar to burn. Gravity of frostbite are often undervalued. *Fall* • Due to fog resulting of LOX leakage or vent. *Explosion* • Due to vaporisation of enclosed liquid	DANGER <18%O2 *Same as for GAN plus* : • Use of adequate gloves, goggles, safety shoes. • Don't stay in cold atmosphere. • Don't walk in cryogenic fog. • Make sure of safety release valve presence on capacity (vessel, pipe) where liquid may be enclosed.	Same as for GAN plus : *In case of skin frostbite* • Water the frost-bitten part for more than 15 mn • Don't undress. • Don't touch the frost-bitten part. • Call for medical assistance
Liquid Argon (Ar) LAr 	• Dew point at atmospheric press. • 186°C • Density/water of LAr: 1,4 (spread aground) Colorless • 1 liter of LAr vaporises into about 780 liters of GAr	*Breathing* • Asphyxiation • *Frostbite* • Similar to burn. Gravity of frostbite are often undervalued. • *Fall* • Due to fog resulting of LOX leakage or vent. • *Explosion* • -Due to vaporisation of enclosed liquid	DANGER <18%O2 *Same as for GAN plus :* • Use of adequate gloves, goggles, safety shoes. • Don't stay in cold atmosphere. • Don't walk in cryogenic fog. • Make sure of safety release valve presence on capacity (vessel, pipe) where liquid may be enclosed.	Same as for GAN plus : *In case of skin frostbite* • Water the frost-bitten part for more than 15mn • Don't undress. • Don't touch the frost-bitten part. • Call for medical assistance

7.2 Summary gases knowledge

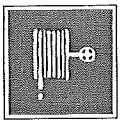
GASES	Characteristics	Hazards	Precautions for handling	Actions in case of accident
Oxygen (O2) GOX 	Oxidizing gas. • Support and accelerate combustion. • Density/air at ambient temperature: 1,1 • Colorless • Tasteless • Odorless	*Combustion* • From 25 % O2 in air, • accelerated combustion • From 30 % vigorous combustion • From 50 % instantaneous combustion, explosion. *Breathing* • Possible cramps, nausea, dizzies...when breathing a mixture with more than 75 % O2.	• Prevention of leakage. • Analyse of atmosphere : • DANGER>24% O2 • Avoid work in overenriched atmosphere. • Procedure, work permit, fire permit. • Training of personnel. • Use clean clothes, no grease, oil ...anti spark tools, equipment must be for « oxygen use » . • Watering systems immediately available .	Alert. • Protect. Don't become the second victim. • Watering in case of fire is the more efficient mean. • First aid to burnt person: • Remove the victim outside the hazardous area • Water the burnt part for more than 15mn • Don't undress. • Call for medical assistance
Nitrogen (N2) GAN 	• Inert gas. • Does not support life • Density / air at ambient temperature: 0,97 • Colorless • Tasteless • Odorless	*Breathing* • Asphyxiation	• Prevention of leakage. • Analyse of atmosphere: DANGER< 18% O2 (leave the place) • Procedure, work permit • Training. • Equipment fo resuscitation available. • Self contained breathing apparatus available.	• Alert • Remove the victim outside the hazardous area (rescuer equipped with self contained breathing apparatus). • Apply resuscitation methods. • Call for medical assistance.
Argon (Ar) GAr 	• Inert • Does not support life • Density/air at ambient temperature: 1, 38 • Colorless • Tasteless • Odorless	*Breathing* • Asphyxiation	• Prevention of leakage. • Analyse of atmosphere: DANGER< 18% O2. (leave the place) • Procedure, work permit • Training. • Equipment fo resuscitation available. • Self contained breathing apparatus available.	• Alert • Remove the victim outside the hazardous area (rescuer equipped with self contained breathing apparatus). • Apply resuscitation methods. • Call for medical assistance.

7.3 Fire extinguishing methods and devices

Fire extinguishers shall be available in different locations of the plant. They should be easily reachable at all time without obstructing the walkways and access. They will be maintained with full load according to local regulation. Extinguishers shall be recharged or replaced immediately after use.

In addition fire hose and hydrants shall be maintained in good working condition and periodically controlled according to local regulation. In service hose shall be inspected and service tested at least annually. Testing shall include the followings:

- Acceptance (proof) hydrotesting
- Visual examination for the following:
  - Cuts at band clamps
  - Coupling slippage or noticeable wear
  - Loose cover
  - Bulges on soft spot
  - Weathering
  - Kinking
  - Physical damage to end connections.



Kinds	Products	Extinguishing devices	Methods	Remarks
	▪ Wood, Coal	▪ Cooling	▪ Water stream or spray	
Solids Fires	▪ Plants	▪ Smothering	▪ With or without additive	
	▪ Papers, Tissues, Plastics	▪ Inhibition Smothering	▪ Powder "ABC" Proof liquids , Foam	
Liquefiable	Particularly flammable liquids: Carbon sulfur, Methylene oxide, Ethylene, Propane.	Inhibition Smothering	Powder Carbon dioxide	In case of flowing: - close valves -dam with sand or earth
Solids	Methanol, Ethanol, Propane Flammable water mixable liquids for example Ether.	Inhibition Smothering	Powder Carbon dioxide Anti-alcohol, Foam	
Liquids	Flammable liquids : Gasoline for cars, planes, etc...	Inhibition Smothering	Powder, Carbon dioxide Foam, Water	
Fires	Heavier flammable liquids Gas oil, Fuel oil, Crude oil	Cooling Inhibition Smothering	Sprayed water without additive Foam powder Carbon dioxide	
	Flammable liquids with boiling point over 100C Oils, asphalt, bitumen liquefiable solids grease Paraffins	Cooling Inhibition Smothering	Sprayed water with or without additive Foam powder Carbon dioxide	
Gas fires	Methane, Ethane Propane, Acetylene Hydrogen etc	Inhibition	Stop the flow Powder Carbon dioxide	If not possible, leave it burning and protect other equipment
Metal fires	Aluminium Magnesium Sodium, potassium....	Smothering Inhibition	Special powder Special liquid, dry sand graphite. Heavy oil.	

8 MANUFACTURER SAFETY DATA SHEETS OF CHEMICAL PRODUCTS AND SUBSTANCES IN USE IN AN ASU

The risk due to chemical products and substances shall always be taken into consideration for the risk evaluation before maintenance operation or handling of these products.

It is recommended to read carefully the MSDS (Manufacturer Safety Data Sheet), the instructions note and tags of all products before any operation.

The most common risks involved by these products can be either:

- Intoxication
- Hot or cold Burns
- Skin or eyes rash
- Respiratory infections
- Skin or respiratory allergies
- Cancers

In addition some of those products can as well cause fires and explosions.

The products involved in an ASU shall be divided in two categories:

- Product used within the installation
- Products produced by the ASU

8.1 Products used within the installation

These products are mainly the following ones. You will find attached the corresponding MSDS (Manufacturer Safety Data Sheet). It is the responsibility of the Operating Management to keep those MSDS up-dated.

- Rockwool for casing insulation,
- Rockwool for piping insulation,
- Perlite for Cold Box insulation,
- Foamglass for piping and tanks insulation,
- Molecular sieve for dessication bottles,
- Alumina for dessication bottles,
- Lubrification oil for compressors,
- Frigorific fluid for Frigorific Group,
- Chemical treatment products for Water treatment,

8.2 Products produced by the ASU

These products are the result of the operation of the plant.

- Compressed air
- Air (refrigerated)
- Nitrogen

- Nitrogen (refrigerated)
- Oxygen
- Oxygen (refrigerated)
- Argon
- Argon (refrigerated)
- Other products (Kr, Xe, He, Ne)

The MSDS gives all the information regarding the product and hazard, emergency, handling and storage, exposure control and personal protection ecological ,disposal and transportation considerations.

8.3 How to interpret MSDS information sheets

The following provides a some guidance on the interpretation of MSDS. These sheets may at first seem complicated and difficult to understand, but they are a reliable source of the data you need to handle chemicals safely.

Her above the explanation of the different sections into which MSDS are generally divided, using portions of a sheet provided by a commercial supplier.

1 Identification of substance

Section 1 gives details of the company issuing the data sheet....

.... and, often, emergency call-out information.

2 Composition / Data on components

The second section identifies the material, and gives the CAS and other registry numbers.

3 **Hazards identification**

The third section summarizes the major hazards associated with use of the chemical. The R and S codes in this section are followed by explanatory text.

4 First aid measures

The fourth section outlines first aid measures

5 Fire fighting measures

Section 5 covers fire fighting and protective equipment.

6 Accidental release measures

Section 6 outlines the procedures to be followed in case of accidental release of the chemical, including methods to be used to clean up spills. Note that these measures are unlikely to be sufficiently detailed if the chemical is particularly hazardous, and local procedures should be drawn up to supplement what is given in the MSDS.

7 Handling and storage

Section 7 is self-explanatory. This is an important section, sometimes overlooked by those using chemicals in the laboratory. It contains information about the possible formation of peroxides in storage, flammability, explosive risks, etc. Pay particular attention to the possible need for flammable storage cabinets, explosion-proof fridges, and also the need to avoid storage near incompatible chemicals.

8 Exposure controls and personal protection

Section 8 provides information on regulatory standards for exposure; in other words, the maximum permitted concentration of the material in the environment to which you are allowed to be exposed. It also usually contains information on suitable types of PPE (personal protective equipment)

9 Physical and chemical properties:

Section 9 is self-explanatory.

10 Stability and reactivity

The next section is also largely self-explanatory.

11 Toxicological information

Section 11 outlines the risks to which you may be exposed when using the chemical. It is therefore a section of crucial importance!

The acute toxicity gives an indication of the kind of quantities of the chemical, which may cause immediate damage to health if swallowed, inhaled or absorbed through the skin.

There follows a section, which gives, often in some detail, an indication of the health effects, which may be attributable to this chemical. This section should be read particularly carefully, since the range of health effects may be broad, and may include carcinogenic or sensitizer effects.

Chemical sensitisation, for example by platinum compounds, is a potentially debilitating problem. Pay particular attention to any information, which may suggest that the chemical is a sensitiser.

Here we find details of the possible long-term effects of exposure to the chemical.

For this chemical there now follow important comments regarding the carcinogenicity. The acronyms such as IARC refer to regulatory or health agencies.

12 Ecological information

Section 12 is largely self-explanatory

13 Disposal considerations

Section 13, which deals with disposal, is often not sufficiently detailed for you to be able to undertake disposal yourself. If you need to dispose of the chemical after use, ensure that you know how to do this safely.

14 Transport information

Section 14 gives transport information, generally as a list of codes indicating the dangers associated with the chemical (flammable, radioactive, very toxic, etc) and the type of transport, which may be used. There are usually UN hazard codes given in this section.

15 Regulations

Section 15 lists the hazard codes, which indicate the principle hazards, associated with the chemical and the precautions, which should be taken when working with it.

16 Other information

Finally, a section of an additional information, such as the name of the person preparing the data sheet, a list of references from which data have been drawn, disclaimers, etc.

SAFETY RULES

CASING – CONFINED SPACE

Risks :

- Inflammation
- Burns by projection, burns by fire
- Oxygen enriched atmosphere
- Oxygen deficient atmosphere, asphyxiation, anoxia
- Dust or burying in mineral wool or perlite

Measures to respect :

ACCESS FORBIDDEN TO NON-AUTORISED PERSONNEL

- **No open flame**
- **Wear clean clothes and gloves** without grease and oil
- **Use degreasing and lubricating agents approved for oxygen service**

- **For intervention :**

WORK PERMIT and CONFINED SPACE PERMIT
MANDATORY IN CASE OF INTERVENTION

Wear adapted Personnel Protective Equipment (gloves, goggles, masks, overall…)
Lock out nitrogen ventilation inlet
Lock out fluids circulation, purge lines when possible
Lock out electrical and control supplies
Open all manholes
Ventilate abundantly the casing
Analyse atmosphere quality before entrance
Control permanently oxygen rate during intervention
Plan emergency rescue organisation in case of accident
Insure permanent watch of the intervention

- **In case of accident :**

Implement rescue means (extinguishers, breathing apparatus, …)
Bring back the victim to safe area
Alert emergency services

Additional Measures :

DANGER OF ASPHYXIATION

DANGER OXYGENE

DANGER
CONFINED SPACE

DANGER OF COLD

DANGER OF IRRITATION

NO OPEN FLAME

ACCESS FORBIDDEN
WHITOUT AUTORISATION

WORK PERMIT AND LOCK OUT
MANDATORY PRIOR ENTRANCE

AIR LIQUIDE

DISCLAIMER : These Safety Rules are not exhaustive and can not be substituted to specialities specific procedures and local applicable regulation.
In case of further information or question, please contact Air Liquide Engineering.

8.4 Summary of the risks involved in the different areas

		Compressors	Absorbers	Cold box	Heater	Air water tower	Nitrogen water tower	Liquid nitrogen storage tank	Liquid oxygen storage tank	Liquid argon storage tank	Liquid oxygen vaporization system	Liquid nitrogen /argon vaporization system	Water treatment	Cooling water tower	Drains	Electrical room	PROHIBITIONS	OBLIGATIONS
Asphyxiation		X	X	X	X	X	X	X	X	X		X			X	X	acces under storages blockhouses zones marked out by chains red & white	portable analyzer ARI if needed
Oxidizing		X	X	X					X		X				X	X	oil greasy substances smoke open flame	portable analyzer fire permit ventilation of clothing after work
Explosion		X		X	X										X	X	smoke open flame cell phone & Walky Talkies	portable analyzer fire permit clothing in Nomexdes after work
Flammable		X		X	X										X	X	smoke open flame	portable analyzer fire permit
Toxic & Irritant		X		X									X	X	X	X	entry to unauthorized persone	clean work clothes face protection gloves
Cryogenic burn		X		X				X	X	X	X	X			X	X		clean work clothes safety mask gloves
Temperature burn		X	X	X	X	X					X	X			X	X		prtotection of hot parts gloves
Revolving machines		X	X	X										X		X		Protection of revolving parts gloves
Pressure		X	X	X	X	X					X	X	X		X	X		periodical inspection of the material

		Compressors	Absorbers	Cold box	Heater	Air water tower	Nitrogen water tower	Liquid nitrogen storage tank	Liquid oxygen storage tank	Liquid argon storage tank	Liquid oxygen vaporization system	Liquid nitrogen /argon vaporization system	Water treatment	Cooling water tower	Drains	Electrical room	PROHIBITIONS	OBLIGATIONS
Electricity		X	X	X	X								X	X	X	X		working permit, according to the type of intervention
Slipping ground		X		X				X	X	X	X	X	X	X		X		cleaning of the ground salting of icy parts
Drowning				X				X	X	X								paid attention
Noise		X	X	X										X				ear protection