GUIDELINES ON SOLVENT DEGREASING

Occupational Safety and Health Division

Ministry of Manpower

(Endorsed by the Working Group On Solvent Hazards Control)

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A. DEFINITION OF TERMS

Solvent Degreasing Terms

"AIR-SOLVENT INTERFACE" is the interface between the exposed solvent and air.

"AIR-VAPOUR INTERFACE" is the interface between the exposed solvent vapour and the air.

"AIR-VAPOUR INTERFACE SURFACE AREA" means the geometric surface area of the open top of the open-top vapour degreasers.

"REFRIGERANT FLOW SWITCH" is a safety switch that turns off the sump heat if the refrigerant in the primary cooling coils fails to circulate or rises above the design operating temperature.

"CONVEYORISED DEGREASER" is any degreaser that uses an integral, continuous, mechanical system for moving materials or parts to be cleaned into and out of a liquid solvent or vapour cleaning zone.

"DRAG-OUT" is the solvent carried out of a degreaser that clings to or is trapped in the part being removed.

"FREEBOARD HEIGHT" is the distance from the top of the solvent to the top of the tank for liquid degreasers; or the distance from the air-vapour interface to the top of the tank for open-top vapour degreasers.

"FREEBOARD RATIO" is the freeboard height divided by the smaller of either the inside length or inside width of the degreaser.

"HIGH VOLATILITY SOLVENT" is a solvent that is not classified as a low volatility solvent.

"LIQUID DEGREASER" is a degreaser that is designed to contain liquid solvent at a temperature below its boiling point and is used for cleaning objects.

"LOW VOLATILITY SOLVENT" is a solvent which has an initial boiling point greater than 120 ^{o}C and whose initial boiling point exceeds the maximum operating temperature of the solvent cleaning operation by at least 100 ^{o}C.

"OPEN-TOP VAPOUR DEGREASER" is any boiling solvent degreaser.

"PERMISSIBLE EXPOSURE LEVEL (PEL)" is the time weighted average concentration of a toxic substance to which persons may be exposed.

"PEL (Long Term)" is the permissible exposure level over an 8 hour working day and a 40-hour work week as specified in the Factories (Permissible Exposure Levels of Toxic Substances) Order, 1996.

"PEL (Short Term)" is the permissible exposure level over a 15-minute period as specified in the Factories (Permissible Exposure Levels of Toxic Substances) Order, 1996.

"PRIMARY COOLING COILS" is an emission control device consisting of coils that carry a refrigerant to condense solvent vapour from the degreaser bath.

"REFRIGERATED FREEBOARD CHILLER" is an emission control device that is mounted at the freeboard above the primary cooling coils, consisting of secondary coils which carry a refrigerant to provide a chilled air blanket above the solvent vapour to reduce emissions from the degreaser bath.

"SOLVENT LEVEL CONTROL SWITCH" is a safety switch that turns off the sump heat when the solvent level drops below the designed operating level.

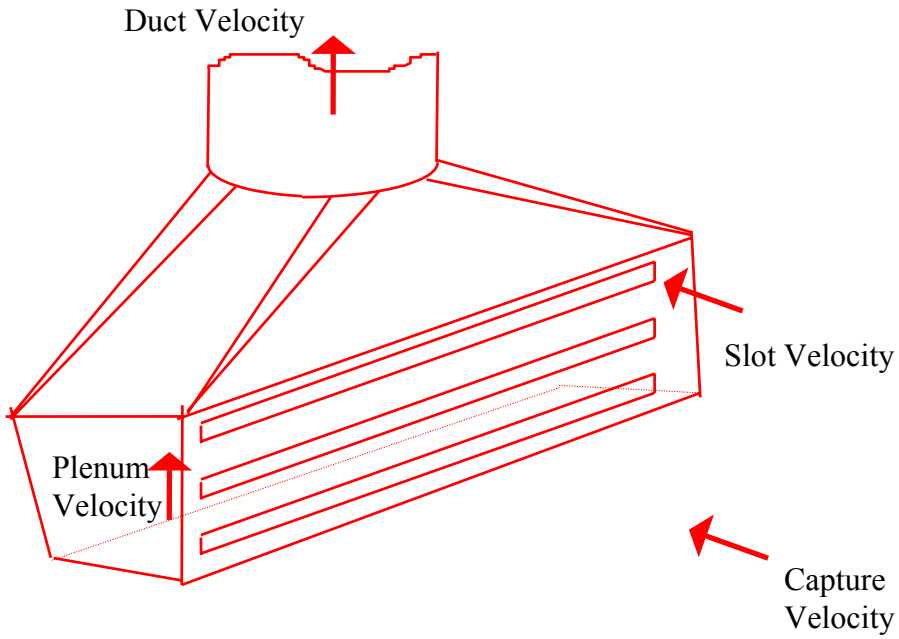
"SPRAY PUMP CONTROL SWITCH" is a safety switch that prevents the spray pump from operating without an adequate vapour level.

"ULTRASONIC" means enhancement of the cleaning process by vibrating the solvent with high frequency sound waves, causing the implosion of microscopic vapour cavities within the liquid solvent.

"VAPOUR LEVEL CONTROL SWITCH" is a safety switch that turns off the sump heat when the solvent vapour level rises above the design operating level.

"WORKLOAD AREA" means the plane geometric surface area of the top of the submerged parts basket, or the combined plane geometric surface area(s) displaced by the submerged part(s), if no parts basket is used.

Local Exhaust Ventilation Terms



"CAPTURE VELOCITY" is the air velocity in front of the hood opening necessary to capture the contaminated air at that point by causing it to flow into the hood

"SLOT VELOCITY" is the air velocity through the openings in a slot-type hood. It is primarily used as a means of obtaining a uniform air distribution across the face of the hood.

"PLENUM" is the pressure equalising chamber of the exhaust hood.

"PLENUM VELOCITY" is the air velocity in the plenum.

"DUCT VELOCITY" is the air velocity through the duct cross section.

"FLOW RATE" is the rate of air flow in a duct usually measured in cubic metres per minute

1. INTRODUCTION

General

Solvent degreasing is the process where grease, oil, wax and other surface contaminants are removed from workpieces with the use of organic solvents. Solvent degreasing is commonly carried out in the electronics and metal working industries.

Many degreasing solvents are harmful to health and therefore require some form of control measures to minimise or eliminate the risk. The three most common solvents used in degreasing and their properties are summarised in Table 1

Solvent	Boiling Point	Vapour Pressure	Density
Methylene Chloride	40 ^{o}C	350 mmHg	1.326 g/cm^3
Perchloroethylene	121 ^{o}C	14 mmHg	1.621 g/cm^3
Trichloroethylene	87 ^{o}C	58 mmHg	1.462 g/cm^3

Table 1 – Physical Properties of Some Common Degreasing Solvents

These guidelines spell out the design specifications and operating procedures for degreasing that need to be taken to ensure a reasonably safe working environment.

Health Effects

Solvents can enter the body through inhalation, skin absorption and by ingestion of contaminated food or drink.

Inhalation of solvent vapours is the most common route of exposure as solvents are usually volatile i.e. they have high vapour pressure and can readily give off vapours even at room temperature.

Exposure to excessive solvents may cause short and long term effects as indicated below:

* Short Term Effects

  - Irritation to the eyes, nose and throat
  - Headaches
  - Nausea
  - Giddiness
  - Loss of consciousness and even death

* Long Term Effects

- Dermatitis or skin disease
- Damage to the central nervous system
- Liver damage by certain chlorinated solvents

The permissible exposure levels of the major degreasing solvents are shown in Table 2.

Solvent	PEL (Long Term)	PEL (Short Term)
Methylene Chloride	174 mg/m^3 (50 ppm)	870 mg/m^3 (250 ppm)
Perchloroethylene	170 mg/m^3 (25 ppm)	685 mg/m^3 (100 ppm)
Trichloroethylene	269 mg/m^3 (50 ppm)	537 mg/m^3 (100 ppm)

Table 2 – Permissible Exposure Levels (PEL) of Some Common Degreasing Solvents

Types of Degreasing Systems

1. Liquid Phase Degreasing

   Liquid phase degreasing consists of a tank containing liquid solvent that may be heated below the boiling point where parts that need to be cleaned are immersed in the solvent. Surface contaminants are then dissolved. The cleaning efficiency is improved with agitation.

2. Vapour Phase Degreasing

   a. Vapour phase degreasing consists of a tank containing solvent that is heated to its boiling point and the solvent vapour rises and fills the tank. When parts are lowered into the vapour zone, the vapour condenses on the cold parts and the surface contaminants are dissolved by the condensing solvent that returns to the base of the tank. The parts are removed when condensation ceases to occur when the parts appear dry. Figure 1 shows the schematic diagram of a vapour degreaser.

   b. Another variation is the vapour-spray cycle degreaser. The parts to be cleaned are placed within the vapour zone as in the straight vapour cycle degreaser. Condensing vapour is collected in a reservoir that is pumped to the spray nozzle and is directed at the parts whereby they are further cleaned and cooled to permit further cleaning action by the solvent vapour.

   c. In addition to the degreasers described earlier that are designed for batch-type operations, conveyorised degreasers are available for a greater cleaning capacity.

Figure 2 shows the schematic diagram of a conveyorised degreaser.

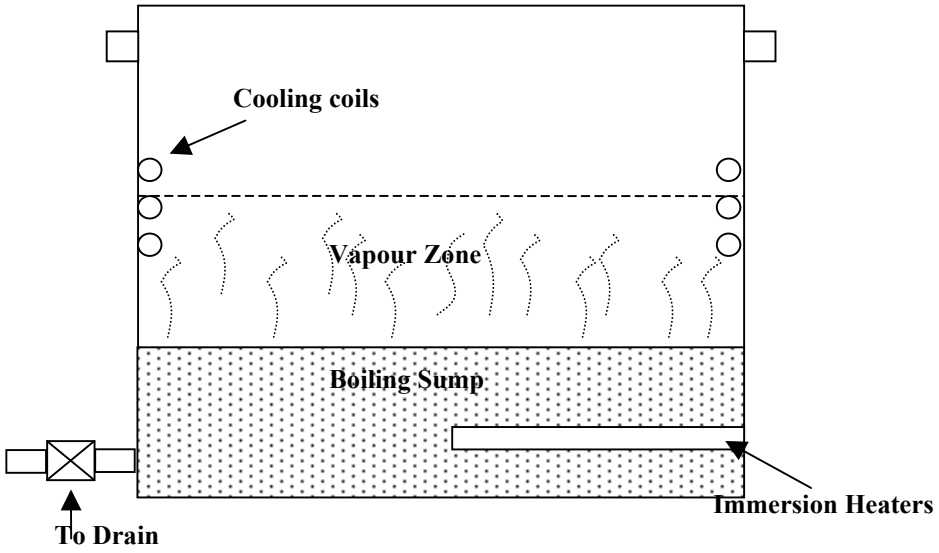


FIGURE 1 - VAPOUR DEGREASER

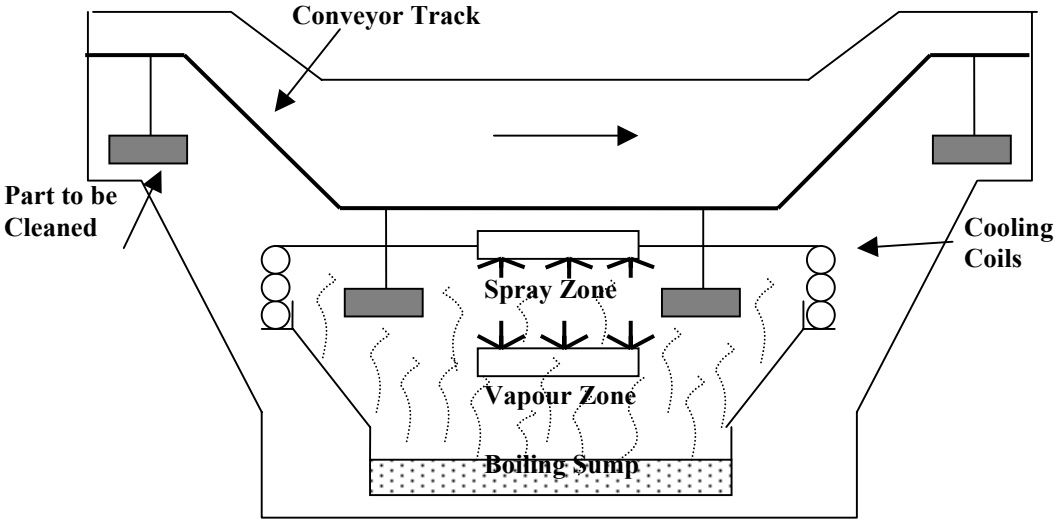


FIGURE 2 - CONVEYORISED DEGREASER

2. GENERAL GUIDELINES

The guidelines in this section are applicable to all types of degreasing machines.

Basic Equipment

1. All degreasers shall be fitted with a cover that prevents escape of solvent vapour when the degreaser is not in operation. One of the following types of covers shall be used for open-top vapour degreasers and liquid degreasers:

   a. Roll-top cover;

   b. Canvas curtain cover;

   c. Guillotine (biparting) Cover;

   d. Any other effective cover that slides off the degreaser in a horizontal motion.

   All covers shall be designed such that they can be opened or closed without disturbing the vapour layer or the solvent surface.

2. Suitable equipment such as perforated or wire baskets shall be provided for draining cleaned parts such that the drained solvent or drag-out is returned to the degreaser.

3. Means shall be provided for draining contaminated solvent from the tank.

Basic Operating Guidelines

1. The degreaser shall be covered at all times except while processing work or performing maintenance on the degreaser.

2. The parts to be cleaned shall be racked in a manner that will minimize the drag-out losses (eg. cup shaped objects should be inverted).

3. Parts shall be drained for at least 15 seconds immediately after the cleaning within the degreasing tank and shall not be removed until dripping of solvent ceases or the parts become visibly dry.

4. Degreasing operators should avoid leaning over the tank.

5. Drainage facility shall be used for removing the contaminated solvent from the tank that minimises or eliminates contact by persons in the surrounding areas. Sludge found at the bottom of the tank shall only be removed once all the solvent is completely drained off.

6. All waste solvents shall be stored in properly identified, sealed containers and handled and disposed of in accordance with the Ministry of the Environment regulations.

7. Solvent spray cleaning shall be done well within the vapour zone. The spray shall consist of a liquid stream rather than a fine, atomized, or shower-type spray. Solvent spray shall be directed downward to avoid turbulence at the air-vapour or air-solvent interface and to prevent liquid solvent from splashing outside of the degreaser.

8. Degreasing of porous or absorbent materials, such as cloth, leather, wood, or rope, is strongly discouraged.

9. Solvent agitation, where necessary, shall be carried out only by pump recirculation, ultrasonic or by other mechanical means.

10. The vertical speed of a powered hoist, if one is used, shall not be more than 3.3 meters per minute when lowering and raising parts into/from the degreaser. This is to ensure minimal disturbance to the vapour zone.

11. Degreasers must be located in well-ventilated areas and away from strong draughts. The average draught rate in the workroom shall not exceed 9.1 metres per minute when measured parallel to the plane of the degreaser opening.

12. Ventilation fans shall not be positioned in such a way as to direct airflow near the degreaser openings.

13. Standing fans shall not be used or positioned in such a manner that solvent vapour is disturbed.

3. LIQUID DEGREASING

1. A degreaser loaded with a low volatility solvent must have a freeboard ratio of at least 0.50.

2. A degreaser loaded with a high volatility solvent shall be fitted with a drainage facility inside the degreaser and shall have either:

a. a water blanket over the surface of the solvent if the solvent has a negligible solubility in water and has a density greater than that of water; or

b. a freeboard ratio of at least 0.75.

3. Wire baskets should be used to hold small parts to permit complete solvent drainage.

4. Should the air concentration level cannot be reduced to below the PEL of the solvent, a local exhaust ventilation system should be installed for the degreasing tank (see section on local exhaust ventilation for details).

4. OPEN-TOP VAPOUR DEGREASING

Design Guidelines

1. Primary cooling coils shall be used to condense the solvent vapour. The cooling systems must be designed such that the temperature measured in degrees Celsius at the coldest point on the vertical axis in the centre of the solvent container shall not be greater than 50 percent of the initial boiling point of the solvent.

2. The following safety switches shall be installed on the degreaser:

   a. Vapour level control switch;

   b. Condenser refrigerant flow switch;

   c. Sump heater thermostat;

   d. Solvent level control switch with manual reset; and

   e. Spray pump control switch, if solvent spray cleaning is incorporated.

   The control system shall be designed such that the safety switches shall act exclusively without regard to other conditions (eg. should the solvent level drop below the designed operating level, the solvent level control switch will shut off the sump heater. A decrease in the temperature sensed by the sump heater thermostat shall not reactivate the sump heater)

3. The degreaser shall have a freeboard ratio of at least 0.75.

4. Open-top vapour degreasers which have an air-vapour interface surface area of more than 1.0 square metre shall have a freeboard ratio of at least 1.0 and shall be equipped with:

    a. a refrigerated freeboard chiller, designed such that the refrigerant temperature at the degreaser outlet does not exceed 5 ^{o}C or the temperature measured in degrees Celsius at the coldest point on the vertical axis in the centre of the solvent container shall not be greater than 30 percent of the initial boiling point of the solvent.

    b. a hoist to facilitate movement of the workload into and from the degreaser.

5. Should the air concentration level cannot be reduced to below the PEL of the solvent, a local exhaust ventilation system should be installed for the degreasing tank (see section on local exhaust ventilation for details).

Operating Guidelines

1. When equipped with a lateral exhaust system, the exhaust fan shall not be operational whenever the degreaser is covered.

2. The workload area shall not exceed more than half of the degreaser's air-vapour interface surface area to prevent emission of solvent vapour through displacement of the solvent vapour by the workload ("piston effect").

3. The vapour level shall not drop by 10 centimetres or more when a workload enters the vapour zone. Introduction of heavy workload will result in collapse of the vapour blanket and air is pulled in and eventual re-establishment of the vapour blanket will expel solvent laden air from the degreasing machine.

4. At start up, the primary cooling coils and the refrigerated freeboard chiller, if any, shall be turned on before the sump heater is turned on.

5. At shutdown, the sump heater shall be turned off before the primary cooling coils and refrigerated freeboard chiller, if any, are turned off. The degreaser must be covered whenever the primary cooling coil is turned off.

6. The workload shall be degreased in the vapour zone until condensation ceases.

5. CONVEYORISED DEGREASERS

1. The following safety switches shall be installed on the degreaser:

   a. Vapour level control switch;

   b. Condenser refrigerant flow switch;

   c. Sump heater thermostat;

   d. Solvent level control switch with manual reset; and

   e. Spray pump control switch, if solvent spray cleaning is incorporated.

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2. The degreaser shall have a freeboard ratio of at least 0.75.

3. A drying tunnel or other effective means shall be installed to reduce drag-out losses.

4. Entrances and exits to the degreaser shall have a clearance between each workload and the edge of the degreaser of less than 10 centimetres or less than 10 percent of the width of the opening.

5. Conveyorised degreasers having an air-vapour or solvent-vapour interface surface area of more than 1.0 square metre shall have either:

   a. a refrigerated freeboard chiller, designed such that the refrigerant temperature at the degreaser outlet does not exceed 5 ^{o}C or -20 ^{o}C if the air-vapour or solvent-vapour interface surface area exceeds 2.0 square metres; or

   b. an enclosure that is connected to a exhaust system that has a ventilation rate of 15.24 cubic metres per minute per square metre of the air-vapour or air-solvent interface surface area

6. LOCAL EXHAUST VENTILATION

Local exhaust ventilation systems are designed to capture and remove the contaminants from the source of emission before they escape into the surrounding environment.

A lateral exhaust hood with a drying area shall be provided for large degreasing tanks with a surface area of exposed solvent greater than 1 m^2.

For degreasing tanks operating for more than 50 hours per week, the exhaust air shall pass through an activated carbon recovery unit to remove the solvent vapour.

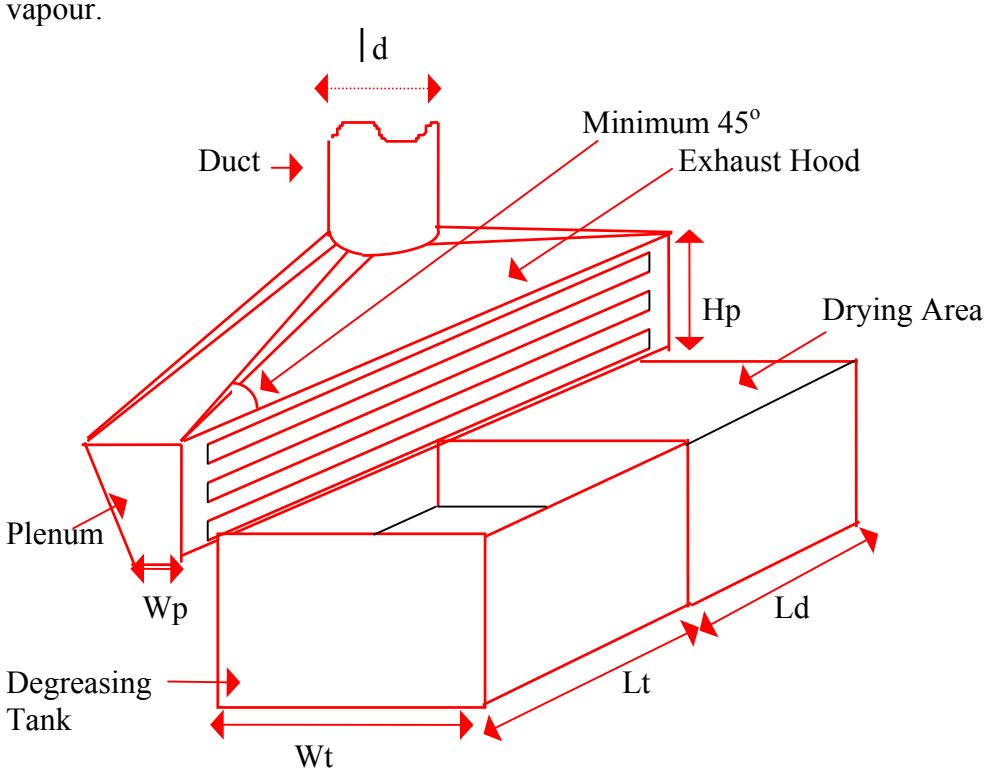

Figure 3 – Lateral Exhaust Hood for Large Degreasing Tank

Design Specifications

Required Flow Rate	Q ≥ 38.1 x (Length of Degreasing Tank , Lt + Length of Drying Area, Ld) x Width of Degreasing Tank, Wt (m^3/min)
Required Slot Velocity	Vs ≥ 610 m/min
Required Duct Velocity	Vd ≥ 1220 m/min
Duct Diameter	$\Phi d \leq (4Q / (\Pi \times Vd))^{½}$
Length of Slot	Ls ≥ (Lt + Ld)
Aspect Ratio of Slot	(Ws/Ls) ≤ 0.25
Length of Plenum	Lp > (Lt + Ld)

Height of Plenum	Hp ≥ Maximum Height of Workload
Plenum Velocity	Vp ≤ 0.5 x Slot Velocity
Width of Plenum	Wp = Q/ (Lp x Vp)

Example:

A vapour degreasing tank with length of 1.2 m and width of 0.9 m requires a local exhaust system with a drying area to be installed to remove contaminants from the source of emission. The height of the wire basket used is 0.1 m.

Preliminary design of exhaust system results in the following:

Length of Drying Area	Ld = 0.3 m,
Length of Slot	Ls = Lt + Ld = 1.5 m
Length of Plenum	Lp = 1.6 m
Height of Plenum	Hp = 0.12 m
Number of slots	n = 4

Required flow rate, Q = 38.1 x (Lt + Ld) x Wt
= 38.1 x (1.2 + 0.3) x 0.9
= 51.44 ≅ 55 m^3/min

Total slot area, ΣAs = Q / Vs = 55 / 610
= 0.09 m^2

Area of a slot, As = ΣAs / 4 = (0.09 / 4)
= 0.0225 m^2

Width of a slot, Ws = As / Ls = 0.0225 / 1.5
= 0.015 m

Aspect ratio = Ws/Ls
= 0.015 / 1.5
= 0.01 < 0.25

Width of plenum, Wp = Q / (Lp x Vp)
= 55 / (1.6 x 0.5 x Vs)
= 55 / (1.6 x 0.5 x 610)
= 0.112 ≅ 0.12 m

Diameter of Duct, Φd = $(4Q / (\Pi \times Vd))^{½}$
= $(4 \times 55 / (\Pi \times 1220))^{½}$
= 0.239 m ≅ 0.2 m

7. PROTECTIVE EQUIPMENT

1 The following personal protective equipment shall be provided to workers who operate degreasers:

a. Impervious PVC gloves if contact with the hands is likely

b. Chemical splash goggles or faceshields if there is a risk of splashing.

c. Suitable respirators if the exposure is above half the PEL of the solvent.

All protective equipment provided shall be solvent resistant.

2 The following provisions shall be made available and be readily accessible for handling accidental contact with the solvent:

a. A wash basin and soap or soap solution to treat accidental solvent splash on the skin.

b. Emergency eye wash to rinse the worker's eyes should the solvent come into contact with the eyes.

END