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PAKISTAN

Technical Report * .

Mission 20 March to 30 April 1985

Prepared for the Government of Pakistan

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Consultant on Safety Aspects of Maintenance Work

4014

United Nations Industrial Development Organization

Vienna

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Recommendations

1. Safety should be involved in all training progremmes of the Preventive Maintenance Development Centre (PMDC) for all levels of skilled workers and managers.

2. Test of knowledge of safety could be useful to provide after training and then should be repeated periodicaly one time a year for skilled workers and one time in three years for managers.

3. A safety laboratory should be organized as a counter part of the PMDC to carry out training in know-how of safety instruments and facilities.

4. All data on instruments and equipment of laboratory should be obtained from supplier together with an accurate and detailed description of their specify and handling.

5. From time to time tests of safety maintenance work in the working places of skilled workers should be provided through the technical authorities of FCCCL and safety teacher of PMDC.

Introduction

The Federal Chemical and Ceramics Corporation Limited (FCCCL) was established in Pakistan in 1972. It owns 15 operating units at various locations and manufactures a large number of chemical products ranging from basic chemicals through pharmacenticals and plastics to man-made fibres.

The FCCCL is making every effort to maximize the productivity of its units through improved maintenance management, comprising the development of a preventive maintenance scheme. Recently completed projects oriented towards implementing the above scheme resulted in a number of measures adopted by each of the FCCCL units.

The next step in bringing about the comprehensive and reliable maintenance scheme is the present project, which is to up-grade the ability of FCCCL maintenance service in preventive maintenance methods and techniques. For the realisation of this project in Ravi Rayon Limited Lahore through the United Nations Industrial Development Organisation (UNIDO) is built the Preventive Maintenance Development Centre for training of highly skilled workers and managers in the filed of maintenance work. To-day the Preventive Maintenance Development Centre is being fitted with the training materials, instruments, tools and equipment.

The programme of training is prepared and one of the section of this programme is safety aspects in chemical plant.

Job Description

The original job description was as follows:-

Consultant will advise on the training aids required for the safe maintenance practises. The training materials will emphasise on safety of personnel as well as equipment in chemical plants. This will include rotary equipment, machine tools,mobile equipment and stationary equipment like tanks, pressure vessels, towers etc.

The revised job description was as follows:-

The consultant will work with the Chief Technical Advisor of the Preventive Maintenance Development Centre and specifically be expected to help:

- To prepare training lectures on the main points of safety aspects in chemical plant;
- Composing list of safety laboratory;
- Composing list of statutes, regulations and orders;
- Composing list of official safety quidance booklets (Published by HMSO* London); (* HMSO- Her Majesty's Stationary Office).
- Composing list of periodicals.

Activities

The work of the consoltant has been divided into two categories:-

- The first one was to prepare training lessons for skilled workes and managers of maintenance work for safety and composing the lists of statuses, Regulations, Orders and Official guidance booklets which can be utilized as a complemental material by teachers in the lectures and by skilled workers for the self study of safety aspects.
- The second one was composing the list of safety laboratory and carring out of order for purchase of these instruments and facilities for this laboratory.

The principle aspects of safety in chemical plant is shown in figure 1 and of the working place - in figure 2. According to figure 1 the plan of the theoretical training course was carring out as follows:-

a. The main hazards in the chemical plant - 1 lecture

b. Plant protection - 3 lectures:

- Plant protection through sefety inspection,
- Methods of inspections;
- Plant protection through safety facilities.

c. Fire protection - 2 lectures;

- Fire protection technique;
- Fire protection equipment.

Cont'd. . . P/3

d. Personal protection - 2 lectures;

- Protection technique
- Protection facilities.

The lectures were prepared in English (see Annex IV) and after translation in Urdu they can be used for training work with skilled workers. All of them were discussed with the Chief Technical Advisor of the PMDC and trained with the two teachers of the PMDC.

The composing list of statuses, regulations and orders, see Annex II, and the composing list of official safety guidance booklets, see Annex III

For the best dissemination of know-how of safety problems it could be very useful to organize the safety laboratory as a counterpart of the PMDC. In this laboratory the skilled workders can be exposed to the main safety. instruments and facilities as well as to get the first know-how in handling of them.

The list of safety instruments and facilities for equiping this laboratory is given in Annex I. The 13 items from this list (see Pos. 1-8 and 11-18) for the total sum 5335 US dollars were included in the requisition form and sent for headquarters purchase. The 3 items from this list (see Pos. 9,10 and 19) were recommended for local purchase.

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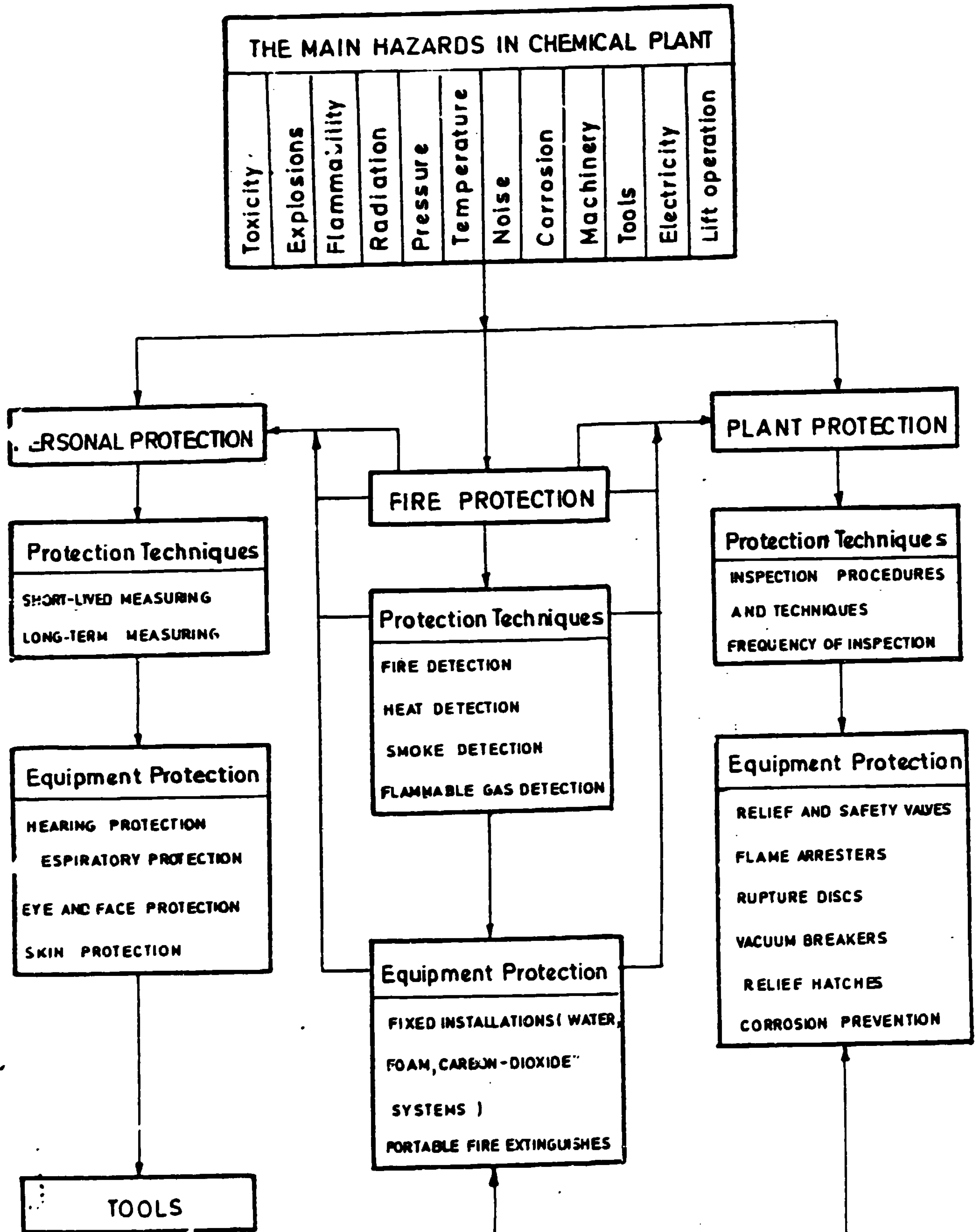

SAFETY ASPECTS IN CHEMICAL PLANT

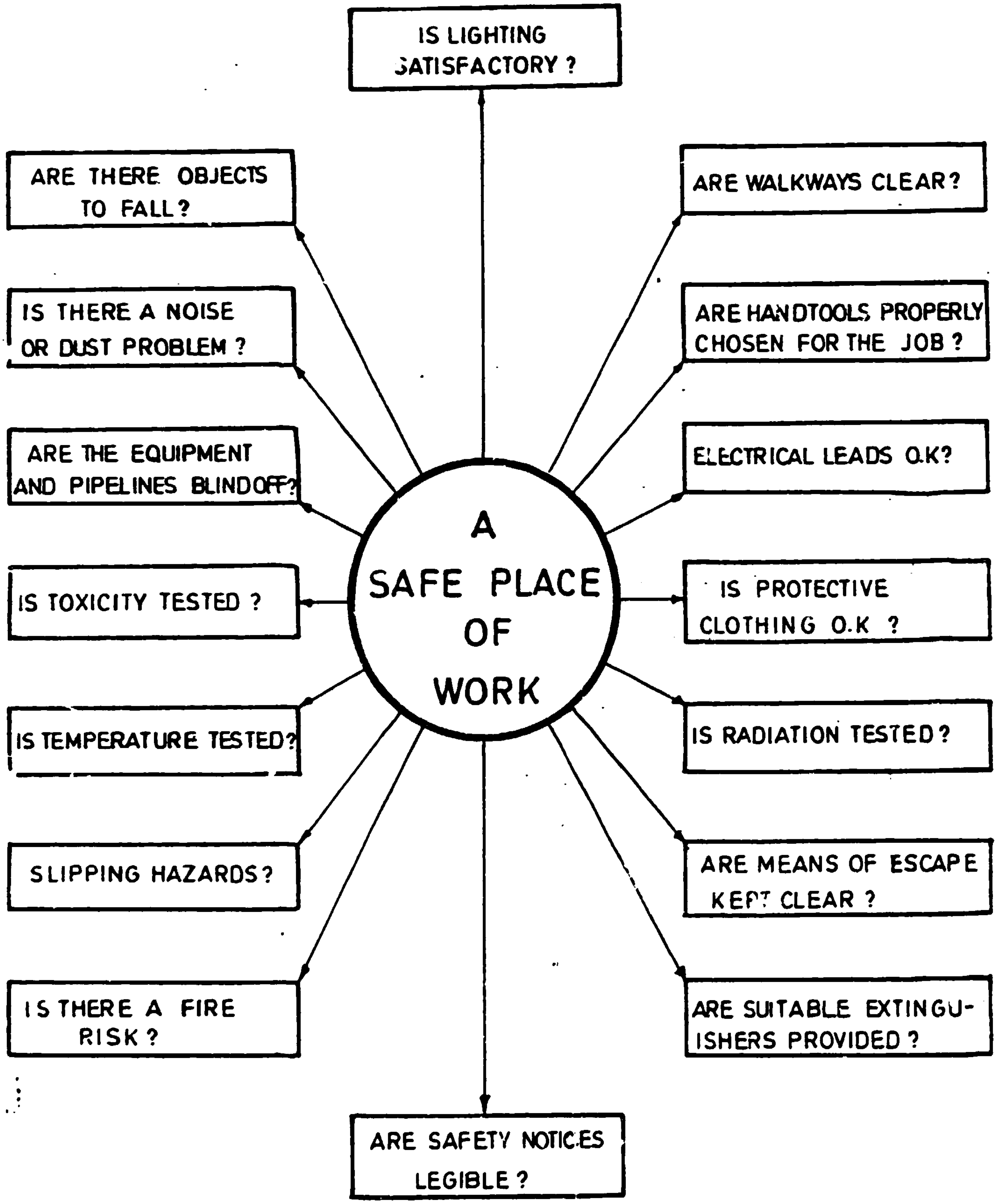
IS LIGHTING SATISFACTORY ?
ARE THERE OBJECTS TO FALL?
ARE WALKWAYS CLEAR?
IS THERE A NOISE OR DUST PROBLEM ?
ARE HANDTOOLS PROPERLY CHOSEN FOR THE JOB ?
ARE THE EQUIPMENT AND PIPELINES BLINDOFF?
ELECTRICAL LEADS O.K?
A SAFE PLACE OF WORK
IS TOXICITY TESTED ?
IS PROTECTIVE CLOTHING O.K ?
IS TEMPERATURE TESTED?
IS RADIATION TESTED?
SLIPPING HAZARDS?
ARE MEANS OF ESCAPE KEPT CLEAR ?
IS THERE A FIRE RISK?
ARE SUITABLE EXTINGU-ISHERS PROVIDED ?
ARE SAFETY NOTICES LEGIBLE ?

FIGURE - 2

Annex - I

Recommended list of instruments and equipment for the safety laboratory:

1. Portable Oxygen Analyser (M.S.A. Ltd.),

   or Oxycom 25D (from Drager).

2. Warnex from Drager (for explosive hazard measurement), or Drager - Combiwarn (for the same purposes).

3. The malti gas Detecter from Drager (for measurement of the most varied gases and vapours).

4. Drager Polymeter (for long-term monitoring of workplaces).

5. Vane Anemometer (Courtesy Abbott Birks)(for ventilation control).

6. Heat Detector (Courtesy chubb fire security Ltd.)

7. Temperature Detector (Courtesy Chubb Fire security Ltd.)

8. Photoelectric smoke Detector (Courtesy Chubb Fire security Ltd.)

9. Corbon dioxide extinguisher.

10. Foam extinguisher.

11. BG 174 and Travox 120 (fully automatic oxygen breathing apparatus sets).

12. Fresh - Air line Breathing Apparatus.

13. Compressed Air Line Breathing Apparatus.

14. Panorama Nova mask (from Drager).

15. Drager Respirator Filters.

16. Test Sets from Drager (for systematic function of instruments testing).

17. Industrial hand - held sound level meter (Courtesy General Acoustics Ltd.).

18. Personal dust sampler (Courtesy Casella London Ltd.).

19. Misc safety Items (mines safety helmet of plastic, Anti chemical gloves, Leather gloves, Asbestos gloves, Rubber gloves, Face shield, Anti chemical apron, Anti acid suit, Fire men's suit, Ear muffs, Fire blankets).

Items

Annex - II

Recommended List of Statutes, Regulations and Order for the safety Laboratory.

1. Alkali etc. Works Orders 1966 - 1971
2. Alkali etc. Works Regulations Act 1906.
3. Chemical Works Regulations 1922.
4. Chains, Ropes and Lifting Tackle (Register) Order 1938.
5. Clean Air Acts 1956 - 1968.
6. Construction (General Provisions) Regulations 1961.
7. Construction (Health and Welfare) Regulations 1966.
8. Construction (Lifting Operations) Regulations 1961.
9. Construction (Working Places) Regulations 1966.
10. Dangerous Machines(Training of Young Persons) Order 1954.
11. Electricity (Factories Act) Special Regulations 1908-1944.
12. Electricity Regulations 1908.
13. Explosives Acts 1875 - 1923.
14. Factories Acts 1937 - 1961.
15. Factories and Workshops Act 1901.
16. Fatal Accidents Act 1976.
17. Fire Certificates (Special Premises) Regulations 1976.
18. Fire Precautions Act 1971.
19. Fire Precautions (Factories, Offices, Shops and Railway Premises) Order 1976.
20. Health and Safety (First - Aid) Regulations 1981.
21. Health and Safety at Work etc. Act 1974.
22. Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972.
23. Industrial Training Act 1964.
24. Petroleum Mixtures Order 1929.
25. Petroleum (Regulations) Acts 1928 and 1936.
26. Protection of Eyes Regulations 1974.
27. Radioactive Substances Act 1980.
28. Work in Compressed Air Special Regulations 1958.

Annex - III

Recommended list of official safety guidance book lets (Published by HMSO*London).

1. Safety in the use of Abrasive Wheels.
2. Safety in Construction Work : General Site Safety Practice.
3. Dust Explosions in Factories.
4. Noise and the Worker.
5. Repair of Drums and Small Tanks : Explosion and Fire Risk.
6. Basic Rules for safety and Health at work.
7. First Aid in Factories.
8. Lighting in Offices, Shops and Railway Premises.
9. Means of Escape in case of Fire in Offices, Shops and Railway Premises.
10. Welding and Flame Cutting using Compressed Gases.
11. Chemical Safety series:
    - CS1 Industrial use of flammable gas detectors.
    - CS2 The storage of highly flammable liquids.
    - CS3 Storage and use of Sodium Chlorate.
    - CS4 The keeping of LPG** in Cylinders and similar containers.
    - CS5 The storage of LPG** at fixed installations.
    - CS6 The storage and use of LPG** on constructions sites.

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* HMSO - Her Majsty's Stationary Office.

** LPG - Liquefied Petroleum Gas.

ANNEX IV

Lectures - " Safety in Chemical Plant "

Contents

Part I The main hazards in chemical plant

1.1 Introduction

1.2 Toxicity

1.3 Flammebility

1.4 Explosions

1.5 Radiation

1.6 Pressure

1.7 Temperature

1.8 Noise

1.9 Corrosion

Part II Plant protection

2.1 Plant protection through safety inspection

2.1.1. Inspection procedures

2.1.2. Frequency of inspection

2.1.3. Inspection techniques

2.2. Methods of inspection

2.2.1. Visual inspection.

2.2.2. Magnetic particle inspection

2.2.3. Dye-penetrant inspection

2.2.4. Hammer testing

..../....

2.2.5. Thickness determination

2.2.6. Trepaning or core drilling

2.2.7. Pressure testing

2.3 Plant protection through safety facilities

2.3.1. Types of pressure relief devices

2.3.2. Location of pressure relief devices

Part III Personal protection

3.1. Short-lived measuring

3.1.1. Methods of assessment of workplace pollution

3.1.2. Standards for workplace environments

3.1.3. Assessment of performance of ventilations systems

3.1.4. Light measuring instruments

3.1.5. Sound measuring instruments

3.2. Long-term measuring

3.2.1. Long-term sampling

3.2.2. Direct monitoring of gases and vapours

3.2.3. Oxygen analysers

3.3. Hearing protection

3.4. Respiratory protection

3.4.1. Respirators

3.4.2. Breathing apparatus

3.5. Eye protection.

3.6. Skin protection

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1.1. Introduction

All manufacturing processes and maintenance works are to some extent hazardous, but in chemical plant there are additional, special, hazards associated with the chemicals used, processes conditions as well as with the variety equipment, instruments and tools used for the processes and maintenance work.

In this chapter only the particular hazards associated with chemical plant will be considered. They are :

- Toxicity
- Explosions
- Flammability
- Radiation
- Pressure
- Temperature
- Noise
- Corrosion
- Machinery
- Tools
- Electricity
- Lift operations

Below we will look briefly all of these hazards.

1.2 Toxicity

Most of the materials used in the chemical plant are poisonous, to some extent. The potential hazard will depend on the inherent toxicity of the material and the frequency and duration of any exposure. It is usual to distinguish between the short-term effects (acute) and the long-term effects (chronic). A highly toxic material that causes immediate injury, such as phosgene or chlorine, would be classified as a safety hazard. Whereas a material whose effect was only apparent after long exposure at low concentrations, for instance, carcinogenic materials, such as Vinyl Chloride, would be classified as industrial health and hygiene hazards. The permissible limits and precautions to be taken to ensure the limits are met will be very different for these two classes of toxic materials, for example :

Compound	mg/kg.
Potassium Cyanide	10
Tetraethyl Lead	35
Lead	100
DDT	150
Aspirin	1500
Table salt	3000

Some L D_{50} Values

Source : Lowrance (1976)

The inherent toxicity of a material is measured by tests on animals. It is usually expressed as the lethal dose at which 50 per cent of the test animals are killed; the LD_{50} (lethal dose fifty) value. The dose is expressed as a quantity in the milligrams of the toxic substance per kilogram of body weight of the test animal. Estimates of the LD_{50} for man are made based on the tests of animals.

There is no generally accepted definition of what can be considered toxic or non-toxic. Kusnetz (1974) gives two examples of attempts to set limits based on LD_{50} values:

$LD_{50} < 1$ mg/kg - extremely toxic

> 15 mg/kg - relatively non-toxic

$LD_{50} < 5$ mg/kg - supertoxic

> 15 mg/kg - relatively non-toxic

These definitions apply only to the short-term (acute) effects. The fixing permissible limits on concentration for the long-term exposure of workers to toxic materials. The, Threshold Limit Value "(TLV)" is the most commonly used guide for controlling the long-term exposure of workers to contiminated air. The TLV is defined as the concentrations to which it is believed the average worker could be exposed to, day by day, for 8 hours a day, 5 days a week, without suffering harm. It is expressed in ppm for vapours and gases, and in mg/m^3 (or $grains/ft^3$) for dusts and liquid mists.

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Recommended TLV values are published in Bulletins by the United States Occupational Safety and Health Administration and the United Kingdom Health and Safety.

1.3 Flammability

The hazards caused by a flammable material depends on a number of factors:

1. The flash-point of material
2. The autoignition temperature of the material
3. The flammability limits of the material

Flash-point

It is the lowest temperature at which the material will ignite from an open flame. The flash-point is measured in standard apparatus, following standard procedures. For many volatile materials the flash-points are below normal temperature (0°C); for example, ether - 45°C, petrol (gasoline) - 43°C.

Auto-ignition temperature

It is the temperature at which a substance will ignite spontaneously in air, without any external source of ignition. It is an indication of the maximum temperature to which a material can be heated in air.

Flammability limits

These are the lowest and highest concentrations in air at normal pressure and temperature, at which a flamme will propagate through the mixture. They show the range of concentration over which the material will burn in air, if ignited. Flammability limits are characteristic of the particular material, and differ widely for different materials. For example, for hydrogen the lower limit is 4.1 per cent v/v and the upper 74.2 per cent v/v; for methane the range is from 3.1 per cent to 32 per cent v/v; but for petrol (gasoline) the range is only 1.4 per cent to 7.6 per cent v/v.

A flammable mixture may exist in the space above the liquid surface in a storage tank. The vapour space above highly flammable liquids is usually purged with inert gas (nitrogen), or floating-head tanks are used.

1.4 Explosions

An explosion is the sudden, catastrophic, release of energy, causing a pressure wave (blast wave). An explosion can occur without fire, as the failure through overpressure of a stream boiler or an air receiver.

When discussing the explosion of a flammable mixture it is necessary to distinguish between detonation and deflagration. If a mixture detonates the reaction zone propagates at supersonic velocity (approximately 300 m/s) and the principal heating mechanism in the mixture is shock compression. In a deflagration the combustion process is the same as in the normal burning of a gas mixture; the combustion zone propagates at subsonic velocity, and the pressure build-up is slow. Whether detonation or deflagration occurs in a gas-air mixture depends on a number of factors; including the concentration of the mixture and the source of ignition. Unless confined or ignited by a high-intensity source (a detonator) most materials will not detonate. However, the pressure wave (blast wave) caused by a deflagration can still cause considerable damage.

Certain materials, for example, acetylene, can decompose explosively in the absence of oxygen; such materials are particularly hazardous.

1.5 Radiation

The radiation emitted by radioactive materials is harmful to living matter. Small quantities of radioactive isotopes are used in chemical processes for various purposes; for example, in level and density-measuring instruments, and for the non-destructive testing of equipment.

1.6 Pressure

Over-pressure is one of the most serious hazards in chemical plant operation. Failure of a vessel, or the associated piping can precipitate a sequence of events that culminate in a disaster.

Pressure vessels are invariably fitted with some form of pressure-relief device, so that the potential over-pressure is relieved in a controlled manner.

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Three types of relief device are commonly used:

- Directly actuated valves: weight or spring-loaded valves that open at predetermined pressure, and which normally close after the pressure has been relieved.

- Indirectly actuat ed valves : pneumatically or electrically operated valves, which are activated by pressure - sensing instruments.

- Bursting discs : thin discs of material that are designed and manufactured to fail at a predetermined pressure, giving a full bore opening for flow.

1.7 Temperature

High temperature, over and above, can cause failure of equipment and initiate a disaster. High temperature can arise from loss control of reactors and heaters; and externally, from open fires

Protection against high temperatures is provided by :

- Provision of high-temperature alarms and interlocks to shut down reactor feeds, or heating systems, if the temperature exceeds critical limits.

- Provision of emergency cooling systems for reactors, where heat continues to be generated after shut-down.

- The selectionof safe heating systems for hazardous materials.

Steam and other vapour systems are safe, as the temperature cannot exceed the saturation temperature at the supply pressure. Other heating systems rely on control of the heating rate to limit the mamimum process temperature. Electrical heating systems can be particularly hazardous.

1.8 Noise

Excessive noise is a hazard to health. The unit of sound measurement is decibel (dBA). We can measure the levels of noise with an Industrial hand-held sound level meter.

Permanent damage to hearing can be caused at sound levels above about 90 dBA, and it is normal practice to provide ear protection in areas where the level is above 80 dBA. For the workers we can manage it with the ear muffs or ear plugs. (Cotton wool does not serve as effective protection against noise).

Attention should be given to noise levels when specifying, and when laying out equipment that is likely to be excessively noisy; such as, compressors, fans, burners and steam relief valves.

1.9 Corrosion

The handling of hazardous materials such as toxic gases, hydrofluoric acid, concentrated sulfuric and nitric acids, explosive and flammable materials radioactive substances, and chemicals of high temperature and pressures demands the use of materials of construction which minimize corrosive failures. Corrosion of a metal wall separating the fuel and oxidizer could cause premature mixing, which could result in a destruction of equipment and in personal injury. Corroding equipment can cause some fairly harmless compounds to become explosive.

1.10 Machinery

There are very few workplaces where machines have no part to play in the business. The main machinery dangers are :

- revolving shafts
- Discontinuous rotating parts
- abrasive wheels
- closing nips between platen motions
- rotating wheel cranks or disks
- revolving beaters, spiked cylinders and revolving drums.

1.11 Tools

Tools can be a cause of accidents when used by workers. For example, when you work upstairs the simple missing of your hammer can be a real potential for injury to a person, wh works downstairs, or for damage to equipment, or - possibly both. You can have a serious problem of careless people, since they appear to injure themselves with their tools -

..../....

or are the hammers all rounded the spanners all gaping, the chisel-heads all burred and the files all bereft of handles.

1.12 Electricity

It is a safe and efficient form of energy and its benefits to mankind as a convenient source of lighting, heating, and power are obvious. But out of control electricity can cause harm as per human body so far the equipment. Electricity heating effect can also cause fire, and it is particularly hazard if you deal with the explosive and flammable gases and liquids.

When maintenance work is to be carried out on a part or piece of electrical apparatus, certain precautions need to be taken to protect the worker concerned from electrical danger. The electricity supply should first of all be swiched out and locked off to ensure that the circuit or apparatus being worked upon is effectively electrically isolated and cannot become live. Using a suitable voltage detecting instrument, that part of the circuit to be worked on should be checked to ensure that it is dead and danger notices. "Don't switch on ! Under repair !" should be placed on the swicher.

In chemical industry, so far as flammable gases and vapours are concerned, areas that are hazardous, are classified according to the probability of occurance of explosive concentrations of gas or vapour.

These classifications, called zones, are as follows

- Zone 0 is a zone in which a flammable atmosphere is continuously present or for long periods.
- Zone 1 is a zone in which flammable atmosphere is likely to occur in normal working.
- Zone 2 is a zone in which flammable atmosphere is unlikely to occur except under abnormal conditions and then only for a short time.

The particular zone determines the types of protection required for electrical equipment in use in that zone.

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Portable electric tools are a convenient aid for different maintenance works. The most common of them are electric drill and portable grinding wheel. However, the necessity to use flexible cables to supply electricity to the tool introduces hazards. For example, such cables are often misused and abused resulting in damaged insulation and broken or exposed conductors. The total itself could also become unsafe if, say, its metalwork became charged with electricity due to a fault. Constant care and adequate maintenance and storage are essential to safe use.

1.13 Lifting operations

A lot of maintenance works are connected with lifting operations. However, any laxity in its use can prove very costly in terms of damage to plant and product, and, worse, of injury to employees. Whether the lifting equipment is mobile, or is fixed in position, agreed safe systems of work and procedures for using it must be followed to reduce any risk to a minimum and to ensure the best utilization possible.

There are a number of common techniques that apply to the safe operation on every type of lifting devices. They include: overtravel switches, protection of bare conductors, load indicators, safety catches, access, safe working load, safe signals, chain slings, wire rope slings, fibre rope slings, eyebolts, etc.

The provision of good conditions for lifting operations and the elimination of hazards depend upon the knowledge and skill of maintenance workers and particularly of manager of work. That's why he should be tested for his knowledge and skill. And a manager of maintenance work before allowing lifting operations has to give job instructions to workers.

..../....

II - Plant Protection

Plant Protection is one of the most important part of safety aspects in chemical industry. We can divide it into two groups such as :

- plant protection through safety inspection
- plant protection through safety facilities

2.1 Plant protection through safety inspection

Safety inspection - the examination of equipment elements at sufficiently frequent intervals to obtain adequate knowledge of physical conditions, both from the standpoint of deterioration and for the most effective carrying on of maintenance work. Effective safety inspection work can be based on established rules and standarized procedures though local conditions vary to some extent, however, and standardized procedures and rules are not always directly applicable.

Safety inspection is usually provided through the special inspection department of the plant. It should be headed by Plant Chief Inspector with an adequate number of qualified subordinates. They should be responsible and mature men with experience both in operations and maintenance crafts. The Inspection Department decisions regarding safety should be final, subject to over-rule only by the plant management.

The Inspection Department is responsible for the execution of all safety inspection work including hydrostatic tests, recommending necessary replacements, recommending abandonment of unsafe equipment, anticipating replacements necessitated by deterioration and advising the proper parties as may be necessary. It cooperates with other departments in the Work of Preventive maintenance and in recommending improvements for the purpose of reducing deterioration.

As a part of the work in promoting safety of equipment, the Inspection Department is required to observe and ascertain the condition of relief valves, blowdown connections and similar emergency provisions or devices when units are taken out of service as a check upon the operability of these elements when they are called upon to function.

2.1.1. Inspection procedures

Inspection procedures are usually customary to adhere to one of the two following methods :

- periodic inspection
- continuous run - to - run inspection

Periodic inspection comprises the scheduling of complete general inspection of equipment along with necessary hydrostatic tests at definite intervals. Replacements made at such inspection times are usually contemplated to last until the next scheduled periodic inspection. This method is varied somewhat by minor interim replacements and also in that certain parts of known slow deterioration rates are inspected at less frequent intervals than those observed during the general inspections.

This procedure is most applicable to small units which conveniently can be given overall inspection at one shutdown and also to the smaller plants. It may be preferable an equipment which runs for very long periods and whose maintenance shutdowns are prolonged.

Continuous run-to-run inspection comprises partial inspection of equipment as required at each shutdown, based upon a continuous and complete system of records indicating the condition of component parts, and the replacement of parts based upon expected deterioration between consecutive operating shutdowns. This procedure permits maximum service life of component parts due to frequency of inspection opportunities. The requirements in coordinated record keeping are exacting, however, as a continuous check on all constituent elements must be kept and replacement directed as they individually reach retirement limits.

2.1.2 Frequency of inspection

The frequency with which the various types of chemical plant equipment and component parts thereof, justify inspection varies to a great extent. The principal factors which determine the inspection intervals include corrosiveness of the material being processed, the severity of operating conditions, the possible consequences of failure, and the age of the equipment. In some cases equipment is contrasted of or provided with linings of corrosion - resistant alloys which greatly reduce deterioration. It is not necessarily true that where corrosion resistant liners are used inspection intervals can be lengthened as a result, for inspection may be necessary to check the effectiveness of the corrosion protection being achieved.

When the system of periodic or complete general inspection is employed, it is possible to establish the maximum intervals at which complete inspection of the equipment should be made. Even under this system there are portions which do not require inspection of those intervals, such as the portions of less severe exposure and less critical duty. It is therefore necessary to establish for a given unit the intervals at which its various constituent parts must be examined.

It is possible to divide each unit into process elements requiring frequent and detailed inspection such as principal vessels, piping, pumps, etc. , and portions such as cold feed supply lines, fuel gas lines, certain vessels in non-corrosive service and the like which require less frequent inspection, and to express the approximate order of frequency with which the different elements should be inspected.

When employing the continuous, run-to-run method of inspection, the same intervals would apply for constituent elements. That is, for a given type of unit, it may be established that all specified important portions thereof should be inspected at certain intervals, whether done at a single inspection period or at various operating shutdowns.

The inspection of all pressure vessels, whether or not they are constituent parts of such units should be set up on a definite schedule, with more frequent inspection being conducted when circumstances justify. Vessels operating at or above 25 psig, with a corrosion and erosion rate of 0.03 inch per year or greater, or where the allowable minimum is being approached within 0.06 inch should be inspected fully at no greater than semi-annual intervals.

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The ASME Code for Unfined Pressure Vessels provides for certain maximum inspection intervals for all vessels including those with partial linings. It provides that the maximum period between inspections shall not exceed one-half of the estimated remaining safe operating life of the vessel, and in addition the intervals should be subject to the following requirements :

Corrosion % of Required Thickness Per Year	Maximum Intervals Between Inspections
10 or above	1 Year
8-10	2 years
6-8	3 years
4-6	4 years
Below 4	5 years

The code provides that vessels whose contents are corrosion - inhibiting and with negligible external corrosion must be examined either inside or outside at least every five years. All safety valve equipment shall be inspected and examined at no greater than yearly intervals, and vessels above ground should receive visual external inspection at least once a year.

As a general rule, all vessels with non-metallic linings such as gunite, brick, plastics, etc. should have the whole liner removed at a maximum of eighteen month intervals. Progressive failure of liners in spots may make frequent inspection necessary

With respect to non-process equipment, the following intervals are recommended as maximum for certain of the important classes of such equipment.

Equipment	Maximum Intervals Between Inspections
Atmospheric tanks	1 month*
Pressure tankage	1 month*
Boilers	**
Dikes	6 months
Oil separator	3 months
Gas collecting system	6 months - 1 year
Transfer pumphouses	6 months
Loading racks and docks	6 months

* Visual inspection from the outside, including maintenance of external parts such as vents and flame arrestors.

** Inspection intervals usually depend upon insurance and state regulations.

2.1.3 Inspection Techniques

The complete examination of equipment to determine fitness for continued operation involves numerous techniques. These comprise chiefly various fields inspection procedures but include also hydrostatic testing and laboratory investigations

In the execution of inspection work certain safety precautions need to be exercised for the protection of inspectors and workmen, the avoidance of harm to the equipment being examined and the maintenance of general safety in inspection area. These include but are not limited to the following points :

a) The carrying on of inspection work is not an excuse for disregarding ordinary safety rules such as those concerning the uses of flames in hazardous areas, the handling of heavy objects over or near operating equipment or the partial dismantling of equipment under operation for inspection purposes.

b) Full safety precautions should be observed as to blinding off, from outside sources, of equipment undergoing inspection or maintenance work before the entrance of workers within vessels or similar areas be entrusted to simple closing of valves without locking, blinding or other precautions. Reliance on valves alone even though locked shut is undesirable because of their tendency to leak. This is particularly important with flammable or toxic vapours. The approval of the operating department familiar with the lineup of piping and other equipment is required before dismantling work for the purpose inspection.

   In connection with the extensive work on process equipment and widespread maintenance jobs on a unit the portable type of gas detector such as "Combiwaren", "Oxycom 25D", "Warnex" or similar are very useful.

c) The medium used for hydrostatic pressure testing may be water or similar non-corrosive and non-explosive liquid. Combustible liquids having flash points less than 110° F., such as petroleum distillates, may be used only for near-atmospheric temperature tests. It is recommended that

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the liquid temperature be not less than 60°F where practicable. The test pressure shall not be applied until the vessel and its contents are at about the same temperature.

d) Except under the special conditions authorised by the ASME Code, or similar authority, air or any other gas, never should be used for strength testing of vessels or other equipment. Failure of a piece of equipment under gas pressure releases large amounts of energy with highly destructive effects on the surroundings, whereas with liquids this effect is negligible. The vessels being hydrostatically tested should be carefully freed of air in the upper portion until the vessel is completely full of liquid.

e) Air never should be used for pressure testing equipment where possibility of combustion of hydrogen sulfide, iron sulfide or other chemicals exist. In no case should oxygen be used as a testing medium.

f) In hydrostatic testing of a vessel not designed for vacuum, care must be taken to vent the vessel top as the liquid is removed. When tested with steam for tightness, such vessels should be provided with automatic vacuum breakers to protect against the vacuum resulting from steam condensation.

g) In hydrostatic testing of equipment elements either singly or as a group, care should be exercised to avoid overstressing any elements not designed for the test pressure employed.

i) In the hydrostatic testing of equipment, consideration should be given to the possible consequences of failure with resultant spillage of testing fluid. This is especially important in the case of flammable testing media, even though the flash point may be substantially above atmospheric temperature, if there is possibility of falling upon heated objects, running into furnaces or in other ways causing a fire hazard.

2.2 Methods of inspection

The detection of flaws in chemical equipment accounts for a large percentage of the work performed by the manager of maintenance work or inspector. Included in the category of flaws would be cracking and voids in welds, unusual corrosion or erosion, metal fatique, structure alteration and the like. Determination of metal thickness is also imperative in establishing equipment condition. For carrying out of inspection of equipment there are several of the following methods.

2.2.1 Visual inspection

This method of inspection is used to determine the apparent condition of the surfaces of equipment, including welds and riveted joints, with respect to corrosion and erosion effects and any other defects. It is usually necessary that the surface be properly prepared by scraping, wirebrushing and even sandblasting. Visual examination is one of the principal means of determining when replacement of such items as furnace tubes, fractionator internals, exchanger parts, and pump and compressor parts is required. In some cases for the parts which are not directly accessible, such as the middle of furnace tubes, some reflecting or telescopic device may be required.

2.2.2 Magnetic Particle Inspection

This method is based upon well-known electromagnetic principles. When a magnetic flux is induced in a magnetic material, its lines flow smoothly through the material unless some point of discontinuity is reached. A point of discontinuity can become a pole and point of origin from which a flux is emanated into the surroundings. Thus, in a simple bar magnet, lines of magnetic flux flow through the metal with very little emanation to the surroundings until the end of the magnet is reached. At this point of discontinuity a heavy flux is released, forming a magnetic pole. A flaw within a magnetic material such as a crack in the surface or a subsurface void will act as a point of discontinuity and form, in effect a magnetic pole. It is possible to distinguish such discontinuities with minute particles of magnetic dust, such as iron filings.

These are strongly attracted to any discontinuity poles, and therefore by piling up and concentrating at such points, they effectively outline the location, extent, and to some degree the character of any defect.

This method of inspection is a valuable tool for locating cracks of such small magnitude that they cannot be detected visually. It is effective for detecting fatigue cracks, in machinery parts, cracks originating in welds and stress corrosion cracks.

2.2.3 Dye-Penetrant Inspection

On non-magnetic materials where the magnetic particle examination is inapplicable or on all materials where a rapid inexpensive check for surface flaws is desired, the dye-penetrant inspection technique is available. This method relies on the ability of a relatively free-flowing material to penetrate surface cracks and flaws after a surface cleaning.

In practice, two types of dye-penetrants are available for use. One depends upon color contrast to effect detection while the other utilizes a fluorescent dye requiring the use of ultraviolet light for observation.

Both methods require that the surface be thoroughly cleaned before application of the dye. The dye is then applied and the surface again cleaned by simply wiping or rinsing with water. With the non-fluorescent type of dye, any flaws in which the liquid is entrapped and thus drawn out will be outlined in a color visible to the eye in ordinary light. If a fluorescent dye is being used, the prepared area is inspected under ultra-violet light.

2.2.4. Hammer Testing

It is a valuable part of inspection procedures and has several functions. Its principal uses include:

a) location of thin or otherwise defective sections of vessels or pipe walls by sound;

b) the checking of pipes, heater tubes, vessels, nozzles, and other parts by the ability to

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withstand the hammer blows, as a precaution against defective sections not found by other inspection methods;

Considerable skill is needed in hammer test, and in the testing of equipment the inspector should be guided by the sound and rebound of the blows and appearance of the metal struck, and should cause additional inspection such as measurement to be made where the hammer tests indicate metal of questionable thickness or condition.

The weight of the testing hammer should vary from 1.5 to 2.25 pounds for testing lines and materials up to three-fourths inch metal thickness. Heavier hammers should be used for thicker materials.

Hammer testing should not be relied upon exclusively, but it should be considered an extension of other methods. It should not be applied to castings, as a rule, to other material of a brittle nature, nor to thin piping, vessels or other parts which normally would be damaged by the blows.

2.2.5 Thickness Determination

The many different types and shapes of equipment which need to be measured require numerous types of measuring devices and methods. As a general rule, it is desirable to avoid cutting into or other destructive operations upon equipment for the purpose of taking measurement. The so-called "destructive" methods of taking measurements should be used only in that case when "non-destructive" methods are lacking. Today ultrasonic instruments are of great usefulness in checking metal thicknesses. This instrument provides direct thickness reading and it can be employed for measurement of equipment elements while they are in operation.

2.2.6 Trepaning or Core Drilling

This method consists of drilling into metal with a special tool so as to obtain a core from the drilled hole. The core permits examination of the condition of the metal with respect to defects. This is a rarely used method, although under circumstances requiring a section of the metal wall examination, it is very useful. The hole resulting from trepaning is substantially large and the closing of it should

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be done by a suitable method such as tapping and plugging followed by seal-welding. In thick-walled vessels, closure by welding alone may set up undesirable residual stresses.

2.2.7 Pressure Testing

This method normally is carried out for one of two primary purposes:

a) proof testing of equipment either when new or at inspection periods to confirm suitability for the operating conditions under which it will be employed;

b) to ascertain the tightness of the equipment prior to being put into operation and to locate leaks.

Usually proof testing is done only with liquid while tests for tightness may be done also with steam or air. The magnitude and the rate of application of the particular piece of equipment tested. During the time the test pressure is applied, complete examination of the equipment should be made insofar as is possible.

Vessels that are not capable of supporting the weight of liquids may be subjected to a pneumatic test in accordance with the ASME Code. In no case should such pneumatic test pressure exceed 125 per cent of the calculated allowable pressure.

2.3 Plant protection through safety facilities

The facilities for excess pressure relief, emergency blowdown and purging along with their associated systems for the safe handling of released liquids and vapours are essential part of almost every process installation in chemical plants. Experience has shown on many occasions that great reduction in property damage, and sometimes in personal injury and death, could have been accomplished by adequate facilities for this purpose.

The term Pressure Relief refers to the automatic release of fluids (liquids, vapors, gases) from a system when the pressure reaches a pre-determined level. The pressure at which a safety or relief valve starts to open is called the Set pressure. The term Blowdown refers to the intentional release of material from a system, either by local or remote control, as an emergency measure for the protection of equipment or for purging by employing the pressure within the system for effecting movement. The term Blowdown facilities embraces the valves, piping, liquid separators,drums, stacks, flares and other associated equipment.

Pressure relief facilities are designed to prevent pressure in equipment from reaching levels where rupture or mechanical failure may occur by automatically releasing material held within the protected piece of equipment until the pressure falls again within safe operating limits. On the other hand, the blowdown facilities are usually manually operated and in an emergency may be used to effect rapid removal of part or all of the contents of the tank, vessel or other system which, for example, may be feeding a fire. The blowdown system also has an important incidental use for purging purposes and removal and disposition of the major portion of accumulated liquids and vapors from process units prior to normal shutdown for inspection or cleaning.

The causes of increased pressure over and above ordinary fluctuations during normal operation are varied. It is difficult in general process unit to anticipate every possible condition which may cause excessive pressure rises, and in operation it may be impossible for operators to stop or even control a rapid pressure rise in equipment (tanks, pressure vessels, furnace coils, heat exchangers, pumps as well as others) in the case of abnormal conditions or emergency. It is for this reason that pressure relief systems are designed to operate automatically.

According to the ASME Code for Unfired Presure Vessels under which most of such presure vessels in countries are designed and fabricated, all unfired pressure vessels shall be protected with suitable pressure relief devices.

2.3.1. Types of presure relief devices

There are many types of pressure relieving devices currently on the market. These include relief valves, safety valves, rupture or frangible discs, and for some services explosion hatches. Of these, the relief and safety valves are the most widely employed on process equipment, although the other devices have numerous important uses.

Relief and Safety Valves

Relief valves comprise those types that commence to release at the set pressure, but not reach maximum discharge rate until the pressure has risen to 110 to 125% of the set pressure. Relief Relief valves are primarily used for liquid service.

Safety valves on the other hand start to release at the set pressure but reach maximum discharge at about 103% of that value. They are used for gas or vapour services.

Relief valves may be of the spring-loaded or lever and weight types. Relief valves for use in liquid service are generally of more simple design than valves for handling vapour or gas, although in principle of operation they are the same. The lever-and-weight type of relief valve is not employed in process service as extensively as the spring-loaded type, but it is used to a limited extent on equipment which operates near atmospheric pressure and under mild temperature conditions. In operation, the pressure at which the valve begins to open is set by adjusting the weight or the position of the weight on the lever, thus regulating the downward force of the valve disc upon the seat. When the upward pressure below the disc is sufficient to counteract the downward force, the disc lifts from its seat permitting the flow to begin. This type of valve is seldom used in liquid service.

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The ASME Boiler and Pressure Vessel Code gives general standards for set pressure and the allowable difference between discharge pressure and maximum working pressure, and standards for testing, marking and installation of pressure relieving devices are also given.

Rupture Discs

Rupture Disc is composed of a pre-forward diaphragm, usually metal, which will rupture at some predetermined pressure level. The disc is held between two special flanges. Its thickness depends upon its diameter and the rupture pressure. The rupture disc is employed where rapid reduction in pressure is required such as in the protection of pressure combustion systems, or the like, where the large excess volumes may have to be relieved. When the pressure in the protected equipment reaches the level at which the disc is designed to rupture, it gives way, and the rate at which pressure is then reduced is limited more or less by the sizes of the rupture disc and of relief piping. This device does not permit continued operation of the equipment after rupture unless a block valve is installed in the line ahead of the disc to permit its replacement after failure. When such a block valve is provided, acceptable practice requires arrangements for locking it open at all times except when a disc replacement is being made.

Rupture discs also find application for protecting spring-loaded relief valves in highly corrosive service. In such applications a rupture disc is fabricated of corrosion-resistant material and installed in the line between the protected piece of equipment and the relief valve of the conventional type.

Relief Hatches

The explosion hatch, relief hatch or explosion door, consists of a specially-designed disc, door, or other closure for an opening in a pressure system, capable of opening under relatively low differential pressure and releasing large quantities of gas or vapor. These devices are used to

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provide pressure relief on tanks, combustion chambers and vessels which operate under relatively low pressure and where large quantities of materials must be released. They are not suited for liquid-relieving service. However, they are the most effective means for low pressure equipment such as tankage or furnaces where combustion irregularities or explosions may result from misoperation and to protect these from high rates of internal pressure generation.

2.3.2. Location of pressure relief devices

In chemical plant installations the location of relief or safety valves on process equipment is important. In this connection, two questions are involved :

a) In what places such devices are required;

b) Where these valves may be best positioned for effective functioning.

Usually the locations in which relief or safety valves are required include the following :

1. On all pressure vessels such as reactors, autoclaves, fractionators, receivers and the like as required by prevailing codes.

2. On various individual pieces of equipment or systems to provide against excessive pressure resulting from thermal expantion of contained fluids including

   a) the cold side of heat exchangers, which if blocked off may be subject to heating from the other side and resultant thermal expansion.

   b) closed piping systems exposed to heating such as tank-farm lines explosed to the sun.

   c) vessels or tanks which may be completely full of liquid or vapour later subject to heating.

3. The discharge of all compressors.

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4. Pumps, where the systems into which they discharge cannot withstand the pumpstalling pressure.

5. On the low pressure side of heat exchangers or on other pieces of equipment subject to internal leaks or failures such as in tubes, where the low pressure side is designed for less than 1/2 of the maximum working pressure of the high pressure side.

In establishing the most desirable locations for relief valves on a specific piece of equipment or system, a number of factors that sometimes also determine the number of valves that must be used need to be considered.

These factors are as follows :

1. It is usually desirable that valves be located as close as possible to the piece of equipment which they protect to minimize the possibility of piping stoppages.

2. Any section of a system which can be isolated by valving or can become isolated by stoppages developing in piping, or in any other way, requires an individual relief valve.

3. Convenience of location for discharge of relieved materials.

In general, relief valves discharging vapours to the atmosphere preferably are connected to the upper parts of the systems which they protect with the discharge piping extending at least 10 feet above the highest operating platform within a 50-foot radius, and at least 20 feet above grade.

Vapour relief valves discharging to the blowdown system may be connected on the protected equipment at the most advantageous position from the standpoint of inlet and outlet piping, providing that the other requirements for valve location are satisfied.

III Personal protection

The human body is composed of several systems such as digestive system, respiratory system, circulatory system, central nervous system. Every system is composed of several organs such as stomach, liver, pancreas, lungs, trachea, bronchiole, heart, eye, ear, skin and so on. It is important to remember that these organs don't function independently but are interrelated so that if one part of the body is not functioning properly it may upset the health of the body as a whole. So in every working place and particularly in chemical plant we have previously to have protection for all human's organ. Surely, in every working place it depends on the real working conditions, and we have to be able to assess the degree of hazard in every working place. For these purposes there are lot of instruments and devices. All of them we can divide into two groups :

- for short lived measuring
- for long-term measuring

3.1 Short-lived measuring.

This group of instruments is useful for assessment of work-place pollution, heat and ventilation, as well as sound level and light level.

3.1.1. Methods of assessment of workplace pollution

There is a wide range of techniques available to measure the degree of workplace pollution. The commonest method of measuring airborne dust is the filter method where a known volume of air is drawn through a pre-weighed filter paper or membrane by means of a pump. The filter is a part of a sampler located in a special holder and connected by tubing to the pump. At the end of sampling period the filter is weighed again and the difference in weight represents the weight of dust collected. This divided by the total volume of air which has passed through the filter, gives the average concentration of dust over the period.

Other techniques for dust measurement include those which use the principle of measuring the amount of light scattered by the dust and one that uses a

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technique which measures the oscillation of a vibratory sensor which changes in frequency with the amount of dust deposited in it.

The number of techniques available for airborne gases and vapours measurement is almost as wide as chemistry itself. Instruments can be used which are specific to one or two gases while others use the principle of infrared absorption and can be tuned to be sensitive to a range of selected gases. The principle of change of colour of paper or crystals is also used for specific gases and vapours. Detector tube and impregnated paper samplers are of this type, but difficulties can be experienced if more than one gas is present as one may interfere with the detection of the other. The chemical absorbe absorbers are usually contained in a small glass tubes connected to a low-volume sampling pump and can be worn by a worker in a similar fashion to the personal dust sampler.

To obtain a correct assessment of a thermal environment, four parameters require to be measured together:

- the air dry bulb temperature;
- the air wet bulb temperature;
- the radiant temperature;
- the air velocity.

The sling psychrometer (sometimes known as the whirling hygrometer) will measure wet and dry bulb temperatures, a globe thermometer responds to radiant heat, and air veolocity can be measured by airflow meter.

3.1.2 Standards for workplace environments

Authorities from several countries publish recommended standards for airborne chemicals, gases, vapours and dust fibres. The Health and Safety Executive in the United Kingdom works to the standards known as the Threshold Limit Values (TLV) for Workplace Environment gives for some 600 chemicals recommended airborne concentrations that represent conditions under which it is believed nearly all workers may be repeatedly exposed day after day without adverse effect.

3.1.3. Assessment of performance of ventilation systems

In addition to the testing of the airborne concentrations of pollutants, it is necessary to check airflows and pressures created in a ventilation system.

Air velocity can be measures by a variety of instruments butanemometers and heated head air meters are the most common. Vane anemometers have a rotating "windmill" type head coupled to a meter and are most suitable in open areas such as shops. The heated head type of air meter is more suitable for inserting into ducting and small slots, but it is unsuitable for use in areas where flammable gases and vapours are released.

3.1.4 Light measuring instruments

The human eye is unrelaible as an indicator of how much light is present. For accurate results in the measurement of the illuminance at a surface it is necessary to use a reliable instrument. Light meters are available for this purpose.

A pocket light meter, normally adequate for most locations, is a photocell which responds to light falling upon it by generating a small electric current which deflects a pointer on a graduated scale measured in lux. Most light meters have a correction factor built into their design to allow for using a filter when measuring different types of light (daylight, mercury vapour lamps, fluorescent tubes etc.).

The level of illuminance measured should be checked against the appropriate standard service illuminance for the location and task.

3.1.5 Sound measuring instrument

There are many sound level meters on the market, but all work in a similar manner. The basic hand-held set consists of a microphone, an amplifier with a weighing network and a real-out device in the form of a meter or digital presentation. The microphone converts the fluctuating sound pressure into a voltage which is amplified and weighed. The electrical signal then drives a meter or digital read-out.

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A typical sound level meter for use by the safety adviser should have the facility for measuring dBA and octave band sound pressure levels.

3.2 Long-term measuring

This group of instruments allow us to assess of workplace conditions for several hours or for the the whole workshift or even for the certain period of time.

3.2.1 Long-term sampling

The air sampling may be carried out in the worker's breathing zone (Personal Sampling) or at a selected point or points in the workplace (Static or Area Sampling). Long-term stain detector tubes are available for this purpose and are connected to a pump which draws air through the tube at a pre-determined constant rate.

Often more accurate methods are required in the assessment of worker explosure and charcoal tube sampling is commonly used. This method is reliable, versatile and accurate, being widely used in checking with hygiene standards.

3.2.2. Direct monitoring of gases and vapours

These devices make a quantitative analysis giving a direct read-out of contaminant level on a meter, chart recorder or other display equipment.

For example, the explosivemeter Warnex from Drager allows direct monitoring of gases and vapours in the working place and has automatic alarm in explosive gases and gasmixtures.

Before use such an instrument must be set up and calibrated for the particular chemical to be measured. Warnex is usually calibrated with methane, the lower explosive limit (LEL) of which in air is 5%, so that the alarm is given at 0.5%. But if required it can also be calibrated to other gases and vapours.

3.2.3. Oxygen analysers.

Deficiency of oxygen in the atmosphere of confined spaces is often experienced in industry, for example inside large fuel storage tanks when empty. Before such places may be entered to carry

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out inspections or maintenance work a check must be made on the oxygen content of atmosphere throughout the vessel. Normal air contains approximately 21% oxygen and when this is reduced to 16% or below people experience dizziness, increased heartbeat and headaches. Such atmosphere should only be entered when wearing air supplied breathing apparatus.

Oxygen analysers are available which measure the concentration of oxygen in the air. One of them is "Oxycom 25D" from Drager. This measures the oxygen concentration of the ambient air in the range of 0 to 25%. The instrument gives an audible alarm when the concentration falls below the set alarm threshhold (set ex-works at 17% O_2). It is temperature-compensated, immediately ready for use and has an automatic operation monitoring system.

3.3 Hearing protection

People can suffer from noise in two ways - it can have a psychological effect, making people short-tempered and causing loss of concentration; or it can have a physical effect, which actually causes temporary or permanent loss of hearing, depending upon the intensity and the duration of exposure.

The TLV for noise - the level to which the average person can be safely exposed for an eight-hour shift every week for a working lifetime -is currently set at 90 dBA. Above that figure, he must wear ear protection (ear waffs, or ear plugs) or be exposed for a shorter period of time.

The exposure time of workers under different level of noise is given below :

Noise level, dBA	Exposure time
90	8 hours
93	4 hours
96	2 hours
99	1 hour
102	30 minutes
105	15 minutes

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3.4 Respiratory protection

For these purposes there are two types of protective equipment :

1. Respirators = purify the air by drawing it through a filter which removes most of the contamination

2. Breathing Apparatus - supplies clean air from an uncontaminated source.

3.4.1. Respirators

There are five basic types of respirators:

- Filtering facepiece respirator - covers the whole of the nose and mouth and is made of filtering material which removes respirable size particles;

- half mask respirator - is made of rubber or plastic and covers the nose and mouth and has replaceable filter cartridges;

- full face respirator - is made of rubber or plastic and covers the eyes, nose and mouth and has replaceable filter canisters;

- powered air purifying respirator - air is drawn through a filter and then blown into a half mask or full facepiece at a slight positive pressure to prevent inward leakage of contiminated air;

- powder visor respirator - the fan and filters are mounted in a helmet and the purified air is blown down behind a protective visor past the wearer's face.

Filters are available for protection against dusts and fibres, and also for removing gases and vapours. It is important that respirators are never used in oxygen-deficient atmospheres.

3.4.2. Breathing apparatus

There are three basic types of breathing apparatuses:

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- fresh air hose apparatus

  air is brought from an uncontaminated area by the breathing action of the wearer or by a bellows or blower arrangement;

- compressed air line apparatus

  air is brought to the wearer through a flexible nose attached to a compressed air line. Filters are mounted in the line to remove nitrogen oxides and it is advisable to use a special compressor with this equipment. The compressor airline is connected via pressure-reducing valves to half-masks, full facepieces or hoods.

- self-contained breathing apparatus

  a cylinder attached to harness and carried on wearer's back provides air or oxygen to a special mask. The equipment is commonly used for rescue purposes.

The British Standard BS4275 gives guidance on the selection, use and maintenance of respiratory protective equipment.

3.5 Eye protection

The eye, given a fair chance, will last for a lifetime, but it can be damaged by excessive heat and light, by electromagnetic and ionising radiations, by aggressive chemical action, by mechanical abrasion and by physical impact. And there are very few working environments which contain none of these risks.

After a survey of potential eye hazards the most appropriate type of eye protection should be selected. Safety spectacles may be adequate for relatively low energy projectiles, e.g. metal swarf, but for dust, goggles would be more appropriate. For people involved in gas/arc welding or using lasers, special filtering lenses would be required.

In the best regulated workplace, and in spite of goggles, visors, screens and other protective gear, someone at sometime is going to get a splash or a piece of something in his eye. He will need

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to find a ready source of clean water, to wash it out again before going for medical treatment. This implies a sufficient quantity of safety showers, or eye-fountains, or eye wash-bottles, strategically placed near the likely source of danger.

The equipment provided will depend upon the type of risk inherent in the process. Where acids, strong alkalis or other corrosive liquids are used in any quantity, a safety shower is essential, supplemented by several eye-wash bottles. These must be placed where they can easily be seen and reached by a person in trouble.

3.6 Skin protection

Protective clothing will provide a reasonable barrier against skin irritants. A wide range of gloves, sleeves, impervious aprons, overalls, etc. is currently available. The factors of the work should be considered when selection of this clothing is being made. For example, when selecting gloves for handling solvents, knowledge of glove material is required :

Neoprene gloves - adequate protection against common oils, aliphatic hydrocarbons; not recommended for aromatic hydrocarbons, ketones, chlorinated hydrocarbons.

Polyvinyl alcohol gloves - protect against aromatic and chlorinated hydrocarbons.

For protective clothing to achieve its objective it needs to be regularly cleaned or laundered and replaced when damaged.

Where protective clothing is impracticable, due to the proximity of machinery or unacceptable restriction of the ability to manipulate, a barrier cream may be the preferred alternative. Skin protection creams should be applied before starting work and at suitable intervals during the day.

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