CHAPTER 19

SAFETY PRACTICES

19.1 INTRODUCTION

As in any utility or industry, dangers are associated with Water Supply System Operation and Maintenance. There is therefore a need for safety practices. Physical injuries, cuts, bruises, and infection are common. However serious injuries necessitating long layoff, loss of limbs, eyesight, death due to accident or electrocution may also occur though not so frequently.

Adoption of safe practices and use of safety equipment may largely minimise occupational hazards.

Accidents do not happen – **they are caused.**

19.2 ACCIDENT INJURIES AND DEATHS IN WATER SUPPLY SYSTEMS

Figures of accidents/injury in various water works organisations or in utility concerns may be collected and included to show the extent of accidents. This can be in the following form or any other forms as available:

Utility *Rates of accidents*

OR

No. of employees *Accident frequency rates*

$$\text{Injury Frequency Rate F.R.} = \frac{\text{Number of injuries x 1,000,000}}{\text{Man-hours worked}}$$

$$\text{Severity rate S.R.} = \frac{\text{Number of days lost x 1,000,000}}{\text{Man-hours worked}}$$

19.3 IDENTIFICATION OF ACCIDENTS

19.3.1 SOURCE

In developing a safety programme it is necessary to know the source of accidents. It is then possible to take precautions and corrective action. Besides knowledge of accidents in the utility itself, review of records or information at other water supply systems or in other utilities is helpful. Record of injuries/accidents maintained by the concerned department of labour, industries or factory department of the state can also be consulted. Other sources of information are safety manuals, insurance company brochures etc.

The main dangers at a water works system include, but are not limited to, the following:

(a) Physical injuries arising from handling objects, falling objects, lifting objects, falls, tools and equipment,

(b) Stepping on or striking objects,
(c) Machinery,
(d) Infections,
(e) Toxic gases,
(f) Chemicals,
(g) Fire,
(h) Electrical shock,
(i) Too much noise,
(j) Collapse of trenches during repair of water mains.

19.3.2 LOCATION

The above dangers may exist at several locations in a water works system. These include, inter alia:

Intakes, Pumping stations, Transmission mains, Distribution system, Water Treatment plants, Storage places which include chemical hazards, large open filters, handling of materials, cleaning of internal sewerage system, septic tanks etc., mechanical & electrical hazards.

The person responsible for the safety programme should constantly on the alert for hazards, which may cause an injury to a workman.

19.3.3 TYPES OF INJURIES

To draw up a safety programme, it is important to know the type of injury that is most prevalent in water supply systems. The general injuries occurring in water supply systems are:

> Bruises, cuts, sprains, fractures, burns, eye irritation and injuries, shocks, irritation by gases and other occupational diseases, deaths, permanent disabilities, temporary total disabilities

Statistical data of major type of accidents, which occur in Water Supply System in the country, have not been well documented. Some data which may serve as a rough guide to understand the overall injury pattern at one of the water utility in the country is given in Table 19.1

TABLE 19.1

STATISTICAL DATA OF MAJOR TYPE OF ACCIDENTS

Cause of Accident	Percentage
Over exertion	20
Chemicals/gases	15
Fall on same level	11
Struck by falling object	10
Struck by moving object	9
Electrical shock injuries	8
Failure to wear safe attire	6
Caught in/on in between moving objects	5
Burns	4
Horseplaying, mischief making	4
Insect/animal bite	3
Others	5

19.3.4 COST COMPONENTS

Cost components of Accident

The cost component of accidents include the following:

- Compensation paid to workers and/or affected persons.
- Medical expenses incurred on the injured/accident persons.
- Cost of repairing or replacement of equipment.
- Loss of production and consequential payment of overtime/damages.
- Legal expenses.
- Industrial relations.
- Loss of good will and reputation.
- Resiting of injured person on resumption and/or additional cost of hiring a new person including training cost.

19.4 SAFETY PROGRAMME

19.4.1 INTRODUCTION

Safety practices require good management. For years, there may be minor injuries like cuts and bruises, but suddenly there could be a loss of limb, eyesight or even death.

Safety organisation is what you make of it. It may be a full-fledged safety organization with a Safety Officer with necessary staff. It could be only the person in charge of the plant with a few personnel picked out for special assignments. Everybody on the job knows what can happen under certain conditions but each is busy with his own duties and responsibilities. However, a safety officer works at safety full time. A Safety Committee may also be constituted. Whether you need a full time safetyman or not depends on the size of the Undertaking/organisation. *However, we need full-time attention to Safety.*

19.4.2 SAFETY PRACTICE PROGRAMME

19.4.2.1 Preliminary step

A safety programme is a must for a water supply system. It must have the full cooperation of the management; otherwise it will not be successful. A safety officer who can devote part-time or full time to the job in a large organisation may be designated as responsible for the programme. In a smaller organisation, that person may be the officer in charge of the plant.

19.4.2.2 Records

Keeping injury records is necessary for a safety programme. It is also mandatory in some of the Acts or Rules and Regulations framed by the Government. With records, the programme is given direction and will succeed.

For maintenance of records, standard forms are available. The formats could include items such as:

(a) Accident report

(b) Description of the accident

(c) Doctor's report

(d) Action taken

(e) Accident analysis

Frequency rate and severity rate may be worked out as in para 19.2

A summary of types and causes of accidents should be prepared periodically; A suggestive format is given in Table 19.2

TABLE 19.2

SUMMARY OF TYPES AND CAUSES OF ACCIDENTS

Type of injury	Primary cause of injury										
	Unsafe Act	Chem-ical	Falls	Hand-ling Objects	Heat	Mach-inery	Falling Objects	Elect-rical	Strik-ing	Misc.	Total
Fractures											
Sprains											
Eye Injuries											
Cuts											
Bruises											
Burns											
Miscellaneous											

There must be a review of all reports by the foreman/supervisor, safety officer and management. There must be recommendations to avert such accidents. A follow-up is necessary to see that proper action has been taken.

19.4.2.3. Searching out hazards

Hazards can be removed and will give increase in safety and will cost little time and money to correct. Some methods are:

- To examine records for conditions and situations that has caused accidents. Recall circumstances that led to the accidents. See if you can put your finger on some of the sore spots in your building, equipment or bad practices that are occurring.
- See what parts of the body are injured in the accidents. Protective gear may be required.
- Look around and inspect in an organised manner. Take help of your supervisors. Dig around for potential causes of personal injury and fire and health hazards.
- Be on the watch for unsafe practices and doing the job the wrong way. Always be on the watch.
- Reduce risks in the workplace, equipment and materials. With the supervisory staff you can cut down the amount of personal handling of tools and materials. It may be cheaper to buy power equipment.
- See that the work is done in the right and safe way.

19.4.2.4 Motivation and training

- For a good safety record, all individuals must be educated in safety measures. They must have conviction that accidents can be prevented. A safety programme must start on the new operator who has been freshly recruited or transferred from another work site. He must be exposed to the importance of safety, proper reporting and policies. Copies of Safety Practices should be supplied to him. Deeper training can be given to him subsequently after a few months. In the case of an individual who has been transferred, only the specific safety requirements in the new job are to be explained to him.
- Training will include how to perform the job. The plant supervisor must train the individuals in all aspects of plant safety. This will include dangers of electrical hazards, fire hazards, handling of tools and proper maintenance of tools to prevent accidents. Special instructions for specific work in confined environment such as pits, manholes, gas etc. must be given.
- The training must be continuous and not a one-time affair. During refresher education, case studies can be discussed. Victims of injuries can give their experience on how the accident happened. Safety posters placed at strategic points around the plant are a constant reminder and contribute to the continuing education.
- Proper guidance and use of tools, equipment must be given. Supervisors must continually check on proper use of tools. They must also see that the methods adopted are right and also safe.
- Motivate people to work safely when they are not being watched. Positive approaches like recognition of safety record, competitive interests etc. can be tried. Importance of good personal relations, a high morale and a sensitive management to the needs and interests of people plays a vital role in the programme of Safety Practices.

19.5 OPERATOR PROTECTION

19.5.1 PERSONAL SAFETY EQUIPMENT

The first step in controlling an unsafe condition is to remove the hazard mechanically. A secondary measure of protection is to provide personal protective equipment to the workman. Study of records has indicated the large number of injuries to various parts of the body. Personal safety equipment is designed to help protect the person's eyes, face, head, nose throat, lungs, ears, hands, feet and body. Such safety equipment cannot protect the worker from unsafe actions or conditions. It can only supplement safe work or work habits.

19.5.1.1 Head protection

- All personnel working in any areas where there may be danger from falling, flying tools or other objects must wear approved hard hats. Such hats should be according to the relevant BIS. Special insulated hard hats must be worn when working around high voltage to protect from electrical shock.
- It is advisable to have detachable cradle and sweat bands for two reasons (1) to permit easy replacement of cradles and sweat bands and (2) to make possible assignment of

one helmet to several workers each with his own cradle and sweat band for sanitary reasons.

- Once broken, the crown of a hard hat cannot be effectively repaired. It must be replaced.

19.5.1.2 Face and Eye Protection

- Impact Goggles must be worn to protect against flying objects. They can be spectacle or cup goggles.

  Spectacle goggles must have rigid frame to hold lenses in proper position before the eyes. Frames must be corrosion resistance and simple in design for cleaning and disinfection.

  Cup goggles should have cups large enough to protect the eye socket and to distribute impact over a wide area of facial bones.
- Chemical Goggles and Acid Hoods for protection against splashes of corrosive chemicals. A hood treated with chemical-resistance material having a glass or plastic window gives good protection. There should be a secure joint between the window and the hood material.
- Face Shields can be used against light impact. Plastic shields should be non-inflammable, free from scratches or other flaws, which introduce distortions.
- Welding Masks must be used from splashes and radiation produced by welding.
- Protective Creams are used to protect the skin from contamination and penetration by oils, greases, paints, dust etc.

19.5.1.3 Hands and Lower Arms

- Protective sleeves, gloves and finger pads are used for different types of hazards and jobs.
- Rubber and asbestos gloves should be long enough to come well above the wrist, leaving no gap between the glove and coat or shirtsleeve.
- Gloves or mittens having metal parts for reinforcements should never be used around electrical equipment.
- Linemen and electricians working on energized or high voltage electrical equipment require specially made and tested rubber gloves.

19.5.1.4 Body protection

Overalls are sufficient for most jobs. Always use rubber aprons when working with chemicals. When working on ladders or scaffolding use extreme caution to prevent falls.

19.5.1.5 Legs and Feet

- Leggings are provided where leg protection is necessary and are in the same category as coats, frocks and aprons, kneepads made of cloth, padding, rubber, cork are used on jobs where kneeling is required.

- Ordinary work shoes are acceptable for many jobs. They should have nonskid soles to prevent slips. Safety shoes are required where there is danger of dropping tools or materials on the feet. Toe guards have been designed for the men to wear when operating machines as air hammers, concrete breakers etc. For working on electrical equipment suitable safety shoes must be used.

19.5.1.6 Respiratory Equipment

In all dusty areas, effective filter masks shall be used to guard against the specific hazard.

Hose Mask should be used by men entering tanks or pits where there may be dangerous concentrations of dust, vapor, gases or insufficient oxygen. Hose mask with blower and the airline respirator are used where the hazard is immediate i.e., hasty escape would be impossible or could not be made without serious injury if there is failure of the equipment.

Oxygen or Air Breathing Apparatus i.e. self-contained oxygen breathing equipment using cylinders or bottles of compressed oxygen or air is used where required. This is a must when the length of the hosepipe on on-line supply of oxygen exceeds more than 45 m.

Gas Masks - Canisters consist of a face piece connected by a tube to a canister. Chemicals in the canister purify contaminated air. No one chemical has been found to remove all gaseous contaminants. It does not supply oxygen and can be used where there is sufficient oxygen.

19.5.1.7 Ear Protection

Where noise levels are high and exceeds specified limits, effective ear-pads or earplugs must be used

19.5.1.8 Training

Supplying the appropriate equipment to the worker does not solve the problem. The employee must know when, how and where to use the equipment provided as well as its limitations. This requires that the men must be trained.

19.5.2 PERSONAL HYGIENE PRACTICES

Every employee must practice personal cleanliness to prevent body infections. A clean plant is safer, both from physical accidents and infection. Hands must be washed with soap after working and before eating or smoking.

Use the first-aid kit for immediate treatment of minor cuts, bruises and scratches.

19.5.3 PROPER USE OF TOOLS

Some of the basic tool rules are:

(a) Always select the right tool for the job. Screwdrivers are not prying bars. Pliers are not wrenches.

(b) Repair or replace broken or worn tools regularly.

(c) Never use tools on or near moving machinery.

(d) Be sure you have enough room, if the tool should slip.

(e) Be sure you have good footing to prevent slipping.

(f) Wear well fitted gloves except when hammering.

(g) Never wear rings or loose clothing around moving machinery.

(h) Always wear goggles whenever using any impact tools, power grinder or sharpener.

(i) After using each tool, wipe, clean and replace in carrier or work belt. A greasy wrench can be dangerous.

(j) Do not lay tools on top of ladders or where they may fall on someone working below.

(k) Always use non-sparking tools on any job where explosive gases could be present.

19.6 SAFETY IN PLANT MAINTENANCE

19.6.1 MAINTENANCE HAZARDS

Plant maintenance also called housekeeping or cleaning up is an important function of the treatment plant and essential for plant equipment. Maintenance requires an operator to handle machinery, manual and power tools, repair electrical equipment, enter pits, sumps, manholes etc. All these functions can pose a hazard and cause injury, fire, disease or death.

Fixed safety features are designed or built into the structures. However there are instances where the maintenance engineer may alter or augment the existing structure. Prompt effective maintenance can prevent many accidents.

19.6.2 CLEANING

Keeping the entire plant clean will provide a much nicer place to work. Just keeping the working areas free of tripping hazards will add safety in the plant. Cleaning should be performed when others are not exposed to danger or inconvenience. Wet floors become slippery. Use notices to warn people.

Provide and use trashcans for used oily rags. Hazardous waste, acids and caustics should be cleaned up immediately.

Doorways, aisles, stairways and work places must be kept free of rubbish to reduce hazards of tripping and fire.

19.6.3 PAINTING

Regular painting is done at most plants. The following considerations must be kept in mind:

- When working with toxic paints i.e. containing lead, zinc or organics, be sure to clean your hands before eating or handling food.
- Avoid exposing your skin to solvent and thinners and try not to use compounds such as carbon tetrachloride.
- When spray painting, use a respirator to avoid inhaling fumes.
- No smoking or open flames of any kind should be allowed around the area being painted.
- When painting or cleaning the spraying equipment avoid closed containers where heat is involved. At a certain temperature called the flash point, spray or vapours could ignite and burn the operator or start fires. Always clean the spray equipment in an area with sufficient ventilation.

- Be very careful when using scaffolding or ladders. They must be strong and in good repair.
- Rags containing paint or oil should be placed in a closed container to avoid fires.

19.6.4 ACCESS TO EQUIPMENT

Safe access to equipment will reduce dangers from falls. Ramps and step stairs provide the safest means. Slope of ramps and rise of steps should not be excessive. Step stairs should have hand railings and the tread at least 9 inches (25 cms).

Vertical ladders should be discouraged. However, they are commonly employed. A vertical ladder of 10ft (3m) or more in length should be equipped with a hoop cage to enable the operator to regain his hold in case of a slip. Rungs of vertical ladders should not be less than 30 cms (12 in) or more than 40 cms (15 in) vertically. Minimum width should be 25 cms (9 in): preferably 30 cms to 40 cms.

Adequate workspace around equipment is important.

19.6.5 GUARDS, RAILS, FENCING, ENCLOSURES, SHIELDS

These are designed to prevent, slipping, falling or contacting machinery when in operation. If they are missing they should be repaired or replaced. When removed for repairs, put a temporary safety line. Protective devices must be replaced promptly.

Settling tanks, basins, manholes, sumps and other underground structures must be provided with railings or fencing. Safety belts must be used where necessary.

19.6.6 LIGHTING

Adequate glare free lighting should be provided especially in the vicinity of steps and vulnerable places. Flood lighting should be provided at suitable places for safety and security of the complex.

19.6.7 VENTILATION

Ventilation is a major factor in water supply systems. This can be secured by:

(a) By open exterior windows or door louvres.
(b) By fresh air intakes and mechanical exhaust fans/ducts.
(c) By use of forced-draft fans.
(d) By use of portable air compressors or air blowers.

19.6.8 SAFETY FROM EQUIPMENT

When maintaining and operating equipment, the following precautions should be taken:

- Always stop the machine before removing any guard.
- Personally lock out all power before starting any equipment maintenance. Put a warning sign and tag on the lockout.
- Do not unlock any power, which has been closed by others.
- Block any counter balance or weighted machine to prevent dead movement.
- Have enough help and hoisting gear to handle heavy equipment safely.
- Block up under any heavy equipment when on jacks or hoists before starting work.

- Keep tools in a kit bag or belt (not on the floor).
- Keep goggles handy. Use them wherever needed.
- Don't be in a hurry. Haste makes accidents.
- An authorized person should handle overhead travelling cranes. Circuit breakers, limit switches, hook and wire should be checked. Only standard hand signals, known to all, should be used. When loads are to be moved give a warning and make sure everyone is in a safe position. Hard helmets must be used.
- When using portable power tools use safety protective devices when operating grinding, chipping, buffing or pavement breaking equipment. Extension cords provide a tripping hazard. When working in damp or wet conditions use rubber mats. Electric tools should be grounded. For pneumatic tools use safety clamps and connectors. Electrical cords and air hoses should be kept away from oils, chemicals or sharp objects.
- Portable electric lamps should not be more than 24 volts and should conform to I. E. regulations.
- In gas or electric welding, the operator must be trained. Fire protection and personal protection practices must be followed. Storage of gas cylinders must be done with the same care as those of other gases in a water supply system.
- All safety valves in the system must be regularly inspected according to the maintenance schedule.
- Where forklifts are used, do not permit anybody, except the operator, to ride on it. Make sure the warning signals are operating. Check brakes. Make sure the forklift load is stacked properly before lifting or moving.

19.6.9 LUBRICATION SAFETY

1. Avoid lubricating machinery when it is running. If you have to do so, ensure that the lubricating point is at 30 cms. away from the moving part or the lubricant should be piped outside a guard.
2. Wipe spilled oil or grease immediately.
3. Never point a grease gun at anyone. Never squirt grease into your hands.

19.6.10 SAFETY IN CONFINED SPACES

Any place where oxygen deficiency or dangerous air contamination can occur and where ready ingress or egress for removal of a person is not available can be defined as a confined space. Some of such places are pits, manholes, basins and tanks. Accumulation of gases and vapours in confined spaces can produce explosive mixtures.

Oxygen deficiency occurs when oxygen is removed or when another gas displaces it. Oxygen is removed from air when it is used up due to bacterial action; by the oxidation of metals; combustion and when inert or toxic gases displace it.

When oxygen in air is reduced to less than 17%, shortness of breath takes place and further reduction leads to loss of consciousness. Death occurs at 10% or less. Toxic gases cause injury or death by their own action.

Safety checks must be carried out when working in such spaces. More information is available in the Manual of Sewerage and Sewage Treatment issued by the Ministry of Urban

Development, Government of India in Chapter 8 (8.9-Hazards; 8.10-Precautions; and 8.11-Safety Equipment).

When working in confined spaces ensure that sufficient air changes as required takes place.

19.7 HAZARDS IN CHEMICAL HANDLING — GASES

Gases commonly used in water treatment in this country are listed in Table 19.3

They are supplied in cylinders or drums. Some chemicals are generated at the plant itself. Exposure to the liquid form of the gases causes damage to human tissues such as skin burn. Most gases are heavier than air and displace air-containing oxygen. It is therefore important to have proper ventilation and use the right type of respirator.

TABLE 19.3

GASES USED IN WATER TREATMENT PLANTS

Name and Formula	Common Name	Available Forms	Specific Gravity	Flamma-bility	Colour	Odour	Containers
Chlorine, Cl_2	Liquid Chlorine	Liquid-Gas	1.468@ 0°C	None	Greenish Yellow	Irritating	Cylinder One-ton
Carbon Dioxide, CO_2,	Dry Ice	Liquid-Gas	0.914	None	Colourless	Odourless	Bulk Liquid under pressure

19.7.1 CHLORINE

Chlorine is considered as a hazard in the water industry. Chlorine gas is poisonous to humans. It is very corrosive when in contact with water. Extreme care must be taken when working with chlorine to prevent accidental injury to operators. Small amount can cause severe coughing and irritation of the nose, throat and lungs.

Precautions to be taken when handling Chlorine are given in Chapter 8 Disinfection

19.7.2 CARBON DIOXIDE

Carbon Dioxide has limited use in water treatment plants but it is dangerous and causes suffocation due to lack of oxygen. Therefore, when using carbon dioxide keep in mind the safety requirements. Since the gas is a heavy vapour, it does not tend to diffuse away rapidly. Persons must be on guard when entering pits, manholes, wells etc.

First aid involves moving the victim to fresh air, giving resuscitation and getting medical attention.

19.8 HAZARDS IN CHEMICAL HANDLING — ACIDS

The antidote to all acids is neutralisation. Most often large amount of water will serve the purpose. If acid is swallowed, then lime water or milk of magnesia may be needed. If vapours are inhaled, first aid usually consists of providing fresh air, artificially restoring breathing or supplying oxygen. Baking soda is used to neutralise acid falling on the skin.

Many acids are used in water treatment. However in this country, Sulphuric acid is extensively used. The properties of Sulphuric acid are shown in Table 19.4:

TABLE 19.4

Name, and Formula	Common Name	Available Forms	Specific Gravity	Flam-mability	Color	Odor
Sulphuric Acid, H_2SO_4	Oil of Vitriol; Vitriol	Solution	1.841	N/A	Clear	Odonrless

19.8.1 SULPHURIC ACID

1. Sulphuric acid is the most dangerous chemical handled at the plant. The main hazard is from contact. Fumes are dangerous but normally at room temperatures, there are not many fumes.
2. Always use protective clothes and equipment. Contact with the acid on body tissue results in severe burns immediately. Immediate flooding with water is essential.
3. Clean the acid spill immediately. Do not leave the area until it is well marked or guarded. Neutralise the acid with soda ash and then flush it down the drain.

First aid is speed in removing sulphuric acid from the body. Continue irrigation with running water and alternating applications of mild alkaline solutions (bicarbonate of soda). Irrigate eyes with large amounts of water. If swallowed, do not induce vomiting but encourage patient to wash out his mouth with large amount of water and then drink as much water as possible. Get medical help immediately.

19.9 HAZARDS IN CHEMICAL HANDLING – BASES

The bases used in water treatment are known as hydroxides. They are used to raise pH. Compounds of sodium, calcium and ammonia are strong bases. Silicate, carbonate and hypochlorite are weak bases. Table 19.5 lists some of the basic compounds used in water treatment in this country.

TABLE 19.5

BASES USED IN WATER TREATMENT

Name and Formula	Common Name	Available Forms	Spec.Grav. or lbs/cu ft	Flamma-bility	Color	Odor	Contai-ners
Calcium Hydroxide and Calcium Oxide $Ca(OH)_2$ or CaO	Hydrated Lime or Quick-lime	Dry Powder, Lump	50-70	N/A	White	Dust	Bags, Bulk, Trucks
Sodium Hydroxide, NaOH	Caustic, Lye	Lump, Liquid, Flake	1.524	May Cause Flammable Conditions	Opaque White	Toxic, Pungent	Drums, Bulk, Trucks
Sodium Silicate, Na_2SiO_2	Water Glass	Liquid	1.35-1.42	N/A	Opaque	N/A	Drums, Bulk Trucks

19.9.1 CALCIUM HYDROXIDE (HYDRATED LIME)

1. Lime has a great affinity for water and a great deal of heat is evolved when the two come in contact. Storage in damp places may cause a fire in nearby flammable materials. Calcium hydroxide (hydrated lime) is less troublesome than calcium oxide (quicklime).
2. They should be stored in a cool, dry place. In damp places fire may be caused in nearby flammable material. Also do not mix dry quicklime with other chemicals that contain water of crystallisation like alum or ammonium sulphate
3. Persons exposed to lime dust must be protected with personal protective equipment. Prolonged exposure to lime dust causes dermatitis especially at points of perspiration. Face shields, chemical goggles must be used when inspecting lime slakers.
4. First aid for lime burns is about the same for any caustic burn - Thorough flooding with water.

19.9.2 SODIUM HYDROXIDE (CAUSTIC SODA)

1. Dry caustic soda should be stored in a dry place where it will not be exposed to moisture, liquid caustic in steel covered tanks.
2. Workers are exposed to splash and mist. They must wear protective equipment like safety goggles, face shields, rubber gloves aprons, boots and cotton overalls.
3. First aid is the same as for any caustic burn. Irrigate well with water.

19.9.3 SODIUM SILICATE

1. Sodium silicate is a liquid. Although non-toxic, non-inflammable and non-explosive it presents the same hazards to the skin and eyes as other base compounds.
2. Avoid prolonged contact with the skin. Wash with plenty of warm water. Use face shield and rubber gloves when working with the solution. Use goggles.

19.10 HAZARDS IN CHEMICAL HANDLING – SALTS

The various salts (chemicals) used in water treatment in this country are given in Table 19.6.

19.10.1 ALUMINIUM SULPHATE (ALUM) AND FERROUS SULPHATE

1. These materials should be stored in a clean dry place, for moisture has a tendency to cake the material.
2. Handlers should wear protective clothing and protective cream on exposed skin surfaces because these chemicals can cause irritation to the skin and mucous membranes and serious injury to the eyes. Use the same precautions for liquid solutions, with added protection for the eyes.
3. Do not use compressed air to clean dry feed machines and equipment. Keep covers on feeding equipment.
4. Remember that mixtures of dry alum and quicklime can explode. Ferrous sulphate dust is more corrosive to equipment, and, when moist, is a good conductor of electricity.

TABLE 19.6

SALTS USED IN WATER TREATMENT

Name, Formula	Common Name	Available Forms	Density, lbs/cu ft	Flammability	Color	Odor	Containers
Aluminum Sulphate, $Al_2(SO_4)_3$ $14H_2O$	Alum, Filter Alum	Liquids, Powder, Lump	1.69 38-67	None	Ivory	N/A	Bags, Tank Truck, Bulk
Ferric Chloride, $FeCl_3$	Ferrichlor, Chloride of Iron	Syrup, Liquid, Lump	60-90	None	Dark Brown, Yellow	N/A	Carboys, Tank Cars
Ferric Sulphate, $Fe_2(SO_4)_3$	Ferrifloc, Ferrisul	Powder, Granule	70-72	None	Red-Brown	N/A	Bags, Drums
Ferrous Sulphate, $FeSO_4 7H_2O$	Coppras, Green Vitriol	Crystal, Granule, Lump	63-66	None	Green	N/A	Bags, Drums, Bulk
Sodium Aluminate, $NaAlO_2$	Soda Alum	Dry Crystal, Liquid	(27º)	None	White, Green-Yellow	N/A	Bags, Bulk
Copper Sulphate, $CuSO_4$	Blue Vitriol, Blue Stone	Crystal, Lump, Powder	60-90	None	Blue	None	Bags, Drums
Sodium Chlorite, NaOCl	Technical Sodium Chlorite	Powder, Flake, Liquid	70 dry	Oxidizer	Light Orange	None	Tank Truck, 100 lb-Drums
Potassium Permanganate, $KMnO_4$	Permanganate	Crystal, Powder	90-100	Oxidizer	Purple	None	Drums, Bulk

Ferrous sulphate dryers can also corrode essential instruments or equipment in the vicinity of dusty conditions. Electrical equipment in the area should be of the dust-proof type and frequently cleaned

5. First aid for skin irritations and mild burns should be the same as for any acid burn. Scrub with plenty of warm water and soap, followed by a good shower as soon as possible. For any irritation of the mouth and nasal passages, irrigate freely with warm water. If the material is in the eyes, flush with large quantities of warm water, and consult a physician.

19.10.2 FERRIC CHLORIDE

1. This is a very corrosive compound and should be treated as you would treat any acid.
2. The salt is highly soluble in water, but in the presence of moist air or light, it decomposes to give off hydrochloric acid, which may cause other problems regarding safety. When handling liquid ferric chloride, normal precautions should be taken to prevent

splashing, particularly if the liquid is hot. Use a face shield to protect your eyes and rubber aprons to protect clothing.

3. First aid for eyes exposed to the liquid is that the eyes must be flushed out immediately for 15 minutes with large amounts of water. Ferric chloride should also be washed off the skin with water, as prolonged contact will cause irritation and staining of the skin.

19.10.3 FERRIC SULPHATE

1. Because of its acidic nature, operators using this compound should be provided with protection suitable for dry or liquid alum.
2. Use protective clothing and a respirator. Avoid prolonged exposure to the dry form because of its acidic reaction with moisture on the skin, eyes and throat.
3. First aid for exposure to the eyes requires the eyes to be flushed immediately with lots of water. The skin should also be flushed with large amounts of water. Prolonged contact may cause irritation.

19.10.4 SODIUM ALUMINATE

1. There are few hazards with this compound, but as with other chemicals, you should use precautions when handling it.
2. Use respiratory protection when handling the dry compound to prevent the inhalation of dust.

   First aid for eyes that are exposed is to flush with water; keep the skin clean with water.

19.11 SAFETY IN CHEMICAL HANDLING – POWDERS

19.11.1 ACTIVATED CARBON

1. One of the greatest dangers in carbon storage is the fire hazard. Storage bins for dry bulk carbon should be of fireproof construction, and equipped with carbon dioxide equipment or water spray for fire control.
2. Bag storage should be in a clean dry place, in single or double rows with access aisles around every stack for frequent fire inspections, and to facilitate removal of any burning carbon.
3. Smoking should be prohibited at all times in the carbon handling and storage areas. Keep carbon away from heated pipes, or any possible fire hazard such as electric motors or electric wiring.
4. Dust-proof motors and explosion-proof electrical equipment that can be kept dust-tight should be used. Damp carbon dust is a conductor of electricity and can short circuit electrical equipment.
5. Dust masks should be worn when handling carbon, and good dust collecting equipment should be used. When loading carbon bins or hoppers, the personnel should also wear dust-proof goggles, a cap, and loose clothing tied at the wrists and ankles.

(a) Controlling fires

Activated carbon burns like ordinary charcoal, without smoke or flame, and glows with intense heat. Such fires are sometimes difficult to detect, and when found, are hard to handle. A fire in a large storage bin or stack may burn for some time before being discovered. The smell of charred paper from the bags, or an area of scorched paint on the side of the hopper is indication that a fire is in progress.

Burning carbon should never be doused with a large stream of water, as the steam produced will scatter burning carbon in all directions. A fine spray or fog nozzle works much better. In working with a carbon fire in a confined area, remember there is danger from carbon monoxide, so air-supplied hoods or self-generating oxygen masks should be available.

Most activated carbon has sufficient oxygen adsorbed in the material so that it can burn in the absence of air. Carbon will start to burn if a temperature of 350 to 450 degrees Fahrenheit is reached, depending on the type of material and the fineness of grinding. The best way to combat the fire is to reduce the surrounding carbon below this ignition point, by soaking with water from spray nozzles

19.12 FIRE PROTECTION

Very little attention is paid to fires. Three elements cause a fire – fuel, oxygen and a means of ignition. If any one is missing, there is no fire. Fire fighting is based on removing one of these elements. In any fire, only the cause or fuel for burning varies.

19.12.1 CLASSIFICATION OF FIRES

TABLE 19.7

Class of Fire	Description	Extinguishing medium	IS No.
A	Fires involving ordinary combustible materials like wood, paper, textiles etc. where the (constant air pressure) cooling effect of water is essential for the extinction of fires.	Water Soda acid type, Water type (gas pressure), Water type	934 940 6234
B	Fire in flammable liquids like oils, solvents, petroleum products, varnishes, paints etc. where a blanketing effect is essential.	Foam Carbon dioxide Dry Powder	933 2878 2171 4308
C	Fires involving gaseous substances under pressure where it is necessary to dilute the burning gas at a very fast rate with an inert gas or powder.	Carbondioxide Dry powder	2878 2171 4308
D	Fires involving metals like blanketing aluminium, zinc, potassium etc. where the burning metals is reactive to water and which requires special extinguishing media or technique.	Dry powder Special dry powder for metal fire.	2171 4861
E	Fires involving electrical equipment where the electrical non-conductivity of the extinguishing media is of first equipment importance.	Carbon dioxide Dry Chemical powder when electrical is de-energised, same as for Classes A and B.	2878 2171 4308

Note: “E” type category has been recently removed.

19.12.2 FIRE EXTINGUISHERS

There is no one extinguisher that is effective for all fires, so it is important that you understand the class of fire you are trying to control. One must be trained in the use of the different types of extinguishers, and the proper type should be located near the area where that class of fire may occur. A preventive maintenance program for fire extinguishers requires a considerable amount of time from the operator and requires a system of record keeping.

Types of fire extinguishers

(a) Stored Pressure, Cartridge Operated, Water Pump Tank, and Soda-Acid

These are suitable for Class A fires. Proper maintenance is essential and a schedule should be drawn up.

1. The method of operation for a stored pressure extinguisher is simply to squeeze the handle or turn a valve. The maintenance is also simple: check air pressure and recharge the extinguisher as needed.
2. For the cartridge type, the maintenance consists of weighing the gas cartridge and adding water as required. To operate, turn upside down and bump.
3. To use the water pump tank type of extinguisher, simply operate the pump handle. For maintenance, one has only to discharge the contents and refill with water annually or as needed.
4. The soda-acid type must be turned upside down to operate; it also requires annual recharging.

(b) Foam Type

Foam type of extinguishers will control Class A and Class B fires well. They, like soda-acid, operate by turning upside down and require annual recharging.

The foam and water type extinguishers should not be used for fires involving electrical equipment. However, they can be used in controlling flammable liquids such as gasoline, oil, paints, grease and other Class B fires.

(c) Carbon Dioxide (CO_2)

Carbon Dioxide extinguishers are common. They are easy to operate, just pull the pin and squeeze the lever. For maintenance, they must be weighed at least semi-annually. Many of these extinguishers will discharge with age. They can be used on a Class C (electrical) fire. All electrical circuits should be switched off, if possible, before trying to control this type of fire. A carbon dioxide extinguisher is also satisfactory for Class B fires, such as gasoline, oil and paint, and may be used on surface fires of the Class A type.

d) Chemical Extinguishers

Chemical extinguishers are either (1) cartridge operated (2) stored pressure. These are recommended for Class B and C fires and may work on small surface Class A fires.

1. The cartridge-operated extinguishers only require you to rupture the cartridge, usually by squeezing the lever. The maintenance is a bit more difficult, requiring weighing of the gas cartridge and checking the condition of the dry chemical.

2. For the stored-pressure extinguishers, the operation is the same as the CO_2 extinguisher. Just pull the pin and squeeze the lever. The maintenance requires a check of the pressure gauges and condition of the dry chemical.

19.12.3 DANGER POINTS

The danger points are:

- Unattended storage rooms where combustibles are present
- Workshops with cleaning liquids, oil and soaked rags
- Laboratories with chemicals, heaters, burners
- Offices where much paper is present.

19.12.4 PREVENTION

1. Emphasis should be on good housekeeping. A clean environment raises morale and reduces tendency for slovenliness and carelessness.
2. Rubbish and waste not properly cared for is the biggest fire hazard.
3. Oil-soaked waste or rags should be stored in metal cans and covered.
4. Additions, alterations must be of non-combustible materials.
5. Combustibles must be kept away from heating equipment or where flames are present.
6. Proper check and maintenance of electrical equipment and wiring should be carried out.
7. Automatic fire-alarm systems should be installed in fire-prone areas.
8. Fire extinguishers and fire fighting equipment must be installed and maintained regularly.
9. Avoid careless use of matches, blow torches, Bunsen burners or smoking.

19.12.5 FIRE DUE TO CHEMICALS

1. Sodium Chlorite, being used for odour control in waterworks becomes explosive and a fire hazard in presence of organic matter. Even a spark or sunlight can set it off. When spilled on a wooden floor, fire is caused with the scuff of a shoe. Spillage on clothes has resulted in locker fires. Fires can be controlled by soda ash or sand— never water. It should be stored by itself far removed from organics, sulphur or acid.
2. Activated carbon is another fire hazard and has been discussed in 18.11- Safety in Chemical Handling – Powders.

19.13 SAFETY FROM ELECTRICAL HAZARDS

Refer to Chapter 11 para 11.8.2 – Safety practices in Electrical works

19.13.1 GENERAL RULES

1. Only trained and qualified persons should be allowed to operate and maintain electrical equipment.
2. When servicing any electrical appliance, kill, lockout and tag all power coming to it.

3. Be sure of proper footing so that you don't fall onto a live wire. Always make sure that the wire is not live. Use a pencil type tester.
4. Hand tools must have insulated handles. Insulated mats must be provided before electrical controls.
5. Ensure that all electrical systems, equipment etc. are properly grounded.
6. Remove metallic rings, watches, eye glasses. Don't use metallic tape measures or metal ladders.
7. Always mount and protect wires and cables to prevent tripping by persons.
8. Electrical controls should be in good working order, easy to reach and plainly identified.
9. Be sure there is someone to help in case of emergency. Don't become careless or overconfident.

19.13.2 ELECTRICAL FIRST AID

1. Immediately free the victim from the live conductor by use of a dry wooden stick, (such as a broom or shovel handle), piece of rubber hose or plastic pipe, or other nonconductor. Never grab the victim or the wire with bare hands, or you will suffer the same consequences.
2. If unconscious or not breathing, artificial respiration should be started immediately and continued until relieved by doctors or professional. Please refer to 9.8.3.1 in Chapter 9.
3. Protect from shock by keeping the victim warm and quiet.

19.14 SAFETY IN THE LABORATORY

Safety in handling and storage of chemicals has already been discussed in the preceding sections — Hazards in Chemical Handling 19.9 to 19.11 Operators do not experience a great deal of exposure to hazardous laboratory conditions. However proper practices must be followed to avoid accidents.

19.14.1 SAMPLING SAFETY

1. Never take field samples with bare hands. Always wear gloves.
2. Do not climb over or go inside guardrails. Use poles, ropes, dippers, or other long distance samplers.
3. When collecting gas samples, do not open tank cover completely. Install a sampling port, if needed.
4. Wear an effective gas mask when taking gas samples.

19.14.2 HOUSEKEEPING

- General cleanliness and correct storage of chemicals and equipment are important for accuracy as well as safety in the laboratory. Basic rules include:

1. Follow a daily general clean up schedule in the laboratory. Dirty glassware or clothing can encourage infection. Put all chipped, cracked or broken glassware into containers marked 'Broken Glass only'.
2. Have a special spot for storing each piece of equipment. After each use, clean, disinfect, and return to its rack.
3. Never work in a poorly ventilated room. Keep the laboratory well lighted. Do not crowd the laboratory. Have plenty of room.
4. Always clean up and discard any spills at once.
5. All workbenches or tables should have chemical resistant tops, or be painted with chemical resistant paint frequently.
6. Do not store any other equipment in the laboratory.

19.14.3 SAFETY WITH CHEMICALS

1. Keep working amounts of chemicals stored out in the lab to a minimum.
2. All bulk chemicals should be stored in original containers, in a separate fire proof store room. Larger bulk containers should always be on the floor.
3. Have individual bulk siphons to transfer chemicals from bulk storage to working stock bottles.
4. All chemicals storage jars should stand on wide shelves with retaining rails to prevent their accidentally being pulled or jarred off.
5. Strong and/or highly corrosive acid and base storage jars should stand in lead, plastic, or ceramic individual trays deep enough to contain the contents if the jar should break.
6. All chemical storage should be as low as possible and never more than shoulder height.
7. Clearly label all chemicals with common and chemical names, formula, strength, and date prepared or received. Replace these labels as needed to keep them legible.
8. Add red "Skull and Cross bones" labels to all containers of toxic chemicals.
9. Workers familiar with their properties must carefully dispose of used chemicals. They must not be flushed down the drain without due consideration of their effect on the sewer system.
10. Keep highly reactive chemicals stored far apart.
11. Perform all work that involves volatile acids, bases or solvents in a hood. Be very cautious with nitric acid. Do not add it to substances that are easily oxidised or nitrated. This can cause a fire or explosion. Other examples are: nitric acid with acetone; with benzene and toulene; with acetic acid.

19.14.4 SAFETY WITH EQUIPMENT

1. Only trained experienced technicians should operate laboratory equipment, especially pressure units.
2. Exact, clear operating procedures, for autoclaves, water stills, and any other special pressure equipment will be permanently posted near same.

3. Valves and switches on such equipment shall be clearly numbered in their order of use. All electrical equipment must be well grounded. Inspect all electrical cords for wear or cracks in insulation, and replace as necessary.
4. Manufacturer's operations, warranty, service, and safety instructions shall be kept in a permanent file.
5. All equipment shall be set up away from gas and electric service switches or valves.

19.14.5 SAFETY WITH GLASS

1. Wear gloves any time you are working with glass.
2. Hold rod or tube in contact with stopper and twist to insert.
3. Wear full or wrap-around goggles or a face shield when working glass.
4. Always support glass units with several padded clamps firmly anchored.
5. Properly shatter and discard all chipped or cracked glassware.

19.14.6 SAFETY IN LABORATORY PROCEDURES

1. Never pipette by mouth. Always use a bulb.
2. Know your procedure and follow a check list.
3. Always wear safety glasses or goggles in the laboratory.
4. Never wear contact lenses in the lab.
5. Have a viewing window so visitors won't enter the laboratory.
6. Always wear a rubber apron when working with chemicals or running any reaction.

19.14.7 FIRST AID AND FIRE PREVENTION IN THE LABORATORY

1. Have an adequate supply of a good eyewash at all times.
2. Keep several fire blankets in an easily accessible location.
3. Special fire extinguishers, clearly labelled and checked for monthly charge, for chemical and electrical use should be openly mounted.
4. Emergency numbers for fire and medical help should be clearly and permanently posted above every phone.
5. All employees, and especially laboratory technicians, should have extensive, regularly refreshed, first aid training.

19.15 SAFETY PRACTICES DURING REPAIR AND OPERATION OF WATER MAINS

19.15.1 PLANNING

A safety practice during construction and maintenance of the water distribution system has two major aspects — preparation and planning and operation. Usually previous methods are followed and these are revised on past experience. However, if we want to complete routine or special jobs successfully, we must plan them. This will eliminate possible hazards.

Proper maps of the system must be maintained and studied. A study of the character of the area in which the work is to be carried out is an accident prevention item.

19.15.2 TRAFFIC CONTROL

1. Warning signs must be placed well ahead of the work area. Signs, barricades and used tyres can be used.
2. Vehicles can be parked between work area and the coming traffic.
3. Use red warning lights or flashers during the night.
4. Use a flag man for one way operation.
5. Traffic police must be informed and their help taken.

19.15.3 SAFETY PRACTICES IN REPAIR AND LAYING OF PIPES

1. Excavations should be closely watched. Type of soil must be studied and necessary precautions taken to provide adequate side slopes or to shore up the trench. The proximity of poles and buildings must be taken into consideration.
2. All soil must be stacked at least three feet from the edge of the trench.
3. Repair of broken mains is a hand job. The ground is usually saturated or washed out. Care must be taken to protect other utilities especially electric cables which can be dangerous. Welding must be done in dry conditions.
4. The workmen must use safety hats and other protective equipment.
5. Only one trained and experienced man should give signals to a crane operator.
6. The inspection of the equipment to be used should be done before it is sent to the site. In case of a burst main, the advance crew should carry plans showing the location of valves to be closed, barricading equipment, signage, valve and chamber keys etc. Portable pumps to drain out the water should also be sent.
7. The pipe for replacement must be blocked to prevent it from rolling. Proper equipment should be used when lowering it into the trench. Sufficient men should also be engaged.
8. When the job is completed, cleaning up must be done to prevent hazards to others.

19.16 SAFETY IN VEHICLE OPERATION

1. Make sure that the vehicle is in proper order including brakes etc.
2. Only licensed drivers should be engaged on the operation of vehicles. One or two drivers should preferably handle each vehicle only.
3. Simple forms should be used to report any unsafe condition by the driver.

19.17 FIRST AID

1. The ideal goal is to have every person trained in First Aid and Cardiac Pulmonary Resuscitation (C.P.R.). A more realistic approach is to two persons in each crew and shift. This training can be imparted through the Red Cross, Fire departments or other organisations.

2. These crew medics can be made responsible for keeping all first-aid kits well stocked. They could serve as instructors for the rest of the fellow workers.
3. First-aid kits must be prominently displayed at various points at the plant and in the vehicles. Special attention must be given to the most hazardous areas like laboratories, workshops, chemical handling facilities etc.

19.18 CONCLUSION

We must remember that everyone is responsible for safety. A Safety Programme is a must for the management. Many accidents occur due to the human factor. Ultimate responsibility may be that of management but the operator cannot also be relieved of his responsibility. The operators decision-making abilities and general behaviour (response time, sense of alarm etc.) are important. Be on the lookout for factors that disrupt the flow of action between the operator's natural senses and actions and the tools and machines.

The operator has a greater understanding of the operator-machine interface. The operator is the appropriate person to indicate the human factor involvement to the cause of accidents.

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