DESIGN & SAFETY REQUIREMENTS OF FIRE HYDRANT IN CHEMICAL PLANT

M.Mugesh[#1], M.Vinothkumar[#2] , S.Kamalakannan[#3] ,K.Visagavel[#4]

#1 PG Scholar, Department of Mechanical Engineering, Knowledge Institute of Technology, Tamilnadu, India.
#2 , #3 Assistant Professor, Department of Mechanical Engineering, Knowledge Institute of Technology, Tamilnadu, India.
#4 Vice Principal, Knowledge Institute of Technology, Tamilnadu, India.

#1mgshmugesh@gmail.com, #2mvkmech@kiot.ac.in, #3skise@kiot.ac.in,

ABSTRACT

In the complexities of relationship between humans and fire and the status of human efforts of control the disastrous effects of fire. A subsequent section examines characteristics and behavior of fire, with a special note on smoke movement in building the text covers these topics regarding fire hazard : Fire hazard of specific materials such as wood , fibers and explosives. Industrial and process fire hazard (e.g solvent extraction) special fire protection and prevention issues regarding indoor and outdoor storage practices, material handling equipment, electrostatics ignition sources ,etc. Fire safety in building design and construction , with attention to high rise structures. Fire hazards in building services (e.g air conditioning and electrical appliance system and the hazards of various types of occupied structure including residential business industrial and educational. The role and responsibilities of public fire departments and water supplies and facilities for fire protection are examined. Several sections offer detailed discussions of fire protection devices and systems including fire alarms, detection devices guard services, Extinguishing agents, water sprinklers, special systems and portable fire extinguishers.

***Keywords*— Design of Fire Hydrant in Chemical Plant as per the Standard & General Safety requirements…**

1. INTRODUCTION

Firefighting is the act of extinguishing fires. A firefighter fights fires to prevent loss of life, and/or destruction of property and the environment. Firefighting is a highly technical skill that requires professionals who have spent years training in both general firefighting techniques and specialized areas of expertise.

The primary goal of this manual is to provide an environment for occupants that

is reasonably safe from fire and products of combustion.

The secondary goals of this manual are to provide a reasonable level of building usability and property protection from the effects of fire and products of combustion.

Fire fighting is the act of extinguishing fires. A fire-fighter fights fires to prevent loss of life, and/or destruction of property and the environment. Fire fighting is a highly technical Skill that requires professionals who have spent years training in both general fire fighting techniques and specialized areas of expertise.

Water is the most commonly used agent for controlling and fighting a fire, by cooling adjacent equipment and for controlling and/or extinguishing the fire. either by itself or combined as a foam. It can also provide protection for firefighters and other personnel in the event of fire. Water shall therefore be readily available at all the appropriate locations, at the proper pressure and in the required quantity.

HAZARDS CAUSED BY FIRE

One of the major hazards associated with firefighting operations is the toxic environment created by combusting materials. The four major hazards associated with these situations are as follows: Smoke, which is becoming increasingly dangerous due to the rise in synthetic household materials. Oxygen deficient atmosphere, 21% O2 is normal, 19.5% O2 is considered oxygen deficient.

Fire Chemistry and Physical properties of wildfires

Fire elements, There are four elements needed to start and sustain a fire and/or flame.

These elements are classified in the “fire tetrahedron” and are:

- Reducing agent (fuel)
- Heat
- Oxidizing agent (oxygen)
- Chemical Reaction

The reducing agent, or fuel, is the substance or material that is being oxidized or burned in the combustion process. The most common fuels contain carbon along with combinations of hydrogen and oxygen. Heat is the energy component of the fire tetrahedron. When heat comes into contact with a fuel, it provides the energy necessary for ignition, causes the continuous production and ignition of fuel vapors or gases so that the combustion reaction can continue, and causes the vaporization of solid and liquid fuels. The self-sustained chemical chain reaction is a complex reaction that requires a fuel, an oxidizer, and heat energy to come together in a very specific way. An oxidizing agent is a material or substance that when the proper conditions exist will release gases, including oxygen. This is crucial to the

sustainment of a flame or fire. A fire can be extinguished by taking away any of the four components of the tetrahedron. One method to extinguish a fire is to use water. The first way that water extinguishes a fire is by cooling, which removes heat from the fire. This is possible through water's ability to absorb massive amounts of heat by converting water to water vapor. Without heat, the fuel cannot keep the oxidizer from reducing the fuel to sustain the fire. The second way water extinguishes a fire is by smothering the fire.

USE OF WATER

The main way to extinguish a fire is to spray with water. The water has two roles: in contact with the fire, it vaporizes, and this vapour displaces the oxygen (the volume of water vapour is 1,700 times greater than liquid water, at 1,000°F (540°C) this expansion is over 4,000 times); leaving the fire with insufficient combustive agent to continue, and it dies out. the vaporization of water absorbs the heat; it cools the smoke, air, walls, objects in the room, etc., that could act as further fuel, and thus prevents one of the means that fires grow, which is by "jumping" to nearby heat/fuel sources to start new fires, which then combine. The extinguishment is thus a combination of "asphyxia" and cooling. The flame itself is suppressed by asphyxia, but the cooling is the most important element to master a fire in a closed area. Water may be accessed from a pressurized fire hydrant, pumped from water sources such as lakes or rivers, delivered by tanker truck, or dropped from aircraft tankers in fighting forest fires. In China, a firefighting tank equipped with water and foam retardant guns is deployed in cases where access to the area is difficult.

TYPES OF FIRE FIGHTING SYSTEMS

There are many types of firefighting systems and some important types of fire Fighting systems are following.

- Fire Hydrant System
- Fire Sprinkler System
- Fire Alarm System
- Deluge System
- Foam Top pourer System
- Vesda System
- FM 200 System
- CO2 Gas Suppression System
- Fire Vehicle

2 LITERATURE SURVEY

Fire Load Calculation on Hospital Buildings in India,**1Manish Nigam, Awadhesh Kumar Singh ,Abhishek Dixi**t , published of September 11th 2001

A Discussion on enhancing water fire fighting systems for tall buildings with an

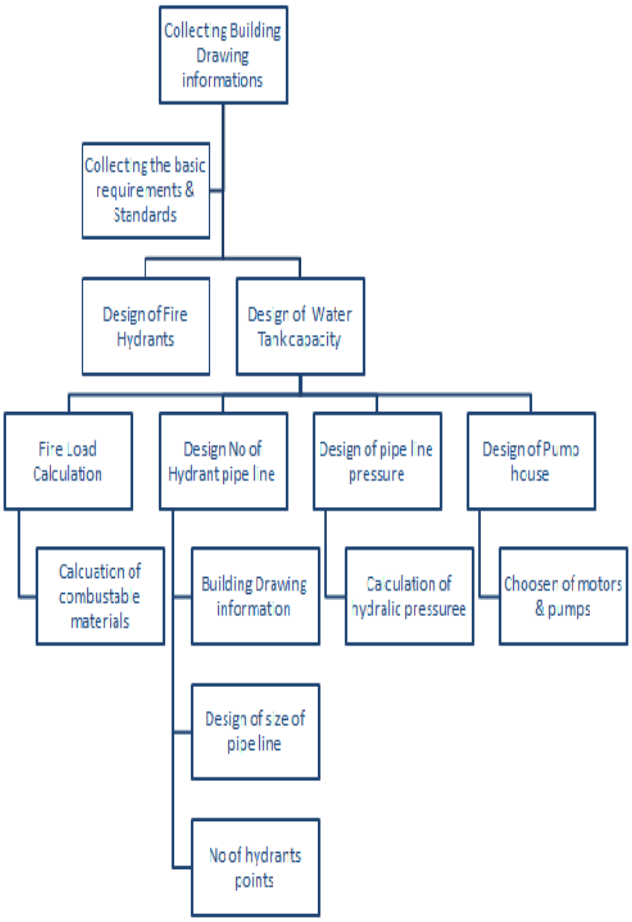
anti-terrorism perspective, k.p. cheung department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong **H.W. Chan Hinkey** Technical Services, Hong Kon 14th September 2008 [1]

Estimation of Fire Load and Its Risk Assessment in Warehouse, **N. Arunraj, C. Senthil Kumar ,K. Vijaya Maruthi** international journal of o09 Auguest 2005[2]

Review on water mist fire suppression system n. Zhu Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China International Journal on Engineering Performance-Based Fire Codes, Volume 6, Number 4, p.230-233, 2004 [3]

Fire Flow Capacity Analysis Based on Hydraulic Network Model, **C.Xiao,J. Pinga,,R. Wanga,*** 16th Conference on Water Distribution System Analysis, WDSA 2014[4]

3 PROBLEM IDENTIFICATION



The proposed Chemical industry has various processes and activities which has high potential risks for fire and explosion.

The industry also carried out Dangerous Operation of as notified under section 87 of the Factories Act, 1948.

- They are not fulfill the NBC, NFPA, Legal requirements
- Existing Fire Hydrant is not working due to poor design
- Incase of fire, difficult to extinguished the fire

- There was More possibilities of cause of fire
- Only fire extinguishers & fire sand buckets available in this site, it only control the initial stage fire
- Stored highly flammable materials & solvents, Like stored class A and Class B solvents
- Bulk storage of solvents stored in tank
- Poor planning of control the fire
- Loss of human life and environment and property
- Damage/Loss of products due to any accident occur

4 PROPOSED METHOD OF DESIGN

Fire load (A) $= \frac{16000X\ 70000}{550}$

= 674400 kcal/m2

Fire load (B) $= \frac{25000\ X\ 10000}{700}$

=2036363 Kcal/m2

Fire load(C) $= \frac{200\ X\ 11950}{100}$

= 357142 Kcal/m2

Fire load (D) $= \frac{54000\ X\ 11240}{900}$

= 23900 Kcal/m2

5 FIRE LOAD

Fire load is the measure of the maximum heat that would be released if all combustibles in a given fire area, burn. The calorific value is the heat of combustion of a material or substance. In a typical building, the fire load includes combustible contents, interior finish and structural elements. Fire load in a building has a significant influence in the severity, rate of fire spread and duration of fire subject to prevailing ventilation conditions.

Total Fire Load Density

= 674400(A) + 20363363(B) + 357142(C) + 23900(D)

= 21418805 kcal

6 HYDRANT

Fire Projects does Fire hydrant system to access water supply in case of fire emergency through above ground connection. Fire hydrant system consist pipes, water tank, pumps, hydrant outlets and or hose reels.

Components Of Fire Hydrant System

- Sufficiently large water reservoir
- Fire pump sets (Main and Standby)
- Jockey pump set

- Hydrant valves
- Fire fighting hoses
- Branch pipe with nozzles
- Landing Valves
- Hoses
- Couplings
- Hose Reels
- Fire Brigade Connectors
- Branch Pipes & Nozzles
- Monitors\
- Butterfly valves

GENERAL CLASSIFICATION OF BUILDINGS

According to the Commentary on National Building Code (Part 4) – Fire and Life Safety, the All buildings, whether existing or hereafter erected, shall be classified according to the use or the character of occupancy in one of the following groups

- Group A Residential Buildings
- Group B: Educational buildings
- Group C Institutional Buildings
- Group D Assembly Buildings
- Group E Business Buildings
- Group F Mercantile Buildings
- Group G Industrial Buildings
- Group J Hazardous Buildings

SITE PLAN

HYDRANT SPECIFICATIONS

- Hydrants shall be the one way or two way type with two 2½-inch
- The operating nut shall open counter clockwise.
- Hydrants shall be traffic type (break away).
- Each hydrant shall have its own auxiliary valve. This valve shall be as close to the water main as practical.
- Leads going from the main to the hydrant shall not be less than six (6) inch.
- All hydrants that receive pressure from a Fire Department connection or an on-site

- suppression system shall be classified as private hydrants and shall be painted red.
- The Van Buren Fire Department shall be responsible for flow color-coding.

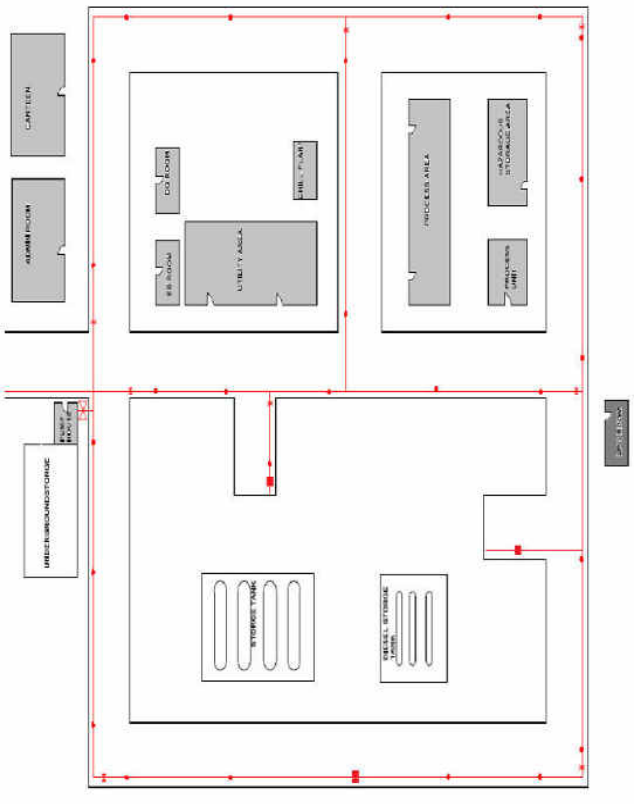
HYDRANT INSTALLATION

- Hydrants shall be installed in accordance with Water Utility requirements.
- Hydrants shall be installed so that the steamer connection will face the street and shall be 18" above the finished grade.
- No obstructions (fences, plantings, structures, earth fill, etc.) may be placed to block access to any fire hydrant by public safety personnel. No obstructions may be placed within 5' of any fire hydrant.
- Where practical, hydrants shall be installed within ten (10) feet of the street intersection.
- Replacement hydrants in developed areas shall be located at least five (5) feet from driveways, streetlights, utility poles or any other objects that may obstruct the use of the hydrant. In new developments, driveways, streetlights, utility poles or any other objects that may obstruct the use of the hydrant shall be located at least five (5) feet from any hydrant installation.
- Each hydrant shall have a gravel drain at the shoe in order for the hydrant to drain correctly.
- Proper installation, and acceptance by the Fire Department and Water Utility of mains and hydrants are required prior to building permits being issued.
- The Water Utility shall inspect new fire hydrants installations prior to acceptance. Correction of deficiencies identified during inspection shall be the responsibility and at the expense of the developer.
- From Table 23 Minimum requirements of Fire fighting Installation based on, hereby Design the Fire hydrant Layout
- As per the standard, Minimum spacing and hazardous condition based, hereby design the hydrants, Hose reel, Hydrant Monitors

S.No	Description	Qty
1	No of Hydrants	27 Nos
2	Outlet	Single
3	Riser type	Wet riser
4	Type of control valve	Butterfly valve
5	No of control valve	8 Nos

6	Suction pipe line size	200 mm
7	Delivery pipe line size	150 mm
8	Wet riser size	63 mm
9	Distance between each hydrant	15 m
10	Hydrant height from the ground level	1 m
11	No of the hose box	27 Nos
12	Length of the hose	15 m
13	Hose reel box	30 m

Hydrant Design



7 DESIGN OF HYDRAULIC PRESSURE

Ideal requirements

Detached and semi-detached housing developments up to two stories. 480 l/min from a single hydrant. Multi-occupied housing developments of more than two stories. 1200 – 2100 l/min from a single hydrant.Transportation service stations and car parks. 1500 l/min from a single hydrant Industrial developments should have a 150mm nominal diameter main network capable of supplying the following flows dependent upon the development area:

- <1 hectare 1200 l/min
- 1 – 2 hectares 2100 l/min
- 2 - 3 hectares 3000 l/min
- >3 hectares 4500 l/min

Shopping centers, offices, recreation, and tourism developments.

1200 – 4500 l/min dependant on nature, extent and height of development.

Primary Schools 1200 l/min from a single hydrant.

Secondary Schools 2100 l/min from a single hydrant.

NFPA 2917 clause 5.1 - Classification of hydrants at 20psi (1.4 bar) residual pressure

- AA – > 1500 US gpm (5680 l/min)
- A – 1000 – 1499 US gpm (3785 – 5675 l/min)
- B – 500 -999 USgpm (1900 – 3780 l/min)
- C - < 500 USgpm (1900 l/min)

8 DESIGN OF TANK

The tank is designed by the standard of NFPA 22 , This standard provides the minimum requirements for the design, construction, installation, and maintenance of tanks and accessory equipment that supply water for private fire protection, including the following:

(1) Gravity tanks, suction tanks, pressure tanks, and embankment supported coated fabric suction tanks

(2) Towers

(3) Foundations

(4) Pipe connections and fittings

(5) Valve enclosures

(6) Tank filling

(7) Protection against freezing

Installation

Installation of the tank in the prepared embankment shall be accomplished with the assistance of the tank manufacturer's field technician.

The tank shall be shipped to the site packaged in a material that is designed for ease of handling by a crane and winch and that facilitates efficient placement in the enclosure.

The fittings shall be installed on site.

At the time of installation, the tank shall be filled, and final adjustments on the tank shall be made to ensure that it rests uniformly against the embankment on all four sides.

Adjustments in anchoring stakes shall be made at this time.

The tank shall be secured entirely around the top periphery of the embankment walls using ropes that pass through straps that are built on the outer surface of the tank and that are tied around the stakes.

The tank also shall be tested for leakage after installation.

Tank size and Calculation

The size of RCC tank 15m x 6m x 5m, because of as per the standard our minimum requirements storage of water should be not less than 450KL,

As Hydraulic tank calculation 1m3 of rectangular tank, water can stored 1000L of water,

1m3– 1000 L of water

Tank Design

Length – 15 m

Breadth – 6 m

Height - 5 m

Volume of the tank – L X B X H

- **15 X 6 X 5**
- **450 m3**

1m X 1m X 1m – 1000 L of water

450 m3 size of tank x 1000 lit of water

= 450 X 1000

= 4,50,000

The capacity of tank to be 4,50,000 lit of water

S.No	Description & Specification	Qty
1.	RCC Underground Storage tank	1
2.	Size of the tank	15 x5 x 6 m^3
3	Area	90m^2
4	Storage capacity	450 KL

DESIGN OF PUMP HOUSE

Introduction

Fire hydrant pump systems (also known as fire pumps, hydrant boosters, fire water pumps) are high pressure water pumps designed to increase the fire fighting capacity of a building by boosting the pressure in the hydrant service when mains is not enough, or when tank fed

Fire Pump Enclosure

- Access (Testing / Service / Repair)
- Piping (10X Rule)
- By-Pass
- Backflow Devices / Strainers / Check Valves / Suction Control Devices / Control Valves
- Pump and Driver
- Controller / Transfer Switch / Pressure Sensing Lines Wiring / Main Electrical Service Fuel Tanks (Diesel)
- Jockey Pump
- Electrical motor pump
- Diesel engine pump
- Relief Devices / Drains
- Heaters or Ventilation
- Test Header Piping
- Closed Loop Metering

9 DESIGN & SPECIFICATION OF HYDRANT SYSTEM

S.No	DESCRIPTION & SPECIFICATIONS	QTY
1	**M.S Pipe Dia 200mm diaNB & IS 1239 part 1**	**50'**
A	M.S Pipe Dia 150mm dia NB GR410	860'
B	M.S Pipe Dia 80mm dia	270'
C	M.S Pipe Dia 50mm dia	30'
D	M.S Pipe Dia 25mm dia	30'
E	Butterfly valve as per IS:13039 with necessary flanges & bolts, nuts, gaskets , Dia 200 mm dia	1 Nos
F	M.S Pipe Dia 150 mm dia	8 Nos
G	M.S Pipe Dia 80 mm dia	3 Nos
2	M.S Pipe Dia 50 mm dia	3 Nos
3	Fire Hydrant, Pillar Type, with Inlet Flanged 4" size with Double	27 Nos

	Deliveries 2½" Female Instantaneous coupling with Blank cap and chain. As IS 937	
4	steel sheet with glass front, size 48”x24”x10”, suitable to accommodate Two length of Fire Hoses 2½"x100’long and One nozzle. As per (8090)	27 Nos
5	Water Jet Nozzle, 18" Long Inlet 2 ½”, Outlet ¾” Orifice	27 Nos
6	Ball valve Maximum service pressure 20 bar	1 Nos
7	Butterfly valve with pressure rating PN16	10 Nos
8	**Fire Fighting Pump Electrically Driven:** Max. Output: 273cu.m/hr Max. Pressure: 170 psi Size (Suction): 8” Size (Delivery): 6” Electric Motor (Siemens): 120 H.P, 2900 RPM Mounting: in steel frame with fittings in concrete structure.	1 Nos
	Fire Hydrant Pump (Diesel Engine Driven) Max. Output: 273cu.m/hr Max. Pressure: 180 psi Size (Suction): 8” Size (Delivery): 6” With 6 Cylinder 108.2 HP Diesel Engine, Water Cooled Electric Start (24 V Batteries) Fitted With Step-up Gearbox	1 Nos
9	**JOCKEY PUMP :** Centrifugal, multi-stage, Size 1 ½ “ x 1 ¼ “ (38 x 30mm) Flow 10.8 cu.m/hr Pressure 101.526 psi (7 bar) Construction main body and impeller of Cast iron, Shaft of carbon ms steel Motor 15 HP, 3-phase, Siemens directly coupled Fitted with Pressure tank, Trim assembly, pressure gauge, ball valves, Y-strainer and pressure witches	1 Nos
10	Pump control cabinet for above mentioned 03 pumps	1 Nos

11	Pump room's fitting & Controls i.e. gate valves, NRV, expansion joints, headers, pressure gauges, supports and painting	1 Nos
12	Pressure switch as per IS 13947 (part 1) 1993	3 Nos
13	Pressure Gauge As per IS 3624,1987 Size 150mm dia	6 Nos
14	Required under ground water tank capacity 450 KL , for 120 minutes of fire fighting	1 Nos
15	Pipe Support & Paint & Etc.(Red)	1 Job

10 MATERIALS COST DETAILS

S.NO	DESCRIPTIONS	QTY	UNIT PRICE
1	Electrical pump	1	3,00,000
2	Diesel engine pump	1	4,50,000
3	Jockey pump	1	80,000
4	Common control panel	1	1,50,000
5	Armored Cables (different size)	45 mtr	20,000
6	Valves	9	45,000
7	Pressure switches	3	7,000
8	Pressure gauges	4	12,000
9	Priming tank 1000 lit capacity	1	15,000
10	Ball valve	10	10,000
11	Single headed fire hydrant valve	27	22,000
12	Double hose box	27	95,000
13	Fire hose	27	25,0000
14	Branch pipe with nozzle	27	85,000
15	Jet water cum foam monitor	3	1,20,000
16	SS foam tank	3	1,20,000
17	Air vessel tank	1 set	15,000
18	**Hydrant pipe line**		
A	M.S Pipe Dia 200mm diaNB & IS 1239 part 1	**50'**	45,000
B	M.S Pipe Dia 150mm dia NB GR410	860'	5,20,000
C	M.S Pipe Dia 80mm dia	270'	1,23,000

D	M.S Pipe Dia 50mm dia	30’	10,000
E	M.S Pipe Dia 25mm dia	30’	5,000
F	Butterfly valve as per IS:13039 with necessary flanges & bolts, nuts, gaskets , Dia 200 mm dia	1 Nos	18,000
G	M.S Pipe Dia 150 mm dia	8 Nos	60,000
H	M.S Pipe Dia 50 mm dia	3 Nos	15,000
19	Under ground water tank construction with complete RCC foundation, vent manhole and inside ladder, Leak proof arranged tank size 5m depth X 6 m width X 15 m Length accommodating 450000 liters of water	3 Nos	2,80,000
20	Non Return valve	2 nos	35,000
21	Wrapping & Coatings	1 Job	1,80,000
22	Pipe Support & Paint & Etc.(Red)	1 job	30,000
23	Civil Works & others	1 Job	2,50,000
24	**Total Cost**	**-**	**3,36,7000**

11 GENERAL SAFETY REQUIREMENTS

Approved IS standard materials should be used.

Electrical connection to be made on as per Central Electricity act, Like Proper earthing & IS standard fittings to be used

Safety equipment should be used for hydrant system.

1.Non Return valve

2.Pressure Switches & Gauges

3.Earth protectors (ELCB, MCB)

4.Double Earthling to be ensured

Flame proof materials & FRLS cables should be used for pump house control area

Avoid to store possibilities flammable materials to cause the fire inside the fire hydrant area

All the motors always in Automatic mode & operator available in this area

Preventive maintenance & Calibration to be done frequently

Leak proof test to be done for Tank

The Storage tank should not used for any other purpose, It always ready to use for incase emergency

Lock out & Tag out procedure should be followed while maintenance.

All the workers aware about Fire hydrant operations , Safety requirements & PPE.

BASIC SAFETY ON WHILE CONSTRUCTION

The following are minimum Safety that apply to all personal. All the personal have a duty and Responsibilities to ensure the familiarization Safety Requirements and comply with all standard requirements.

- During construction & Installation period, more accidents happened, So the following Safety precaution should follow by the workers .
- Authorized Safety Professional & Engineers should be present during construction & Installation.
- Reporting the Hazards
- Basic personal Protective Equipments
- Vehicle Safety
- Emergency Procedures
- Safe operating Procedure
- Work permit system should be followed
    - Construction safety
    - Hot / Cold work Safety
    - Height work
    - Scaffolding
    - Loading & Unloading
    - Excavation
    - Confined Space entry
    - Lifting Tools & Equipment Safety
    - Ladder safety
    - Loto system

CONCLUSION

- Fire protection engineering design criteria to meet the goals identified above, by protecting Employees visitors, and staff; maintaining the continuity of important clinical and administrative activities; and protecting industrial property. This generally will require the installation of hydrant system to protection in industrial buildings.
- Fire hydrant system protection shall be required to protect Industrial property or for compliance with the Life.
- National building code and National fire protection association states the recommendation and requirements of fire protection system.
- This all categories of construction and renovation projects, station level projects.
- This is intended to apply to new construction. It can be used as reference with respect to existing features.

REFERENCES

[1] Manish Nigam, Awadhesh Kumar Singh ,Abhishek Dixit, Fire Load Calculation on Hospital Buildings, , September 11th 2001

[2] N. Arunraj, C. Senthil Kumar ,K. Vijaya Maruthi international journal of 09 August 2005, Estimation of Fire Load and Its Risk Assessment in Warehouse

[3] K.P. cheung , H.W. Chan Hinkey, A Discussion on enhancing water fire fighting systems for tall buildings with an anti-terrorism perspective, 14th September 2008.

[4] C.Xiao,J. Pinga,,R. Wanga, 16th Conference on Water Distribution System Analysis, WDSA 2014: Fire Flow Capacity Analysis Based on Hydraulic Network Model

[5] IS: 778 -1984 specifications for copper alloy gate, globe and check valves for water works purposes.

[6] IS: 884 – 1985 specifications for first-aid hose reel for fire fighting

[7] IS: 3844 – 1989 code of practice for installation and maintenance of internal fire hydrants and hose reels on premises.

[8] IS: 903 – 1993 specifications for fire hose delivery couplings, branch pipe, nozzles and nozzles spanner.

[10] IS: 5290: 1993 landing valves - specification