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Salient Aspects and Critical Parameters to be considered in Optimized Design of Fire Hydrant Systems for Fire Hazards in Indian Conditions.

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ABSTRACT:

Most of the industries are integrated with various processes in sequence starting from the raw materials to the finished products including its packaging and ready for dispatch. Production generally continues round the clock. Man, materials structures and machineries are the pillar of the industries, but associated with different kinds of fire-hazards and risks, therefore need to be maintained and protected. These hazards are most of the cases fire prone and in case favorable conditions are satisfied , fire incidents occur and it not only hampers the various processes/activities and production, but also leads to loss of life, resources and properties and pollute the environment. Therefore fire incidents always need to be prevented and incase it occurs, then it needs to be extinguished at its initial stages before spreading it widely. Various kinds of hazards are the sources of fire. Therefore these hazards are required to be identified with respect to their characteristics, potentialities and accordingly extinguishment arrangement are to be provided adequately

Among all the fire protection systems that are in vogue in the world the most widely used systems are the water based fire hydrant systems. The reasons for using water as a fire extinguishing medium are obvious. Water is available in plenty in most places or is available at economical rates and as a fire extinguishing medium, water is quite effective. Water extinguishes the fire by acting of two ways. By cooling the burning media and by the vaporization of water. When water evaporates, it absorbs the latent heat of evaporation from the burning medium and the steam that is generated dilutes oxygen availability in the zone of burning. But, in order to obtain extinguishment, the amount of water applied must be adequate in relevant to the specific fire.

INTRODUCTION:

The hydrant system mainly consists of a reservoir of water, fire pumps and water piping distributed throughout the protected areas. In its simplest version, the hydrant system consists of overhead tank on the top of the building or premises and a down comer pipe from which branches are taken at every floor level at one or more places and provided with hose reels and hoses. This kind of system is adequate for small buildings of light hazards of one or two storey.

For larger areas or high rise building, the water reservoir is normally provided at the ground level with a pump room adjacent to or near the reservoir. An underground ring main water piping is provided at about 5-10 metres away from the face of the building, surrounding the entire building. Further one or more riser mains are provided depending on the floor areas. Both the riser main and the ring main are connected to the fire pump. The riser main are normally taken up to the terrace of the building.

The fire pump maintains a constant supply of water under pressure at all the outlet points. Yard hydrants are installed at various points on the ring main and provided with adequate length of hoses, branch pipes and nozzles. Similarly at every floor level, branches are taken from the riser main and fitted with the landing valves, hoses and nozzles as well as hose reels. Design details like the number of yard hydrant required, number of risers, the length of hoses etc. are dependent on the type and the extent of the protected area.

Hydrant systems are generally used for the protection of high rise buildings, god owns, ware houses, hospitals and almost all types of industrial premises like steel, cement and power plants, petroleum refineries, chemical processing plants, jute mills, etc.

CONDITIONS OF FIRE OCCURRENCES:

An initiation of fire requires three parameters in the adequate proportions to be satisfied simultaneously. These parameters are (i) Combustible materials/fuel ii) Oxygen iii) ignition . combustible materials/fuel are generally available in the hazards which when combined with other two parameters at required proportions /level initiates fire and it spreads on satisfaction of these parameters. Therefore , satisfaction of these three parameters in required proportions makes a closed triangle known as " **Fire Triangle** " whose three sides represents fuel , oxygen and ignition at its proportionate level . In case any one or two of these parameters is made isolated / absent or made reduced in its minimum required proportioned level, fire- triangle will not be completed and hence fire will either not be initiated or be extinguished.

CAUSES OF FIRE:

Fire- incidents occur/ initiated generally from the following events/activities:-
i) Malfunctioning of electrical distribution equipment and electrical short-circuits.
ii) Excessive fluctuations in electrical loads
iii) Storage of flammable/explosive articles
iv) Improper handling/storage of fuels/flammable liquid
v) Overheating
vi) Lightening/Sparking
vii) High rate of air flow/cyclone
viii) Explosion ix) Earthquake
x) Leakage of combustible-gases
(xi) Friction
(xii) Other causes associated with heating.

Table – 1: Classifications of fire as per NFPA Standards

Type	Class of Fire
A	Fires in ordinary combustibles (wood, vegetable fibers paper and the like)
B	Fires in flammable liquids, paints, grease, solvents and the like
C	Fires in gaseous substances under pressure
D	. Fires in Reactive Chemicals, active metals and the like
E	Fires in electrical equipments

Design Basis of Fire Hydrant System:

The protected areas are classified into light, ordinary and high hazards categories. The classification depends on the fire risks of every specific areas and as per the National Fire Protection Associations, USA and National Building Code.
Light Hazard Occupancies are offices, hospitals, schools, Cinema Houses and various industries like fabrication and tanning factories, ceramic manufacturing, poultry farms etc.

Ordinary hazards comprises biscuit and beedi factories, card board manufacturing, coffee purifying premises, coir factories, printing presses etc.

High hazard occupancies are distilleries; oil extraction plants, etc belong to high hazard A category while petro-chemical plants, refineries, fertilizer plants etc belong to high hazard category B.

TYPES OF FIRE HYDRANT SYSTEMS:

In general, hydrant system is classified either as wet systems or dry system. A wet system consists of a hydrant system where water remains in the pipes under pressure, whereas the dry system obviously is not filled with water. Dry systems are normally used in cold climates. When water freezes in cold conditions, certain increase in volume results in the bursting of pipes and freezing itself would prevent the use of the systems in times of an emergency. Apart from the cold climatic conditions, generally wet system is largely used to cater the emergency situation in time.

Sources of Water:

The general sources of water supply for a hydrant system are:

(i) Stored, Static fire pump underground or overhead,
(ii) Natural reservoir like tank or river
(iii) Sea Water.

Sea water is used as a reservoir in industries or areas located close to the sea like port trusts, atomic energy establishments etc. However, use of sea water requires adequate precautions to be taken with regard to the material of constructions of pumps and its impellers, pipes, tanks, fittings and other accessories in respect of corrosions. A single source of water supply is acceptable in case it is capable of automatically supplying the entire quantity of water required for full protections of the properties and life from fire. Where this is not possible, more than one source may become necessary like water from municipality mains, bore well piping or tank water supply.

Table2: Minimum capacity of static water storage for fire hydrant services.

Nature of Risks	**Capacity of Static Storage .**
Light Hazards	Not less than 1 hour's aggregate pumping capacity with a minimum of 135,000litres.
Ordinary Hazards	Not less than 2 hour's aggregate pumping capacity

High Hazards (A)	Not less than 3 hour's aggregate pumping capacity
High Hazards(B)	Not less than 1 hour's aggregate pumping capacity

The fire pump and water in the fire sump should not be used for other water requirements of the industries or buildings.

SELECTIONS OF FIRE PUMPS:

The heart of the hydrant system is the pump. Fire pumps operate in emergencies that occur at the same time as other catastrophes such as storms, riots, hurricanes, floods, etc. Fire pumps have only brief period of test operation and rare period of operations in fire extinguishment. Yet the pump must be reliably capable of instant starting and running after days, week or even months of inactivity. Therefore, regular maintenance and test are the paramount importance for these pumps. Fire pumps should be equipped with the devices protecting it from short circuits, low voltage and other damaging conditions. Parts of pumps like impeller, shaft , sleeve, wearing rings etc should e made from non-corrosive metal preferably of brass or bronze.

The fire pumps in hydrant systems are normally of centrifugal type consisting of two parts impeller and casing. The impeller imparts a high velocity to the water while casing transforms most of the kinetic energy into pressure energy.

The types of centrifugal pumps in use for hydrant system can be classified as horizontal and vertical pumps. It can also be classified as horizontal end suction, horizontal split casing and vertical turbine pumps. In most of the smaller systems, horizontal end suction pumps are used, whereas larger systems use horizontal casing pumps or vertical turbine pumps depending on the situations. The pump can further be single stage or multi stages depending on the capacity and pressure head requirements. The pump should be selected based on the number of hydrants, flow and head requirements of each fire protection systems.

Table3: Selections of pump capacity and delivery pressure.

Nature of Risks	Numer of Hydrants	Pump Capacity in Litres/sec(M^3/hour)	Delivery Pressure at rated capacity; Kgf/Cm^2g)
Light Hazard	Not exceeding 20	27(96)	5.6
	Exceeding 20 but not exceeding 55	38(137)	7
	Exceeding 55 but not exceeding 100	47(171)	7
	Exceeding 100	47(171) plus 47(171) for every additional 125 hydrants or part thereof.	7/8.8
Ordinary Hazard	Not exceeding 20	38(137)	**7**

	Exceeding 20 but not exceeding 55	47(171)	**7**
	Exceeding 55 but not exceeding 100	76(273)	**7/8.8**
	Exceeding 100	76(273) plus 76(273)for every additional 125 hydrants or part thereof.	
High Hazard (A)	Not exceeding 20	47(171)	**7**
	Exceeding 20 but not exceeding 55	76(273)	**7/8.8**
	Exceeding 55 but not exceeding 100	114(410)	**7/8.8**
	Exceeding 100	114(410) plus 114(410) for every additional 150 hydrants or part thereof.	**7/8.8/10.5**
High Hazard (B)	Not exceeding 20	Two of 47(171)	7
	Exceeding 20 but not exceeding 55	Two of 76(273)	7/8.8
	Exceeding 55 but not exceeding 100	Two of 114(410)	7/8.8
	Exceeding 100	Two of 114(410) plus one of 114(410) for every additional 200 hydrants or part thereof.	8.8/10.5

WATER FLOW RATES:

The pump flow rates depends on the number of hydrants used in each hazard and varies from 27 litres per second for a light hazard to 273 litres per second for a high hazards B category. While selecting the pumps, great care should be taken care for not only the specified flow rating and specified head is met by the pump, but also the pump is designed with a capability to deliver 150% of the rated discharge at minimum 65 % of the rated head.

PRIME MOVERS:

The prime movers used for running the pumps are generally electrical motors or diesel engines. However, in some industries, steam turbine operated pump sets are also used. While selecting the electric motors, once again a safety factor of 20% in the BHP required at designed capacity is normally allowed. Further, it should be capable of meeting the BHP requirement of the pump at 150% flow with 65% design head. Generally only direct coupled systems are in use.

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While selecting the diesel engine as the prime over, the capacity rating is given with a safety factor of 20% over the required BHP. Further diesel engine capacities are to be de rated for ambient temperature, humidity conditions as well by the electric driven pump set can be used.

While designing the power supply feeder to the electric motor, it is to be ensured that the power is fed directly from the transformer itself or from the incoming side of the LT board. Further, it should be entirely independent of supply to any other equipment in the premises. If the power is switched off for the entire premises, this feeder should still be capable of supplying power to the pump sets. However, in case where two transformers are used to supply power to a LT board with a bus coupler between the two supplies or a transformer supply and a diesel generator supply is used, then the feeder for the fire pump can be taken from the bus bars.

Further, the fire pump circuit should be protected at the origin by automatic circuit breakers and it should be set so as to allow the motor to be overloaded during emergency up to the maximum limit permissible by the manufacturer. In addition, the under voltage release or no voltage coil of the circuit breaker shall e removed. It is a customary practice to use direct on line starters for the electric motor running the fire pumps. This has been adopted mainly to reduce and minimize the breakdown of contactors which may hinder the operation of the fire pump sets.

Jockey Pump:

Most of the fire protection systems have to maintain a uniform and relatively high starting pressure to develop the head instantly for the fast flow in case of fire. This requires the fire pump to start and stop frequently. In order to maintain the high static pressure and to reduce the wear and tear of the main fire pump, it is better to provide a jockey pump mainly to make up the pressure loss due to leakages in the piping network. This will avoid the frequent starting and stopping of the main pumps which are of relatively larger capacities. In addition, frequent starting and stopping of the main pump may lead to reduce the efficiency of the pump unit and even damage the fire protection systems through continued water hammer.

Generally, the capacity of the jockey pump shall be in between 3% and 10% of the installed pumping capacity with 100 % standby provision and the pump should be capable of developing 10% higher head than that of the maximum design pressure in the piping network. But, the capacity of which shall not exceed 180 liters/minute.

AUTOMATIC FIRE HYDRANT SYSTEMS.

Normally, the fire pump operation is either manual or automatic. In manual installations both starting and stopping is done manually. But to avoid the delay between detection of fire and actuations of the hydrant systems for fire extinguishment at its early stages, automatic systems is envisaged to instantly operate either the jockey or the main fire pumps or both the pumps. When water get discharged through any of the hydrant/landing valve, the water pressure in the pipelines get reduced which actuates the pressure switches having independent high and low settings. Each pump in its discharge line is provided with its own pressure switch and its connections shall be made with the pipe lies at the downstream side of the non-return valve.

SUCTION CONDITIONS:

Both positive and negative suctions are applicable to the pumps. Positive suction takes place when the pump casing and impeller are below the level of the water (Net positive Suction Height) and negative suction conditions prevails when the pump is installed above the water level. The positive suction conditions are vastly superior whereas the negative suction conditions are most widely prevalent. This is because; most of the fire sumps are underground below passages, while the pump rooms are located above the ground within the buildings. In negative suction, it is to be ensured that priming will never be a problem. It includes providing a priming tank of adequate size which will prime the pump all the times. The water inflow into the priming tank should be from a reliable source. But, in case of high hazard categories, provisions of positive suction is mandatory.

DESIGN OF PIPING NETWORK, HYDRANTS, HOSES AND ITS INSTALLATIONS:

In general, ring mains are recommended to be employed which ensure the flow of water from both directions Piping systems should be reliable and economic. However, the use of loop systems should be fully analyzed and wherever possible should be implemented. Control valves should be placed to assure two real parts of flow from source to point of use and also to be able to isolate not more than 5 to 6 hydrants at a time. Hydrants should be located keeping in mind the attendant fire hazards at the different sections of the premises to be protected and so as to extend most effective services. It shall be so distributed as to provide protections for the building on all sides and need not to be equidistant from each other .

At least one hydrant post shall be provided for every 60m. of external wall measurement in case of light hazard occupancy, for every 45m in case of ordinary hazard and every 30 m. of external wall measurement or perimeter of unit battery limit in case of High Hazard Occupancy. In case where, owing to the size or layout of the building, any point within the buildings is at a distance of more than 45m from an external fire hydrant, an internal hydrant system shall be provided so that no portion of the floor is more than 45m. from an external hydrant or 30m from an internal hydrant.

The sizing of the pipes are made based on the number of hydrants in the whole systems and also considering the running pressure at the hydraulically furthest hydrant is not less than 3.5 Kg/cm^2g in case of light and ordinary hazards and 5.25Kg/cm^2g for high hazard occupancies. The flow velocity of water through piping network is generally limited to 2.5m/second and does not exceed 3m/second anywhere in the systems. The size of the mains is generally selected between the sizes of DN100 and DN 150 considering the variations of numbers of hydrants from 5 to 100. In calculating the number of hydrants in the system, a double headed hydrant shall be counted as two, affixed monitor of 63mm size having nozzle bore of 32 mm shall be counted as three, a fixed monitor of 75mm size having nozzle bore of 38 mm shall be counted as four and a fixed monitor of 100 mm size having nozzle bore of 45mm as six hydrant points. The pressure loss calculations for the piping systems should be based on either Darcy-Weisbach formula or empirical Hazen- Williams formula.

Water shall be available immediately to all hydrants/fixed monitors at all times, with all cut-off valves being kept open. Except where impracticable, all hydrant/landing valves outlet shall be situated 1 m above ground level. The stand posts shall e 80mm in diameter for single headed hydrants, 100mm for double headed hydrants, monitors of 63mm and 75mm size and 150mm for monitor of 100mm size.

Table 4 : Relevant applicable standards for fire hydrant systems.

Standards	Captions
NFPA 25	Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
NFPA 291	Recommended Practice for Fire Flow Testing and Marking of Hydrants
IS:13039:1991 (Reaffirmed 2000)	External Hydrant Systems- Provisions and Maintenance
IS :908:1975	Specification for fire hydrant, stand post type
IS 5290:1993	Specification for landing valves
IS 5714:1981	Specification for hydrant, stand-pipe for fire fighting
IS 909:1992	Specification for underground fire hydrant, sluice valve type
IS 884:1985	Specification for first-aid hose reel for fire fighting
IS 901:1988	Specification for couplings, double male and double Female instantaneous pattern for fire fighting
IS 3844:1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises

Locations and number of hose stations will depend upon several factors such as fire loads, accessibility and positions of watch posts. If hose is kept in central hose stations, for each of the first ten hydrants/landing valves, in the compound of the premises, two lengths of hose each of 15m and an additional 15m. length for each hydrant in excess of ten shall be provided. In case of large installations having more than 100 hydrant outlets, total number of hose lengths required may be limited to 100 plus 20 percent of the number of hydrant outlets in excess of hundred.

In general, the materials used for piping is mild steel(MS), cast iron(CI) or Galvanized Iron(GI). While cast iron pipes are used for all underground piping, mild steel and GI pipes are used for above ground piping. In case MS pipes are laid underground, these are to e protected with wrapping and coating as per IS:10221.It is economical to use CI piping for laying below surface as it does not need any further surface treatment and the life of CI piping is longer than MS pipes when used underground. Class A CI pipes are used up to a pressure of 10 Kg/cm²g and beyond that Class B pipes are recommended. Similarly, for above ground laying, medium duty or schedule 40 MS pipes are used. The entire hydrant systems including it piping, fittings, valves ,accessories, pump , hydrants, instrumentations and control are to be tested to ensure the availability of the designed and specified base pressure at the hydraulically remotest hydrant. The whole systems and its components are to be painted with red colour conforming to Indian Standard IS:5(Shade No.536).

ROUTINE OPERATIONS:

As the fire fighting pump sets are not in continuous operation, it is necessary that these are periodically checked as per the recognized standards. It is recommended to test the running of the whole systems once a week and to keep the diesel generator running at least ten minutes a week. This will ensure that the pressure switches are operating at the set pressure properly and the system has no leakage or blockage.

CONCLUSION:

Most of the industrial, infrastructural facilities, buildings and domestic premises are associated with fire -hazards which are very difficult to be avoided for the development of the civilization. But, these hazards being the part of the environment need to be protected from fire for the benefits of the production, life, properties, normal activities of the society and environment. All hazards are needed to be identified with respect to its flammable characteristics, potentialities, and probabilities of fire-incidents and risks. Risk analysis and its management are also to be taken care in the design of fire extinguishing systems. Accordingly, depending on the site-conditions, fire hydrant systems of suitable types and capacities are to be provided as per the relevant and recognized standards. These systems are provided for immediate use on fire in its incipiency and are effective only at its early and moderated stages.

It is also important that all personnel in and around the fire hazards should be trained properly to know at least the basic concept of fire, its causes , characteristics and its harmful effect and must also be trained to know how to operate the fire hydrants provided in there area of work Awareness are also to be developed amongst the people to take all sorts of possible preventive measures against fire and its extinguishment to protect the life and properties.

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