Property Risk Consulting Guidelines

XL Risk Consulting

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PRC.14.0.1

FIRE PROTECTION WATER SUPPLIES

INTRODUCTION

Fire protection water supplies consist of single or multiple water sources. They are connected to fire mains sized and arranged to deliver the required water demands to sprinkler systems, fire hydrants and fixed monitors.

Fire protection water supplies are sometimes referred to as “primary” and “secondary.” Primary water supplies consist of those that did not require a mechanical device to move the water such as a gravity tank, a public water connection, or a pressure tank. A “secondary” supply required using mechanical devices, most commonly fire pumps.

The terms “primary water supplies” and “secondary water supplies” have also been used to define water supplies on the basis of redundancy. Additional water supplies recommended for redundancy are often termed “secondary” supplies. To dispel the confusion, the terms “initial” and “second” are used to describe water supplies in this material.

POSITION

Many facilities do not require a second water supply. The need for a second water supply is generally determined after an evaluation of risk hazards, loss potential and value at risk has been made.

AXA XL Risk Consulting does not recommend combination domestic/fire protection systems. A dedicated fire system is more reliable than a combined system because of the following:

- High pressures necessary for fire fighting could damage domestic piping and equipment.
- Continuous flow will increase tuberculation in ferrous pipes.
- System pressure cannot effectively be controlled and supervised, i.e., it is difficult to arrange the prompt automatic starting of fire pumps.
- Process use during a fire emergency could reduce the flow available for fire protection equipment.
- The potential for impairments is increased since more personnel have access to the system.

Initial Water Supply

The initial water supply must be highly reliable and should satisfy:

- The maximum anticipated demand (pressure and volume) for automatic extinguishing systems (sprinklers, water spray, deluge, and foam) and for inside and outside hose stream or monitor applications.

- The demand requirements for a minimum duration, specified in hours. (See PRC.14.1.1.0 and PRC.14.1.1.1.)

An initial water supply may consist of one or more water sources. For example, a public water source and a fire pump with a suction tank may be inadequate when evaluated separately, but when combined, they may satisfy the overall demand and duration.

Public or Comparable Private Water Systems

Public or private water systems usually serve as an initial water supply for a facility and must be evaluated for reliability. They should not have any of the following weaknesses:

- Major seasonal or periodic fluctuations in pressure or flow resulting from varying user demands or filtering capacity, drought, or unreliable sources.
- Lack of an emergency generating source or designed for redundancy per NFPA 20 for essential electric motor driven pumps.
- Limited elevated tank or standpipe capacity.
- Frequent impairments resulting from old or corroded piping, poor maintenance, or antiquated equipment.
- Flood or fire exposure to the main pumping station.
- Extended repair times resulting from lack of personnel or repair parts to restore service on an emergency basis.
- Insufficient sectional valving which prevents continued service when isolating the system for maintenance and repairs.

Fire Pumps Taking Suction From a Public or Private Water Systems

When a public or private water system has the required volume but lacks the pressure needed for the fire protection design criteria, a listed fire pump may be used to meet the flow and pressure requirements under the following conditions:

- A full size bypass is installed around the pump.
- The pump is started automatically and stopped manually by a listed control panel.
- The water system can deliver at least 200% of rated pump capacity at 20 psi (1.4 bar).
- The pump driver is a diesel engine or an electric motor fed from a highly reliable electrical power source meeting the requirements of NFPA 20, as modified by PRC.14.2.1.
- A fire department connection is provided downstream of the fire pump. The local fire department should have appropriate pumper equipment and trained personnel.
- Alarms received at a constantly attended location supervise the pump running, pump trouble signals, and sprinkler waterflow.
- When the fire pump is impaired, the public water alone or in combination with another water source provides at least 10 psi (0.7 bar) static on the top line of sprinklers, and is capable of causing the sprinkler waterflow alarm to operate. A pressure tank or small gravity tank are examples of other water sources that can provide the required 10 psi (0.7 bar).

AXA XL Risk Consulting recommends that the supply for a fire pump be capable of providing 200% of the pump rated capacity at 20 psi (1.4 bar). When the water pressure in a water main falls below 20 psi (1.4 bar), portions of the system at higher elevations may be under negative pressures. Negative pressure can cause backflow where cross connections exist between potable and nonpotable water systems.

Fire pumps do not normally operate beyond 150% of rated capacity. AXA XL Risk Consulting recommendation to supply 200% of the pump rated capacity compensates for conditions that can decrease the available water supply. These conditions include:

- Increases in local area demands.
- Fluctuating water supplies due to varying seasonal usage or varying user demands.

- Deteriorating water main conditions over time.

When the water supply can provide 150%, but not 200% of the pump's rated capacity at 20 psi (1.4 bar), it is necessary to **thoroughly** investigate the water supply and the potential for local area demands to change. Questions to consider in the evaluation include:

- Is the water system well gridded?
- Are there multiple pumping supplies?
- Is the area well developed or is there potential for additional growth or water use?
- Does the industry in the area use large amounts of water?
- Do the seasonal demands vary significantly?
- Is there potential for drought or other condition that would reduce the available water supply?
- Is the public supply extremely reliable?

If the water supply is not likely to deteriorate or if the area demands are not likely to increase, the supply may be considered acceptable.

Water supplies that cannot provide 150% of the rated pump capacity at 20 psi (1.4 bar) are not acceptable. Some water authorities may allow suction pressures less than 20 psi (1.4 bar) when suction pressure regulating devices are used, however, AXA XL Risk Consulting does not recommend their use. See PRC.14.2.1. In some cases, a smaller fire pump at a different pressure rating may be able to meet the fire protection water demand while maintaining acceptable suction pressures.

Size the fire pump to meet the total demand without exceeding 120% of its rated capacity. Base the pressure rating of the fire pump on both the required demand pressure and the available suction pressure from the public water supply. Avoid using pumps whose shut-off pressures exceed the piping system pressure ratings.

Fire Pumps Taking Suction From a Suction Tank

Automatic fire pumps may be installed to augment other water supply systems or to provide the entire initial water supply needs of a facility.

Depending upon the size and insurable values of the property, a single fire pump and suction tank as the sole water supply does not meet the "highly reliable" criteria of an initial supply. This is because the supply depends upon either electric power or the successful operation of a combustion engine. Unlike the failure of a fire pump on a public or private water system, the failure of the sole fire pump results in the complete loss of water for sprinklers or hose streams.

A single fire pump and suction tank in combination with another water supply source is considered sufficiently reliable to serve as the initial supply if:

- The pump meets the water demands without exceeding 120% of its rated capacity.
- The other water source provides at least 10 psi (0.7 bar) static on the top line of sprinklers, and is capable of causing the sprinkler waterflow alarm to operate.

If two fire pumps make up the initial water supply, size each to meet at least the automatic sprinkler demand or two-thirds of the total demand, whichever is greater. One pump may be driven by an electric motor if the power supply is reliable. Otherwise, drive both pumps by diesel engines. In rare cases two electrically driven pumps may be used if they are fed by independent electrical power supplies so that a single electrical impairment will not take both pumps off line.

If two fire pumps make up the initial water supply, two suction tanks are preferred, although divided tanks and cisterns are sometimes used. A divided tank should have a combined capacity for the total demand and specified duration.

A single undivided suction tank may be acceptable. However, the filling water supply must be able to refill the tank in 8 hours and provide an emergency supply to the fire protection system when the tank is out of service for cleaning or repair. This emergency supply must provide at least 10 psi (0.7 bar) static on the top line of sprinklers, and be capable of causing the sprinkler waterflow alarm to operate.

When purchasing multiple pumps for a new facility, consider future expansion. It is possible, at a moderate cost, to design the facility to meet the future need for a redundant supply. This would involve selecting pumps that meet 100% of the demand rather than two-thirds. In addition, the suction source arrangement could be designed to provide two independent supplies to meet 100% of the supply requirement.

Fire pumps usually take suction from large aboveground suction tanks. These tanks may be filled either manually or automatically from a public water supply, a well or another water source capable of filling the empty tank within 8 hrs. If the fire pump suction tank is equipped with automatic fill, the suction tank must be sized to hold at least two-thirds of the total water requirement. If the automatic fill source cannot supply the remaining capacity, increase the suction tank size.

Consider reservoirs, ponds, lakes, river headraces or tailraces, and other natural bodies of water as acceptable suction sources if:

- Vertical turbine fire pumps are used or the source is arranged to always provide a positive head to the suction side of a horizontal pump. Horizontal pumps in pits are not recommended, because leaks or ruptures in the piping could flood pits and impair pumps. Also, pits constitute a confined space which limits entry during emergencies and for periodic inspection and maintenance.
- The supply will not be jeopardized at any time by drought, flood, tides or ice. Possible ice buildup on the surface of the water must be anticipated and provisions made to keep the entire surface from solidifying.
- Required backflow prevention devices conform with PRC.14.5.0.2.
- Trash gates and screens are properly arranged and maintained in accordance with NFPA 20 and 25.
- Nuisance marine life forms, such as clams, mussels or algae, do not impair the water supply. Proper inspection and control measures must be in place.
- The quality of water is such that silt will not plug sprinkler lines or cause piping to corrode.

A deep-well fire pump may be used in lieu of one of the fire pumps and suction tank arrangement. The specifications and installation, including long term well capacity tests, should be in accordance with NFPA 20.

Break tanks are small, automatically filled reservoirs which maintain a sustained water supply for the installed pumps. Break tanks are used where public authorities require physical separation between the public water system and the fire protection system; in high-rise structures where pressure loss due to elevation precludes normal fire pump installations; and in earthquake prone areas to enhance the reliability of the water supply in case the water mains break.

Break tanks are an acceptable suction source only when the automatic fill provides water at a rate equal to or greater than 200% of pump capacity. Filling a break tank “over-the-top” with an appropriate air gap prevents draining of the entire tank if a leak occurs in the fill line to the tank. This method also prevents cavitation due to incoming water being too close to the suction line of the tank. The water from the automatic fill device should fall freely through a “stilling pipe” into the tank as far away as possible from the pump suction inlet and be arranged to avoid strong eddy currents and entrainment of air.

The break tank can be placed inside or outside a building and arranged either above or below grade. The overall reliability of the break tank arrangement depends on the:

- Suction source reliability and its capacity.
- Fire pump’s ability to meet the required demand.
- Pump driver reliability.

The break tank should be sized to hold at least a thirty minute supply of water at rated pump capacity. Sufficient tank capacity is essential. Even on a momentary loss of suction, (a horizontal split-case) pump will become air bound and be damaged from overheating. Vertical turbine and end-suction

pumps resume pumping as soon as water is restored to the tank. However, an extended loss of the suction supply will also damage these pumps. In all cases, provide a low-water-level alarm sounding in a constantly attended location.

When the fire pump is out of service, a direct connection between the public and private systems is of value, assuming the municipal water department permits such a connection. The connection may normally be kept shut or may have a removable spool piece.

A single fire pump and break tank is not sufficiently reliable as the sole initial water supply unless:

- A bypass is provided around the pump.
- The public water can exert 10 psi (0.7 bar) static pressure on the top line of sprinklers and can cause the sprinkler waterflow alarm to operate.

Multiple break-tank and pump arrangements should meet the requirements for multiple fire pumps.

In addition to the arrangements shown on the Figure 1, the following items apply for all break-tank installations:

- Where two or more break-tanks are used, connect the suction supplies together with valving to allow either source to feed the pumps. This connection may be installed either inside or outside the pump house.
- Provide high and low tank level supervision, and temperature supervision if the pump room is subject to freezing.
- Provide an overflow drain to a safe location; size the drain according to the fill line.
- Provide a manual bypass around the automatic fill, sized to maintain sufficient water in the tank.
- The break tank filling facilities must be capable of delivering 200% of the pump capacity.

Gravity Tanks

Gravity tanks or standpipes of sufficient capacity and elevation may qualify as an initial water supply if the empty tanks can be refilled within 8 hours from public water, from wells, or from other sources. Although multiple tanks are preferred, a single tank is acceptable if the filling source is connected to the fire protection system to maintain continued protection. Providing another water source, even of limited capacity, can help maintain limited protection during routine tank maintenance.

Combined fire protection and process water gravity tanks are acceptable if the process water tap is located so that a sufficient reserve is left for fire protection use. Combined gravity tanks may require more maintenance due to the water turnover.

Pressure Tanks

A pressure tank is unacceptable as the sole initial water supply, because its volume is limited. Multiple pressure tanks may be acceptable, however, for limited hazard applications. Pressure tanks can be used with a fire pump and a suction source or a gravity tank system to create an acceptable initial water supply, and to ensure that sprinkler system waterflow alarms operate.

Acceptance of this arrangement ultimately depends upon the size of the pressure tank. The tank should be able to supply the sprinkler water demand until the fire department arrives.

Wells

Wells commonly used to fill suction tanks or elevated gravity tanks are generally unacceptable as the initial water supply, because their volume is limited.

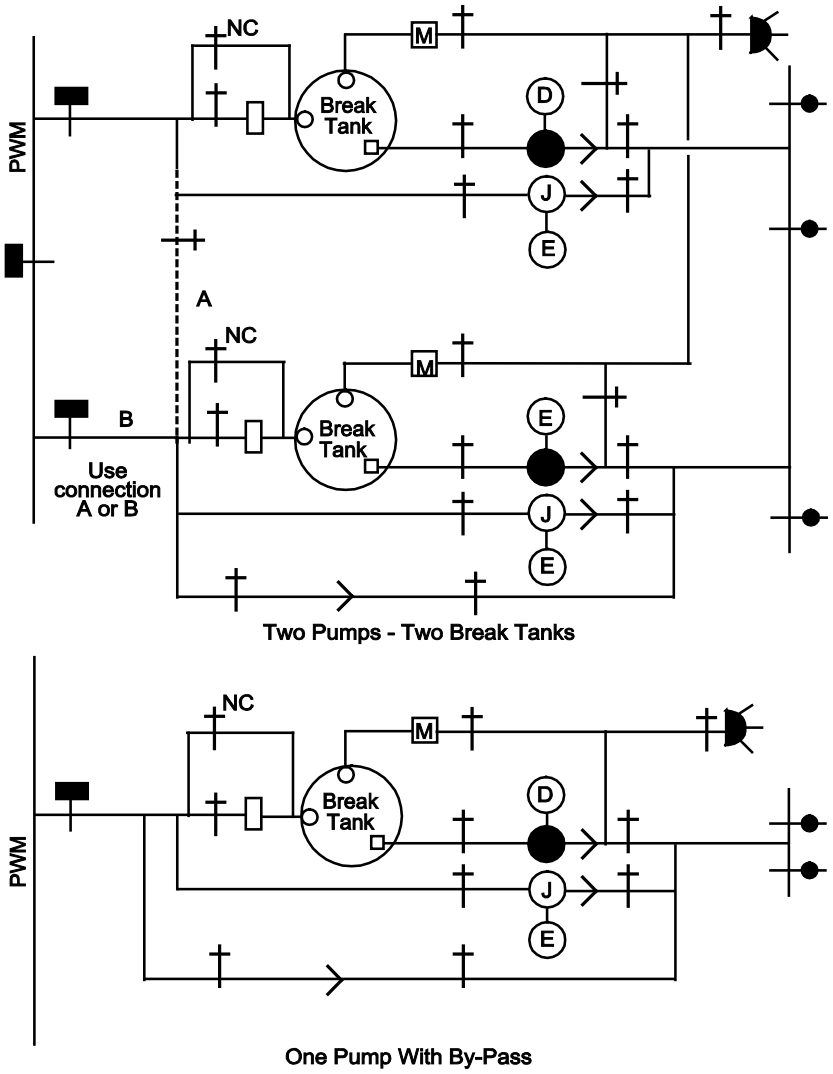

Figure 1. Typical Break-Tank Arrangement.

= Altitude valve
M = Flow meter
= Fire pump
J = Jockey
= Vortex plate
= Over the top fill
NC = Normally closed
= Curb box valve
= OS&Y valve
= Check valve
= Test header with hose valves
= Post indicator valve

Second Water Supplies

Even carefully selected and designed water supplies will occasionally become impaired when pipes fail or when supplies are shut off for maintenance, relocation, or improvement. As hazards and, more particularly, values increase significantly, a redundant, or second water supply gains importance as an appropriate loss prevention measure. Obviously, duplicating any source that qualifies as an initial water supply can provide an acceptable second supply.

When initial and second water supplies are provided, they must be arranged so that any single incident or impairment cannot affect them simultaneously. This normally requires looped fire protection mains and a careful arrangement of divisional valves.

Fire Pumps

A single fire pump may be used to meet the requirement of a second water supply if it meets 100% of the demand requirement.

In order to qualify as both the initial and the second water supply, multiple fire pumps must be arranged so that 100% of the fixed system and manual firefighting demands can be met under any of the following adverse conditions:

- Impairment of the largest single suction source. This could apply to suction tanks, gravity tanks, and small drainage canals. Loss of a lake, sea or large river is considered very unlikely.
- Impairment of the largest fire pump due to pump driver failure.
- Impairment of any section of the fire mains.
- Failure of any common suction or discharge piping.
- Partial or total failure of the electrical power system.
- Impairment of the fire protection equipment due to explosion damage at high hazard facilities.

Separate pumping stations at opposite ends of the facility provide better fire protection than one station in which all the pumping equipment is concentrated. However, when using one station, arrange it as indicated in Figure 2.

This fire pump arrangement generally has built-in versatility and includes several optional features, such as additional valving to isolate equipment, automatic fill line connections and the two jockey pumps. Because jockey pumps run frequently on large fire main systems, they are more likely to break down or wear out. A second jockey pump allows flexibility and continued automatic service. The design also has a fire department connection and a hydrant connection on the storage tank for pumper suction for fire department emergency use.

Public Water

Under limited circumstances, the public water supply can be used as both an initial and a second water supply. Generally, this will require special testing to simulate one or more critical supply impairments. The following criteria must be met:

- The public water supply must be fed by multiple sources and be a high-volume system, i.e., relatively flat pressure/volume curve.
- At least two standard connections must exist between the public water supply and the private fire protection underground. If any single connection is out of service, the remaining connection(s) to the facility underground must be adequate for sprinklers and hose streams.
- Connections must be remote from each other on a strongly gridded public system or taken from independent water sources, each capable of meeting the fire fighting demands for the facility.
- Sufficient accessible valving of public water mains must be available to promptly isolate any possible break without reducing the water supply below the minimum needed for both sprinklers and hose streams. An emergency crew must be available to promptly respond at all times.
- Maintain an accurate and up-to-date record on the location of all valves. Reposition valve curb boxes to new grade elevations during road construction and road resurfacing.
- Until a single break is isolated, the public water system should not reduce the pressure and volume available at the automatic sprinkler equipment below a point at which the supply is considered adequate for sprinklers only. To estimate a break, determine the resultant flow of the following:

- For a 6 in. (150 mm) main, one 2½ in. (65 mm) butt.
- For a 8 in. (200 mm) main, one 4 in. (100 mm) butt.
- For a 10 in. (250 mm) or 12 in. (300 mm) main, one 4½ in. (110 mm) butt.

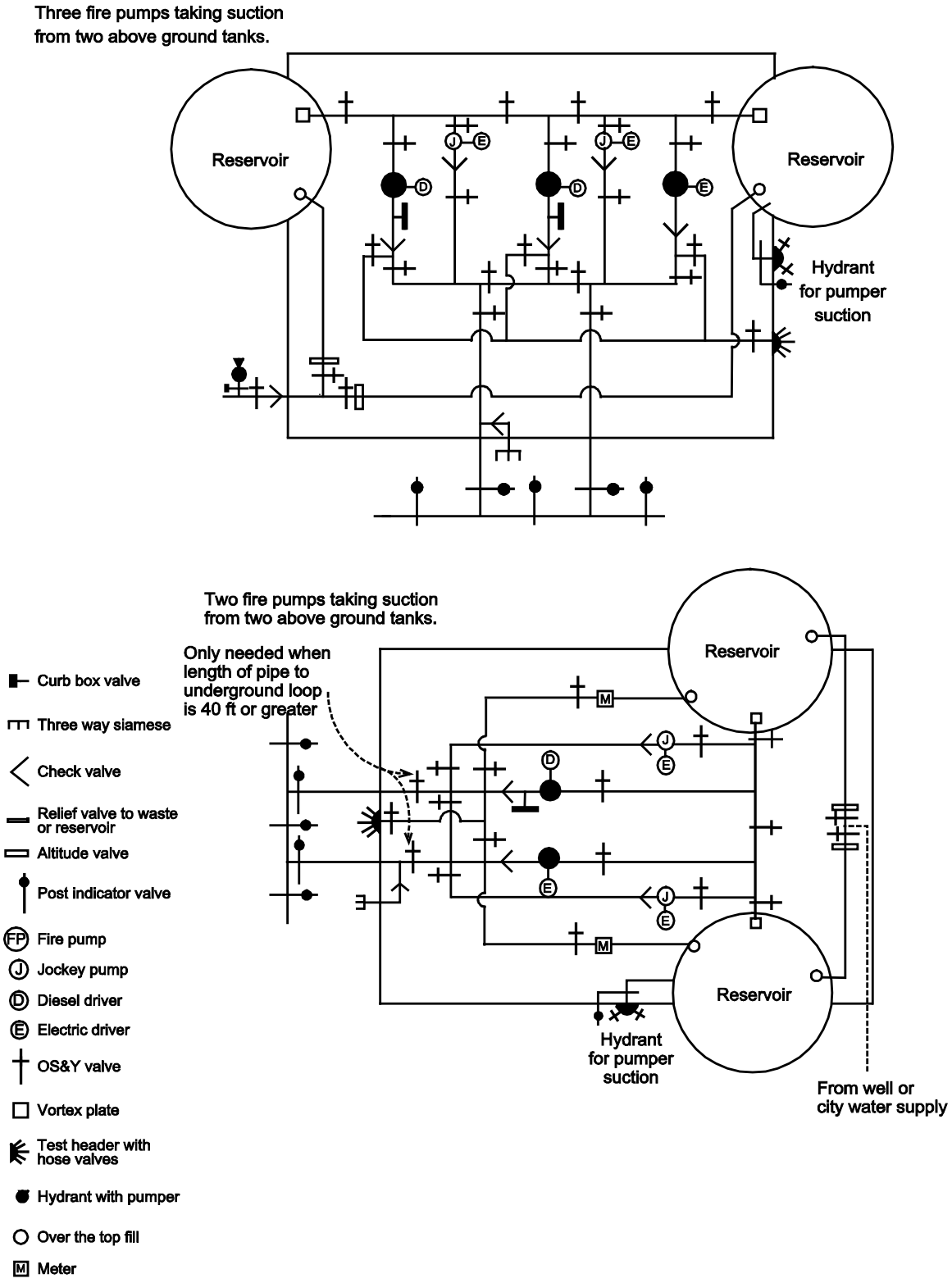

Figure 2. Acceptable Fire Pump Arrangements - Initial And Second Supply.

Example: A break in an 8 in. (200 mm) main at 50 psi (3.5 bar) operating pressure will discharge 3040 gpm (11,491 L/min) (4 in. [100 mm] hydrant butt at 50 psi [3.5 bar]). (See PRC.14.1.2.0.)

Reliability Of Water Supplies For Oil And Chemical Plants

The reliability of water supplies under reasonably adverse conditions is essential especially in facilities with large loss potentials, high values or high hazard operations. Such facilities require a second water supply.

Water supplies and distribution systems in oil and chemical plants should be adequate to supply the water demand for four hours even with an impairment having the greatest impact on the fire protection system. Therefore, in these occupancies, the overall water supply rating is based on the second water supply. This impairment could be due to the loss of the largest suction source, electrical power failure, fire main break, etc. In addition, for high hazard chemical and petrochemical plants, steam turbine, electric motor or gasoline engine driven fire pump, should not be considered as part of the water supply unless their reliability has been evaluated and found to be acceptable. The results of the analysis must show these pumps can remain operable following a major incident.

According to a recent review of the 100 largest losses, fire pumps failed most often when a vapor cloud explosion occurred. Steam and electric utilities are particularly vulnerable to explosions. In 92% of the cases where fire pumps failed, the pumps were driven by steam turbines or electric motors.

High-Hazard Chemical and Petrochemical Plants

In addition to the potential loss of electric or steam supplies resulting from an explosion, loss of power to critical operations could create unsafe conditions that may lead to an explosion. Loss of agitation, cooling or instrumentation, especially in exothermic reactions, could lead to runaway reactions. Utility independent fire pump drivers, such as diesel engines, are therefore recommended.

Electric or steam driven pumps may be considered “reliable” and be an integral part of the water supply being evaluated, if the reliability of their utility sources is thoroughly analyzed and found to be adequate. Arrange the power supply of the pump in such a way that a single event, such as an explosion, substation fire, electrical short or loss of one electrical feed, will not result in a complete loss of pump operating power. Multiple power feed lines, dual power plants or sources, double bus distribution systems, underground electrical lines, appropriate load shedding programs, emergency power generators, duplicate electrical substations and motor control centers will generally increase the reliability of the electrical feed to fire pumps.

Refineries and Oil Terminals

A loss of power to a refinery or oil terminal should not lead to runaway reaction conditions. Explosions and fires may still impair pumping supplies. AXA XL Risk Consulting therefore recommends at least 50% of the fire pumps be diesel driven.