



# Property Risk Consulting Guidelines

XL Risk Consulting

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PRC.14.1.1.0

## ESTIMATING FIRE PROTECTION WATER DEMANDS

### INTRODUCTION

What constitutes an adequate water supply has generated much discussion over the years. NFPA Standards provide some guidance but leave many areas to judgement. For example, when pipe schedule designs are used, NFPA 13 provides guidelines only for Light Hazard, Ordinary Hazard Group 1 and 2 Occupancies, Extra Hazard Group 1 and 2 Occupancies and storage occupancies. Other occupancies are referred to the "Authority Having Jurisdiction." Sprinkler densities and hose stream demands are given in NFPA 13 for hydraulically designed systems, but, even in these cases, the system must be designed before the exact requirements are known.

Most facilities contain a variety of hazards requiring sprinkler systems of differing design. Even when the greatest sprinkler or process water spray demand in a facility has been determined, there may be other factors which could lead to a larger overall demand. The layout of a facility may require large hose demands to prevent fire spread to adjacent areas if the initial fire is not controlled. The protection for yard storage (as found in a paper mill) may create the largest demand. Potential exposures, e.g., a lumber yard, can also affect the amount of water required for manual fire fighting efforts.

The purpose of this guide is to provide a consistent approach to determining the adequacy of a water supply for AXA XL Risk Consulting serviced risks except Oil and Chemical Occupancies. The water supply demands required by this method are not meant to define an "ideal" supply, but one that would be expected to handle credible fire emergencies. It does not take into account the redundancy needed for large or high-valued risks, but reflects the requirements for an initial supply. Finally, as with any method, it cannot take into account all of the factors that could possibly affect water demands. Good judgement must be exercised when applying the method to a specific risk.

### SCOPE

This guide is to be used for all AXA XL Risk Consulting serviced risks except Oil and Chemical Occupancies and applies to all occupancy hazards in those risks from Light to Extra Hazard. Options are provided for all types of systems including pipe schedule and hydraulically designed systems. Oil and Chemical Occupancies are covered in PRC.14.1.1.1.

### METHOD

Analysis of a risk to determine the potential water supply demand is a two step process. First, the facility must be evaluated to determine what scenarios might generate the largest demand. Second, the probable demands under reasonably adverse conditions must be determined and compared for each of these scenarios.

A water supply should be capable of supplying the largest demand. This is often the combination of the largest sprinkler system and hose demand, although not always the case.

### **Building/Occupancy**

The water supply for a building or occupancy should be adequate to supply simultaneously each of the following conditions:

- The greatest sprinkler system (or deluge, water spray, foam water or other water based extinguishing system) demand in the facility. When evaluating the demand for deluge, water spray, or other special systems, the possibility of simultaneous discharge from multiple systems must be considered.
- The hose stream requirements associated with the occupancy protected.
- Any exposure protection required, e.g., water curtains, hose streams, to prevent the spread of fire to adjacent fire areas.

### **Yard Storage or External Structure**

The water supply for a yard storage or external structure should be adequate to supply simultaneously each of the following conditions:

- The water demand needed to protect against or combat any fire in yard storage or to protect any external structure, tank, etc.
- Any exposure protection required for buildings threatened by a fire in yard storage or in the external structure.

### **Exposure Protection**

The water supply should be adequate to supply the anticipated water demand needed to protect buildings threatened by fire from the most severe credible exposure hazard, e.g., hose stream and open sprinkler protection for a neighboring lumber yard fire.

### **Catastrophic Hose Demand**

The water supply should be adequate to supply the anticipated hose stream and exposure protection demand needed to protect the remainder of the facility if a fire is uncontrolled in any one fire area.

The determination of the water supply needs for each of these cases can be broken down into two basic steps:

- Sprinkler system (or other water based extinguishing system) demands.
- Manual fire fighting demands.

Once these demands are determined, the adequacy of an existing water supply can be evaluated or the water supply requirements established for a new facility.

## **SPRINKLER SYSTEM DEMANDS**

Sprinkler systems are of two basic designs: hydraulically calculated and pipe schedule. Each design requires a different approach when estimating the water demand.

### **Hydraulically Designed Systems**

The sprinkler density required to protect the hazard (usually specified in gpm/ft<sup>2</sup> or L/min/m<sup>2</sup> over an area of application, or number of operating sprinklers and sprinkler operating pressure) is selected from the appropriate standard (NFPA 13, NFPA 15, NFPA 16 or other guide) and the pipe sizing is based on friction loss calculations. With this type of system, the demand (flow and pressure) needed at the base of the riser becomes a known quantity.

### Existing Systems

For an existing hydraulically designed system, the system flow and pressure at the base of riser should be known. To determine the adequacy of the system design, it is necessary to:

- Determine the occupancy hazard being protected. Refer to PRC.12.1.1.0 for guidance on Occupancy Hazard Classification.
- Verify that the sprinkler system design is adequate for the current hazard.
- If the design is adequate, use the calculated base of riser demand.
- If the design is not adequate, recalculate the system demand based on the correct occupancy type using graphical analysis or hydraulic calculations.

### Proposed Systems

For proposed hydraulically designed systems, the flow and pressure required at the base of the riser will not be known until the system is designed. Therefore, it is necessary to estimate the minimum flow and pressure required to design the system.

The minimum theoretical flow required is obtained by multiplying the design density by the area of application. However, water is not distributed evenly to all sprinklers. Sprinklers closer to the riser discharge more water due to the higher available pressure. As a result, the theoretical flow-rate must be increased by 10% before it can be used as an estimate.

Where Control Mode Specific Application (CMSA) sprinklers are to be used, the pressure required should be selected as follows:

- Where a density of 0.30 gpm/ft<sup>2</sup> (12.2 L/min/m<sup>2</sup>) for 3000 ft<sup>2</sup> (279 m<sup>2</sup>) or less is needed, the residual pressure available at the estimated demand should be at least 50 psi (3.4 bar). Where the building is more than one story, nominal 15 ft (4.6 m), in height, the elevation loss should be added to this pressure.
- Densities above 0.30 gpm/ft<sup>2</sup> (12.2 L/min/m<sup>2</sup>) should have a residual pressure available at the estimated demand of at least 75 psi (5.2 bar).

Where ESFR sprinklers are to be used, the high discharge pressure at the sprinkler may require pressures greater than 75 psi (5.2 bar) at the base of the riser.

There will be cases where lower pressures may be adequate to supply the recommended sprinkler design. A typical example is a strong public water supply at moderate pressures, 40–60 psi (2.8–4.2 bar), with an extremely flat supply curve.

When in-rack sprinklers are provided, both the ceiling and the in-rack sprinklers should be hydraulically calculated. The calculations should be balanced at the point where the in-rack and ceiling flows combine. When the in-rack sprinklers are supplied by a separate riser, the flows should be balanced at the common connection to the underground.

### Pipe Schedule Systems

The older approach in sprinkler system design is the pipe schedule system where each pipe is sized according to the number of sprinklers that it supplies. This type of system has considerable flexibility, however, it has a drawback in that the water supply requirements are not known. The sizing was developed over the years by “experience” and provided adequate protection with most water supplies. NFPA 13 provides pipe sizing tables for Light, Ordinary, and Extra Hazard occupancies.

The demand for a pipe schedule system is more difficult to determine due to the variations in spacing allowed. As with hydraulically calculated systems, a systematic approach is used to develop a probable demand.

1. Determine the occupancy hazard being protected. (See PRC.12.1.1.0 for guidance on Occupancy Hazard Classification.)

2. Determine the density required to protect the hazard. The density should be selected from the following:

**Light Hazard** - Hydraulically calculate the sprinkler system, since AXA XL Risk Consulting does not recommend light hazard pipe schedule systems.

**Ordinary Hazard Group 1** - 0.12 gpm/ft<sup>2</sup> for 3000 ft<sup>2</sup> (4.9 L/min/m<sup>2</sup> for 279 m<sup>2</sup>)

**Ordinary Hazard Group 2** - 0.17 gpm/ft<sup>2</sup> for 3000 ft<sup>2</sup> (6.5 L/min/m<sup>2</sup> for 279 m<sup>2</sup>)

**Extra Hazard Group 1** - 0.28 gpm/ft<sup>2</sup> for 3000 ft<sup>2</sup> (11.4 L/min/m<sup>2</sup> for 279 m<sup>2</sup>)

**Extra Hazard Group 2** - 0.38 gpm/ft<sup>2</sup> for 3000 ft<sup>2</sup> (14.7 L/min/m<sup>2</sup> for 279 m<sup>2</sup>)

3. Determine the pipe schedule and the spacing between sprinklers and branch lines used to install the system.
4. Using Table 1, select the system configuration that best matches the system layout, and obtain the most remote area demand. Note that this demand is applicable **at the connection of the last operating branch line to the cross main.**

These tables are based on wet systems and are calculated with a C factor of 120. Dry systems are calculated with a C factor of 100, so the results must be adjusted. This difference in C factor will result in an average flow increase of 10% and an average pressure increase of 40%. Therefore, when dry systems are being analyzed, the flows from the table should be multiplied by a factor of 1.1 and the pressure by a factor of 1.4.

5. Add the friction loss from the remote area back to the riser. This loss is estimated to avoid documenting the riser details needed to make an exact calculation. The procedure to use is as follows:

Assume that the cross main and riser are 6 in. (150 mm).

Using this distance and the flow obtained in step 4, calculate the friction loss back to the base of the riser using a C factor of 120 for wet systems and a C factor of 100 for dry systems.

Make an estimate of the distance between the remote area of the system and the riser, and multiply this distance by 300% for center feed systems and 600% for side feed systems.

6. Add the elevation loss to the top of the sprinkler riser.

**TABLE 1**  
**Wet Pipe Sprinkler System Remote Area Demands**  
 (For dry systems multiply flow by 1.1 and pressure by 1.4)

Spacing Line Head Density			Side Feed Systems						Center Feed Systems					
			6 Heads		8 Heads		10 Heads		6 Heads		8 Heads		10 Heads	
			gpm	psi	gpm	Psi	gpm	psi	gpm	psi	gpm	psi	gpm	psi
<b>Ordinary Hazard Pipe Schedule (1953) (2-3-5) ½ in. orifice, K = 5.6 3000 ft² Area of Application</b>														
8.0	12.5	0.12 <sup>*</sup> 0.17	632 729	30 39	665 759	34 44	664 757	40 52	645 737	27 36	648 740	38 51	645 736	35 45
8.5	15.0	0.12 0.17	532 744	37 71	572 774	35 68	522 730	41 78	515 721	31 59	513 717	33 64	512 716	38 72
9.0	12.0	0.12 <sup>*</sup> 0.17	605 743	31 46	597 733	36 53	593 728	37 55	613 751	28 41	578 711	29 43	576 708	33 49
10.0	10.0	0.12 <sup>*</sup> 0.17	617 704	29 37	671 765	33 43	666 760	37 48	637 744	24 32	641 731	27 36	640 731	32 42
10.0	12.0	0.12 <sup>*</sup> 0.17	528 717	32 57	558 756	33 60	558 757	37 67	541 735	27 48	540 734	29 53	542 740	33 61
12.0	9.0	0.12 <sup>*</sup> 0.17	587 722	29 43	619 760	32 48	617 758	41 61	607 743	27 40	640 785	34 51	590 725	33 50
12.0	10.0	0.12 <sup>*</sup> 0.17	516 701	31 56	544 739	34 62	542 736	39 70	444 604	24 44	522 709	28 51	522 710	33 59
12.5	8.0	0.12 <sup>*</sup> 0.17	611 698	28 36	650 742	30 39	659 751	38 49	620 707	25 32	630 718	25 32	625 713	31 40
15.0	8.5	0.12 0.17	497 696	33 63	517 723	31 59	562 785	40 75	520 715	25 47	537 749	27 52	537 774	33 64
<b>Ordinary Hazard Pipe Schedule (1906) (1-2-3) ½ in. orifice, K = 5.6 3000 ft² Area of Application</b>														
8.0	9.0	0.12 <sup>*</sup> 0.17**	942 942	37 37	987 987	40 40	1021 1021	45 45	964 964	29 29	977 977	31 31	961 961	36 36
9.0	8.0	0.12 <sup>*</sup> 0.17*	937 937	37 37	969 969	39 39	1019 1019	48 48	926 926	30 30	961 961	31 31	948 948	36 36
9.0	12.0	0.12 <sup>*</sup> 0.17	657 805	36 53	648 795	38 57	644 790	43 63	635 779	30 45	628 821	34 51	623 764	38 56
10.0	10.0	0.12 <sup>*</sup> 0.17	662 756	33 42	722 822	38 48	717 817	43 55	690 787	28 36	690 786	32 41	685 780	36 46
12.0	9.0	0.12 <sup>*</sup> 0.17	627 770	33 49	664 814	36 53	660 809	47 69	693 852	30 45	634 778	32 47	627 769	36 53
<b>Extra Hazard Pipe Schedule ½ in. orifice, K = 5.6 3000 ft² Area of Application</b>														
7.5	12.0	0.28 0.38	1144 1527	77 137	1102 1475	67 120	1083 1449	67 120	1090 1458	52 96	1067 1428	56 101	1065 1426	65 116
8.0	10.0	0.28 0.38	1150 1535	68 121	1131 1512	55 98	1103 1476	54 96	1101 1473	41 73	1079 1444	43 77	1077 1443	50 89
9.0	10.0	0.28 0.38	1143 1527	78 139	1123 1501	71 126	1096 1466	68 122	1090 1445	53 93	1073 1437	54 75	1074 1438	63 113
10.0	8.0	0.28 0.38	1166 1556	73 130	1110 1484	52 93	1132 1512	54 96	1083 1449	46 77	1105 1477	40 72	1103 1476	49 88
10.0	9.0	0.28 0.38	1148 1533	80 142	1112 1486	69 123	1121 1499	66 118	1098 1456	50 88	1101 1471	54 97	1095 1465	62 111
12.0	7.5	0.28 0.38	1162 1552	84 150	1098 1469	67 120	1130 1509	67 120	1044 1388	54 95	1088 1456	52 96	1108 1481	61 110

**Note:** Actual density exceeds that shown due to 7 psi minimum head pressure.

**Example:**

Building A is a machine shop protected by a wet ordinary hazard pipe schedule sprinkler system. The sprinkler system is a center feed system with 8 head branch lines. The spacing is 12 ft (3.7 m) between the branch lines and 10 ft (3 m) between the sprinklers. The elevation from the floor to the sprinkler heads is 18 ft (5.5 m). The building is protected by a single riser, and the most distant area is 200 ft (61 m) from the riser.

- A machine shop is an Ordinary Hazard Group 2.
- Required density is 0.17 gpm/ft<sup>2</sup> for 3000 ft<sup>2</sup> (6.9 L/min/m<sup>2</sup> for 279 m<sup>2</sup>).
- From Table 1, the remote area demand is 709 gpm @ 51 psi (2680 L/min @ 3.5 bar).
- Friction loss to the riser flowing 710 gpm (2683 L/min) through 600 ft (183 m) of 6 in. (150 mm) pipe is approximately 12 psi (0.83 bar).
- Elevation loss is 0.433 psi/ft × 18 ft (0.098 bar/m × 5.5 m) or 8 psi (0.55 bar).
- Total pressure required is 51 psi + 12 psi + 8 psi (3.5 bar + 0.83 bar + 0.55 bar) or 71 psi (4.9 bar).
- Sprinkler demand at the base of the riser is 710 gpm @ 71 psi (2684 L/m @ 4.9 bar).

**Exposure Protection**

When sprinklers are providing exposure protection and would be expected to operate in conjunction with the sprinklers in the area under evaluation, the demands for the exposure protection systems should be added to the sprinkler demands calculated above. For example, the demand for sprinkler protection for a conveyor opening in a fire barrier wall should be included when analyzing the inside demand, whereas exposure protection on the outside of a building due to inadequate separation from yard storage would be included in the analysis of the yard storage area.

AXA XL Risk Consulting recommends that all sprinkler systems for exposure protection be hydraulically calculated. Existing pipe schedule exposure protection systems should be calculated to determine the demand.

**Multiple System Operation**

When more than one sprinkler system is expected to operate, i.e., both in-rack sprinkler and/or exposure protection systems and ceiling sprinkler systems, the calculated system demands for each system should be balanced to the highest pressure before the flows are added together to determine the total sprinkler demand.

**MANUAL FIRE FIGHTING (Hose Stream) DEMAND**

The selection of a credible water demand for manual fire fighting efforts depends upon several factors. Some of the factors include the hazard being protected, the provision of inside hose connections, whether or not the building is of combustible construction, the exposures to the area being evaluated, and the catastrophic loss potential.

**Flow Requirements**

The water requirement for hose streams is based on occupancy hazard. The base hose stream demand, for both inside and outside hose streams, for sprinklered occupancies is as follows:

- Light and Ordinary Hazard - 500 gpm (1890 L/min).
- Extra Hazard, Group 1 - 750 gpm (2835 L/min).
- Extra Hazard, Group 2 - 1000 gpm (3780 L/min).
- High Piled Storage - Refer to PRC Guidelines PRC.8.1.0, PRC.10.2.1, PRC.10.2.3, PRC.10.2.6 and PRC.12.1.1.0.

This basic hose demand should be increased by 25% when any of the following conditions exist:

- **Combustible construction** — The presence of combustible building materials requires an additional hose demand to limit building damage.
- **Possible delay in public fire department response** — Many sprinkler designs contemplate fire control, but not extinguishment. The delay in public protection response may allow the fire to grow and require additional water for manual fire fighting.
- **Minimum protection design** — Designs in accordance with minimum NFPA standards, but less than recommended by the AXA XL Risk Consulting, may not provide the desired degree of fire control and require additional water for manual fire fighting.
- **Limited access** — Occupancies, located in a remote interior section of a large building, resulting in limited access may delay or inhibit manual response.

The demand for hose streams should be included, regardless of whether the hydrants are on public or private mains, since the fire department will use public hydrants located on mains supplying private mains if private hydrants are not available. AXA XL Risk Consulting expects hydrant protection to be available and, if not provided, hydrants should be recommended.

Where **manual fire fighting** is the essential line of defense, as in the protection of yard storage, protection from exposure fires, or when the sprinklers have failed to control the fire, alternative methods must be used to determine the hose demand. Due to the varying nature of yard storage, i.e., commodities, piling arrangements, hydrant layout, etc., it is difficult to provide guidelines that will cover all situations. Each situation will require individual review, and the following features should be considered in any evaluation:

- Location and type of yard hydrants.
- Number of hydrants that may be used.
- Presence and size of monitor nozzles.
- Distance between the storage and plant buildings or structures.
- Construction of exposed buildings.
- Layout and size of piles.
- Commodity being stored.
- Location of plant doors with regard to hydrants.

Water demands may be as low as 1000 gpm (3780 L/min) for small yard storage areas or as high as 6000 gpm (22,680 L/min) or more for large log storage piles. As a general rule, 500 gpm (1890 L/min) should be available for each yard hydrant that might be expected to be used. The demand for monitor nozzles should be based on the rating of the nozzle at 100 psi (6.9 bar) and straight stream flow. If the specific rating is not known, use 500 gpm (1890 L/min).

Where there is a severe exposure, e.g., lumber yard, flammable liquid tanks, yard storage of rolled paper, similar logic should be used when evaluating the exposure protection requirements. Guidance for log storage and other severe hazards can be found in other AXA XL Risk Consulting publications or PRC Guidelines.

While AXA XL Risk Consulting expects the sprinkler systems to control any fire that may occur, **occasionally sprinklers may fail**. This may be due to an impairment, or be the result of an occupancy change where the sprinklers have not yet been reinforced to protect the new hazard. While these situations may not be predictable, they pose problems to manual firefighting which must be considered.

Small facilities with a single fire area would not usually require more than the basic sprinkler and hose demand for manual firefighting. Larger facilities with several fire areas will require additional water to prevent the spread of fire. When sprinklers have failed to control the fire, the amount of additional water needed will depend on:

- The type of cutoff and rating, e.g., fire wall vs. fire barrier wall, 1 hr vs. 2 hr rating, or the separation between the hazard and the exposed building or structure. (See PRC.2.2.1.)

- Building construction.
- Hazards in adjacent areas.
- Size of the fire area burning out of control.

Some of the water demand allocated for sprinkler protection of the occupancy may be available for use to prevent spread of fire when the sprinklers have failed to control a fire. It may be possible to shut-off sprinkler systems that are not operating effectively, e.g., mains have broken following roof collapse, if the sprinkler control valves are located outside and are accessible.

Secondary supplies (see PRC.14.0.1) can also be used to supply the additional hose demands required for manual fire fighting efforts when provided. The demand for a specific risk should be estimated based on the above factors. Fire departments may use several thousand gpm for hose when a fire is out of control and this should not be overlooked.

### **Pressure Requirements**

As a general rule, 75 psi (5.2 bar) should be available for hose stream use. Lower pressures are acceptable in areas where there is a strong public fire department equipped with pumpers to boost the public water pressure, or where alternate suction sources are available, such as cooling tower basins, ponds, rivers or swimming pools.

### **TOTAL WATER DEMAND**

The total water demand is estimated by totaling the sprinkler and hose stream demands. Where the pressures required for the sprinkler and hose demands differ, the flow required for hose should be added to the sprinkler flow at the required sprinkler pressure. This total demand and pressure is then compared with the water supply to determine if the existing supply is adequate.

### **DURATION OF WATER SUPPLY**

Water supplies should be capable of delivering the anticipated demand as long as fire fighting efforts are necessary. In reality, this duration depends on a number of factors including the occupancy hazard, building construction, and the layout of the facility. The following should be used for water supply evaluation purposes, barring unusual circumstances:

- Light Hazard Occupancies – 1½ hours.
- Ordinary Hazard Group 1 & 2 Occupancies - 2 hours.
- Extra Hazard Occupancies - 3 hours.

**Warehousing Occupancies** - Refer to the applicable NFPA standards and associated PRC Guidelines.

### **SUMMARY**

The estimation of the water demand for a facility is a complex issue, and not one that can be determined by a simple formula. The hazards, exposures, building features, facility layout, fire department availability, and many other hazards must be taken into consideration, and good judgement used when evaluating a risk.