Technical Principles and Practices of Fire Prevention

Module Mercantile

MODULE OBJECTIVES

The students will be able to:

- *Identify mercantile occupancies.*
- *Identify the major fire and life safety hazards in mercantile occupancies.*
- *Given examples of potential hazards in mercantile occupancies, recognize the hazard and suggest a code-based solution for correcting the deficiency.*
- *Identify the major components of a heating, ventilating, and air conditioning (HVAC) system.*
- *Describe the procedures to inspect and ensure operational readiness of smoke removal or control systems.*
- *Describe the appropriate procedures to verify fire flow for a site.*

MERCANTILE OCCUPANCIES

Mercantile occupancies exist for the display and sale of goods, wares, or merchandise, and are open to the public. This category includes stores, shopping centers, auction barns, supermarkets, farmers' markets, and other similar occupancies. Mercantile occupancies appear in a wide variety of sizes from tiny shops to super stores and covered malls. They are characterized by undivided sales areas, and frequently have heavy fire loading. The combustibles occur in ways that promote rapid fire spread.

An example of the rapid fire spread likely in even a small mercantile occupancy is a craft supply store in a suburban strip mall. The store was 30 feet by 75 feet with two bathrooms in the rear. One of the bathrooms was, in fact, a storage room. The fire started in the storage bathroom at about 2:15 p.m., while the store was open for business. Occupants promptly reported the fire. First-arriving units saw fire in the rear of the store and went to the front door with a handline. As they entered the store, they faced a wall of fire moving toward them. They backed out to get heavier lines and within minutes, the roof was collapsing.

This fire was not unusual. There have been a number of reports of fires in occupied stores where customers literally were running for the exits to escape the fire.

The National Fire Protection Association (NFPA 101, *Life Safety Code)* subgroups this occupancy into:

- Class A: More than 30,000 square feet or more than three floors of sales area.
- Class B: 3,000 to 30,000 square feet of sales area above or below street level.
- Class C: Less than 3,000 square feet at street level.

Covered malls have special requirements.

INSPECTION CONSIDERATIONS IN MERCANTILE OCCUPANCIES

Common problems in mercantile occupancies include material handling, seasonal problems, storage of flammable liquids, means of egress problems, and special locking mechanisms.

Fire Protection Systems

Most mercantile occupancies require an automatic fire sprinkler system to achieve a reasonable level of fire and life safety. Building codes require sprinkler protection based on the size of the floor area and number of stories in height. Ensuring that the system is in good operating condition is an important consideration during inspection.

The system must be on, valves must be open, and test records must be on site and available for inspection. Sprinkler heads should not block merchandise hanging from the ceiling. Storage must be more than 18 inches below the sprinkler head deflector. Display racks, mezzanines, and other structures possibly added later may shield combustibles from the sprinkler system. Additional information on inspecting sprinkler systems is found in the module on storage.

Systems protecting rubber tires, aerosols, other hazardous merchandise, and rack storage more that 12 feet high will require a water supply that can deliver a higher density of water per square foot of sprinkler coverage.

Material Handling

Mercantile occupancies have a steady flow of merchandise moving into the occupancy, and a steady flow of trash and packing materials moving out of the occupancy. These materials may block aisles and exits. Rear exits are very susceptible. Materials allowed to accumulate can exceed the design load of the suppression system. Trash or waste handling rooms require a one-hour separation from mercantile areas.

Seasonal Problems

During holiday seasons, excessive merchandise may obstruct exit paths and increase fire loads. In the winter, access problems occur due to snow, and emergency vehicles may not reach the occupancy easily. Parking and traffic around shopping centers and malls can create severe access problems at such times. During some holiday periods, a high-occupancy level may cause congestion. A fire likely would necessitate a longer evacuation time.

Storage of Flammable Liquids

Merchandising

Small quantities of flammable liquids are common and are permitted in mercantile occupancies. Larger quantities require a permit and may change the occupancy to a high-hazard classification.

Other Hazardous Materials

Mercantile occupancies frequently contain other hazardous materials, including liquefied petroleum gas (LPG), pesticides, swimming pool chemicals, and aerosols. Size and type of LPG containers limit the number allowed. Other fire code provisions may apply to toxic materials and oxidizing agents. Compatibility can be a concern with strong oxidizing pool chemicals not stored or displayed with flammable or combustible liquids.

Egress Paths

Unobstructed signs should mark egress doors which need to remain unlocked during occupancy. Special alarm or delay locks of an approved type are permitted. Some doors may be locked when a minimum number of employees are present. The main aisles must remain clear of merchandise and other obstructions. While stocking shelves or receiving deliveries, the occupants must assure that temporarily blocked aisles do not create excessive travel distances or lead to dead ends.

Covered Malls

Special design criteria apply to all covered malls. Anchor stores may have means of egress separate from the mall. The operational readiness of fire protection systems is critical. Interior corridors provide both emergency egress and merchandise delivery, so inspectors need to verify that all exit corridors are kept clear. Control of small leasing areas within the common mall area is critical to prevent obstruction to the required clear width space in the mall area.

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

Overview

HVAC systems exist in most occupancies and present unique problems for the inspector.

Heating and ventilation always have been critical design-limiting factors in building construction. Imagine a massive covered mall in New Hampshire heated with open fireplaces. Or, imagine the same mall in the Southwest cooled with some open windows. During the last century, advances in air-quality management system technology have changed radically the way new buildings can be constructed. The change from open fire to ultra-high efficiency indoor air-quality management systems has occurred over a relatively short span of time.

The first step was to bring fire inside to an open fireplace. Fireplaces are inefficient and dirty. Significant amounts of heat go up the chimney. Creosote and related products of combustion provide fuel for chimney fires. The fireplace can serve only a limited area. Large buildings had many fireplaces resulting in multiple opportunities for igniting the building or contents. Fresh air ventilation came from building leakage or open windows, and cooling from open windows.

The cast-iron stove has most of the same deficiencies as a fireplace. However, the stove was more efficient and it could burn coal effectively.

The development of boilers allowed central heating by natural convection through radiators filled with circulating steam or hot water. Much less heat went up the chimney. Large buildings were supplied with heat from a single boiler or from a boiler that served more than one building. Better temperature control and improved occupant comfort resulted. Fresh air and cooling occurred from leakage, open windows, and fans. Thinner fins in the radiators and heat exchanges, and forced air further increased efficiency and effectiveness. Building size still was limited by the need for windows for ventilation and cooling. Building designs included narrow cross sections, lightwells and courts, and exterior walls with large indentations to provide more windows. Buildings were L shaped, U shaped, E shaped, or formed into a square with an open area within.

Air-Conditioning Systems

Finally, the development of larger air-conditioning systems coupled with fluorescent lighting enabled the development of very large buildings. The building's mechanical system made managing the inside environment and the properties related to personal comfort much easier.

Many people think of air conditioning only as a cooling system. Air conditioning actually includes the treatment and distribution of air to meet the comfort requirements of people in confined spaces by controlling temperature, humidity, and cleanliness. Except for individual units, the systems include duct work and fans that have the potential to spread the heat and smoke of a fire. Because of the cost of conditioned air, most larger buildings do not allow occupants to open windows and thus "waste" the treated air.

The HVAC system adds or removes humidity and heat. A controlled amount of outside air enters the building, and a controlled amount of inside air leaves, usually through bathroom vents.

In the most simple system, moving air over finned metal tubing supplies heat. Air movement may be through natural convection, through baseboard units, or forced by a small fan. A thermostat controls either the flow of hot and cold water through the tubing or the operation of the fan. The building's natural leakage provides fresh air.

Larger buildings require more complex systems. Air gets cleaned by passing through filters or electrostatic air cleaners. Filters may be reused, disposed of or coated with an adhesive material. The filter and the adhesive material should be selected to avoid the serious hazard of a filter fire. Buildup of combustible particles on the filters also can be hazardous. Through these systems, humidity, heat, and a controlled amount of outside air enters the building. Industrial applications may include higher levels of air cleaning for "clean" rooms or the removal of contaminants and pollutants.

Heating appliances and equipment are among the most prevalent causes of fires because their function is to operate at or above the normal ignition temperature of many combustible materials.

A defective or overheated heating unit is one of the leading causes of fires. Some related hazards commonly found are

- improper installation;
- improper maintenance;
- improper operation;
- inadequate clearance between appliance and combustible materials;
- inadequate clearance of flue pipes and vents; and
- inadequate clearance of steam pipes.

For additional information on the installation of equipment, the inspector should consult local codes and these additional standards:

- NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

- NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*.

- International Mechanical Code.

Distribution System

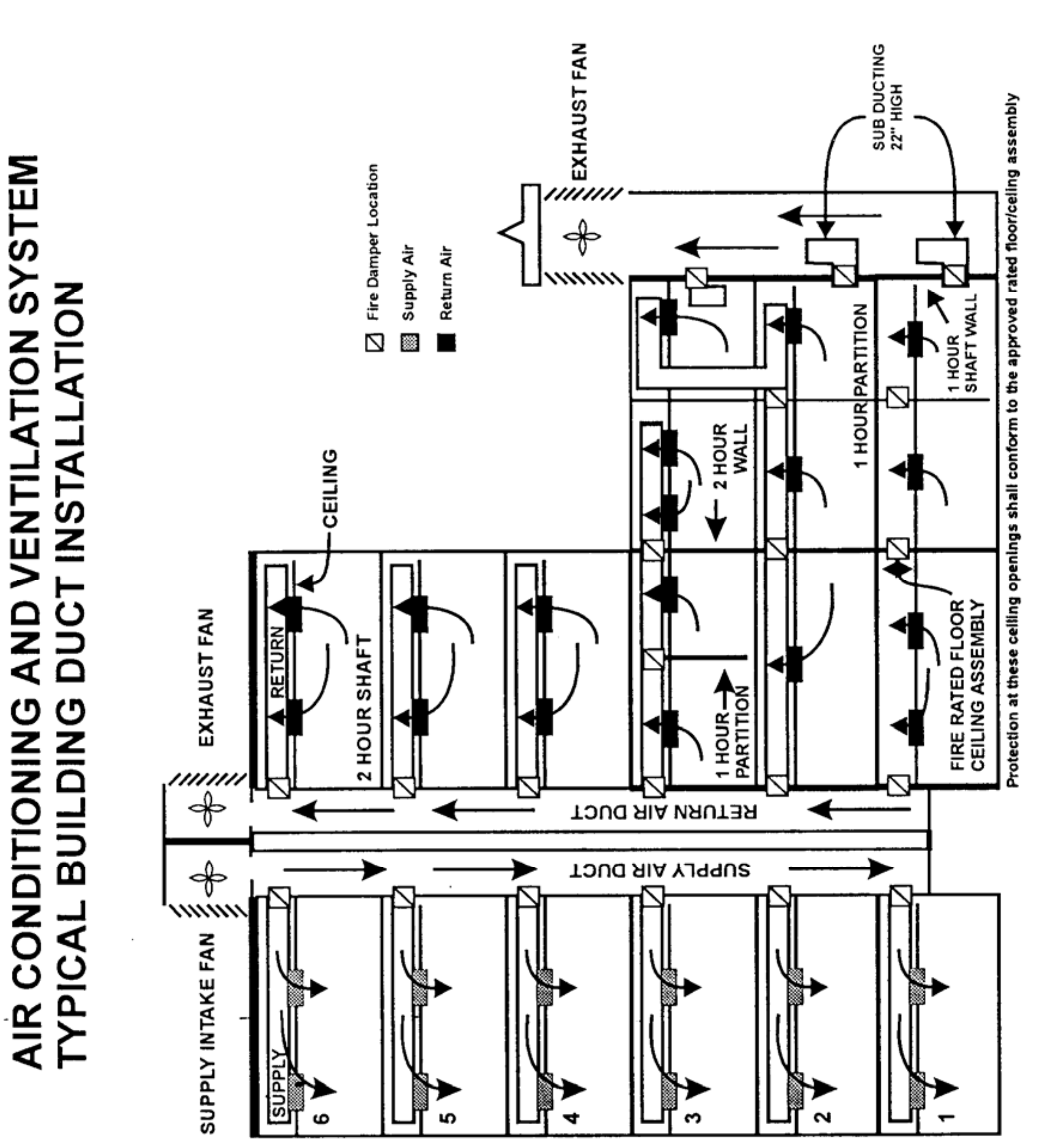
A large system has extensive duct work. The ducts pass through the floors and walls that enclose separate fire areas. The distribution system collects and redistributes air throughout the building or portions of the building. The system will replace part of the air in the building with a controlled quantity of outside air. The space above a dropped ceiling frequently serves as a return air plenum. Cables and other materials used in the plenum space must be selected to reduce the possibility of fire and smoke development in the plenum. In the event of a fire in the building or in the filter system, the duct work can spread smoke, toxic gases, and heat rapidly through the area and feed fresh oxygen to the fire. In some buildings, air-handling systems may continue to spread products of combustion until the system is shut down or redirected manually, or until the fire causes one part of the system to fail. Newer buildings have built-in safeguards to shut down the HVAC system automatically to prevent smoke distribution through the building. Except when the HVAC system functions as part of a smoke control system, automatic shutdown requires the installation of smoke detectors in duct work when the system exceeds an air flow of 2,000 cubic feet per minute. Ducts passing through fire-resistance-rated separations of 1 hour or more are required to be protected with approved fire dampers.

Operational Readiness of Exhaust or Smoke Control Systems

Building codes require certain buildings to have a built-in system to control and exhaust smoke. The system may use part or all of the normal HVAC system or it may be a completely independent system. These systems can be very complex, and the functional design of the system is frequently not obvious. The inspector must determine the designed mode of operation before evaluating the system readiness. In many cases, it is possible to test the function of only some of the components, and not the total system.

The system may include exhaust fans to remove smoke and supply fans to pressurize some part of the structure. The system will contain fire dampers and air limitation dampers (smoke dampers). Finding these dampers can be very difficult, and testing them may be nearly impossible. The owner of the system, or the owner's designee, is responsible for testing the system. The systems must be tested at least every six months, and written records, maintained by the owner, must be available for inspection.

Distribution System



DETERMINING AVAILABLE FIRE FLOW

As you drive down a country road, you pass through a small town and observe a fire hydrant in the town center. Four miles further, you see another hydrant at the entrance to a new housing development. The two hydrants look identical, but are they the same? The hydrant in the town is the only hydrant in a very small private system. The available fire flow is less than 100 gallons per minute (gpm). The second hydrant at the new development is on an 8-inch branch main 30 feet from a 20-inch main. This is the first hydrant in a large system, and it is located within 1,000 feet of a one-million-gallon elevated storage tank. The mere presence of a fire hydrant does not mean adequate fire flow.

Continuing on your trip, you drive through the major suburbs of a large city. A consolidated water commission serves a population of more than a million and a half people. The commission has a reputation of providing excellent fire protection flows. How would you know that in some of the older residential areas some of the original small mains installed before the commission was formed are still in use? The static water pressure at nearby hydrants on new and old mains could be the same, but flows will be very different. Fortunately, firefighters in this area know the approximate flows of their hydrants and can adjust requirements as needed.

We test fire hydrants to determine the flow available for fire suppression, for fire protection systems, or to evaluate the condition and functioning of the water delivery system. The fire-flow testing procedures in this module are applicable to all occupancies, not just mercantile.

An important part of any fire department preincident planning (PIP) process is the matching of available fire flow with the anticipated demand at a particular location. The only practical method of determining the available fire flow in a water distribution system is to perform fire hydrant flow testing. Without proper color coding or accurate flow test data, there is no way to know the available fire flow.

The utility that supplies the water supply also is responsible for testing most public fire hydrants. The responsibility for testing private hydrants rests with the owner or the owner's insurance company. Under some circumstances, an inspector may have to conduct a hydrant flow test. More frequently, the inspector will get results from a third party. The inspector needs to understand the process and how to use the results.

Fire suppression water supply criteria can be found in the following sources:

- Insurance Services Office (ISO) requirements;
- NFPA 1142, *Standard on Water Supplies for Suburban & Rural Fire Fighting*;
- Iowa formula;
- National Fire Academy (NFA) formula;
- Uniform Fire Code (UFC) requirements; and
- International Fire Code, Appendix.

Sprinkler and standpipe design criteria can be found in these sources:

- NFPA 13, *Standard for the Installation of Sprinkler Systems*;
- NFPA 14, *Standard for the Installation of Standpipe & Hose Systems;*
- other NFPA requirements; and
- local requirements.

System Condition

One benefit of a regular testing program is the ability to detect the diminished capacity of water mains. Over time, scale on the inside wall (called tuberculation) can reduce the inside diameter of the main. Testing also can discover closed valves, and allows one to check the operation of pumps.

Test Method

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Fire Hydrants* is the best method to follow, because it ensures a standard test with results comparable to other tests. There are many fire service water supply text books and manuals that include detailed instructions.

Testing

Most testing is done to determine flow available for fire suppression and fire protection systems. It is the only practical way to measure available flow. The static pressure is not an indicator of system capacity. Static pressure normally indicates the difference in altitude between the hydrant and the water source. A hydrant on a 4-inch main and a hydrant on a nearby 16-inch main may have the same static pressure, but the available flow in the two hydrants will be radically different.

The starting point for any fire-flow evaluation is the utility supplying the hydrant. The utility's database should have the needed information. It also may be willing to do the testing for you. If not, it can supply the necessary information and maps to enable you to evaluate the system and determine the correct hydrants to test.

The test requires that three data elements be collected: the static pressure in the main, the flow in gpm from a hydrant, and the residual pressure when the water is flowing. Using these three pieces of data and special hydraulic graph paper, you can determine available flow. Available flow normally is calculated at 20 pounds per square inch (psi) residual. The pressure should not go below 20 psi in the mains during testing or operation. There is one exception, however: if the static pressure is below 40 psi, the calculation is made to one-half of the static pressure.

Selecting Hydrants to be Flow Tested

Fire hydrant testing involves using one hydrant to measure the system pressure (the test hydrant) and one or more hydrants to flow water. The test hydrant is the hydrant nearest the property or hazard being evaluated. Use water system maps to evaluate main sizes, and to locate valves and the arrangement of the mains in the area. Mains may have loops and bridges to reduce friction loss, or they may be dead-end lines. It may be possible to determine the direction of flow. Choose hydrants that are close to the hazard or another point where you seek flow information.

The flow hydrant is the one from which water actually will flow during the test. The best choice for the flow hydrant is the adjacent hydrant situated downstream in the line of normal water flow in the main. The normal flow always will be from larger mains to smaller mains in a circulating system because water normally takes the path of least resistance. In a grid system with multiple supply points, it may not be possible to determine direction of flow. This will not significantly affect the accuracy of the test. In some cases, it may be necessary to have several flow hydrants opened to draw enough water from the main to cause a sufficient drop in the pressure.

After selecting the test hydrants and the time of the test, the inspector must get permission from the owner of the hydrant. If practical, a member of the owner's maintenance staff should be present during testing. If these are private hydrants, the owner may receive a bill for the water used.

Tools and Equipment

There are some basic tools needed for hydrant inspection.

- notebook; pen or pencil;
- good ruler scaled to 1/16 inch;
- two different types of gauges:
  - the pressure gauge with appropriate fittings to attach to hydrant outlets measures the static and residual hydraulic pressure in the system; and
  - the Pitot tube gauge measures the velocity pressure of the stream when it is no longer restrained by the wall of the hydrant;
- special graph paper to plot results;
- set of discharge tables for circular outlets; and
- one or two hydrant wrenches.

Some optional tools may come in handy:

- electronic flow meter;
- specialized gauges;
- specialized electronic calculators; and
- additional gauges for more complex water system evaluations.

Safety Considerations

There are various precautionary steps an inspector needs to take before starting the inspection. Examine the outside of the hydrant for signs of damage. Make sure all hydrant caps that you will **not** remove for the test are on tight. Check the area where the water will flow. The force of water flowing through a 2-1/2-inch opening can cause considerable damage if discharged into an inappropriate location. Additional personnel may be necessary to route traffic or pedestrians around the discharge area. Be cautious about testing in subfreezing temperatures to avoid an ice problem, especially on roads and sidewalks.

Dry barrel hydrants should be both opened fully and closed fully. The dry barrel hydrant has a valve in the base to drain the water. If the hydrant is partially open, this valve is open. This allows the pressure of the water to undermine the hydrant.

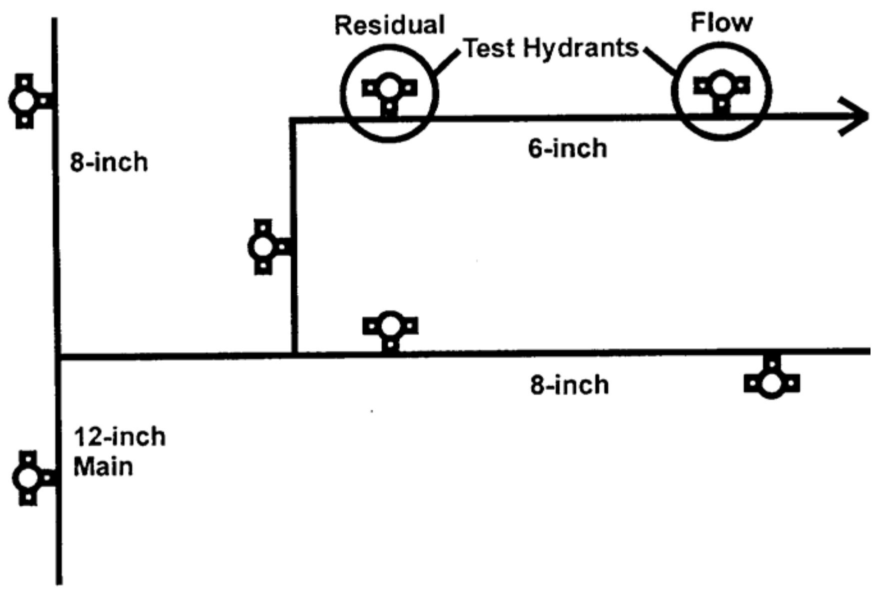
Procedure

The procedures for testing water flow are not complex; however, the inspector must complete each of the nine steps in its proper turn.

Step 1

Select the hydrants in the test area and assemble necessary tools, equipment, and forms. Get necessary authorizations to test. Use water system maps to pick one hydrant to measure static and residual pressure and one or more hydrants to measure flow. It is preferable to have the water flow past the residual pressure hydrant. If the system is looped, it may not be possible to determine the direction of flow.

STEP 1: SELECT TEST HYDRANTS



Step 2

Prepare the test hydrant and measure the static pressure.

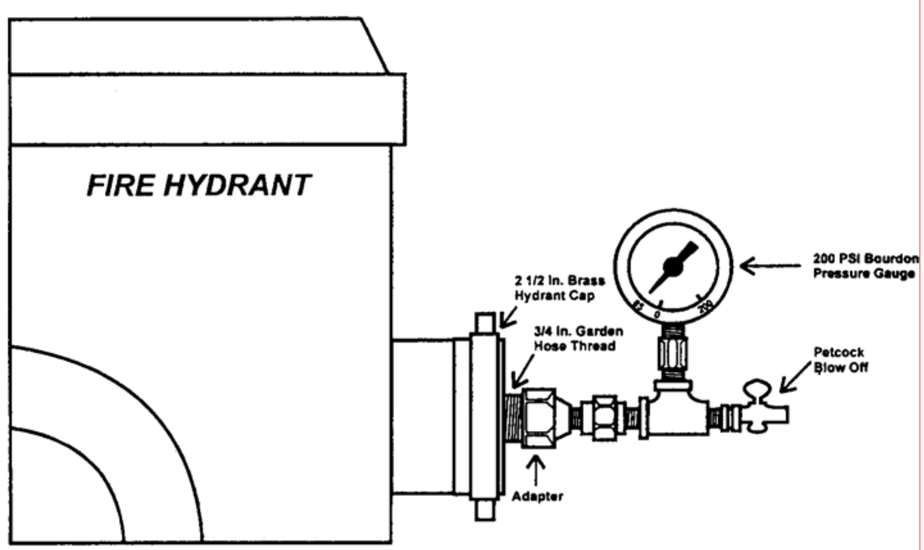
Examine the outside of the hydrant for signs of damage or any markings. Make sure that those hydrant caps not removed for the test are tight. Remove the cap where the gauge will be installed and remove any debris in the opening. Open the valve slightly and briefly flush the hydrant. Attach the gauge to an outlet of the test hydrant and open the bleeder valve. Slowly open the hydrant to the fully open position and bleed air from the hydrant. Close the bleeder valve.

Read the static pressure. It is called static pressure because, theoretically, this is the pressure in the main when no water is flowing. Since water is almost always moving for domestic use, a true static condition exists very rarely. Sometimes you can test private mains to get a true static pressure during a time when no activity is taking place. Generally, the pressure reading with no test water flowing is accurate enough for most purposes.

Special forms make hydrant testing easier; these forms are available from several sources. Enter the time and date of the test in the appropriate location. Identify the hydrants to be tested and indicate their designation as pressure and flow. Diagram the size of the water main and the direction of flow, if known. Enter the first test data--static pressure--on the form.

STEP 2: FLUSH PRESSURE HYDRANT

- Remove Cap
- Attach Gauge To Outlet
- Slowly Open And Bleed Air
- Record Static Pressure



Step 3

Remove the cap and briefly flush the flow hydrant. Measure the internal diameter to the nearest 1/16 of an inch. Check the configuration and determine the coefficient for the hydrant. The coefficient usually is found in raised numbers on the hydrant.

Prepare the flow hydrant in the same way as the test hydrant. Make sure that the caps that will not be removed are tight. Check the exterior of the hydrant for damage and any markings. Check the area where the water will flow. Remove the cap from the flow hydrant outlet you will use.

Check the configuration of the outlet. Anything--a valve, a nozzle or a hydrant butt nipple--in the path of flowing water is a partial obstruction. About 1890, John R. Freedman developed the formulas used to determine flow through a circular opening. Freedman compared ideal flow to actual flow and determined that a coefficient was needed to determine the actual flow through the opening accurately.

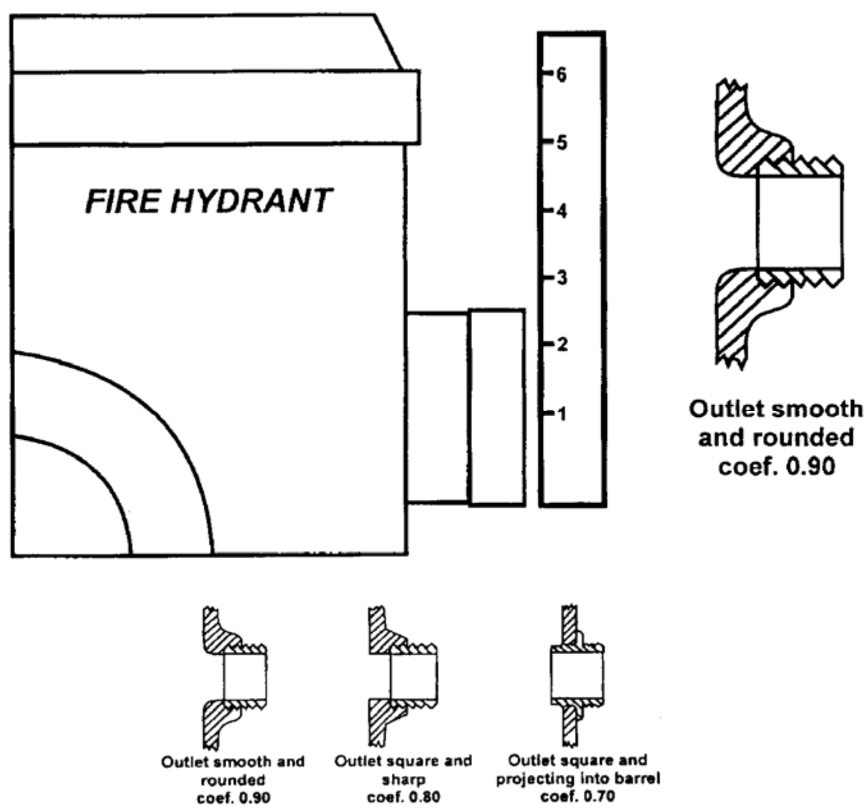
The hydrant coefficient is the measure of the degree that the outlet impedes the flow of water. In a perfect design with no loss, the flow would equal the area of the opening multiplied by the velocity of the water, and the coefficient would be one. Because that is not possible, the theoretical flow from the hydrant is reduced by a factor of .9, .8, or .7 to get the actual flow. The more restriction and turbulence created, the lower the coefficient.

Measure the inside diameter of the opening. All hydrants are not exactly 2-1/2-inches. The actual diameter is critical for accurate results. The larger outlets or steamer connections on the hydrant normally are unreliable, because the stream from larger outlets contains void spaces that degrade the accuracy of the flow calculations.

Enter the inside diameter and the coefficient on the form. If you use a special flow adapter, record the coefficient and the diameter.

STEP 3: FLUSH OUTLET HYDRANT

- Remove Cap
- Flush And Check Outlet Configuration
- Measure Inside Diameter Of Opening
- Record Diameter And Coefficient
- If An Adapter Or Nozzle Is Used, Record Its Diameter And Coefficient



Step 4

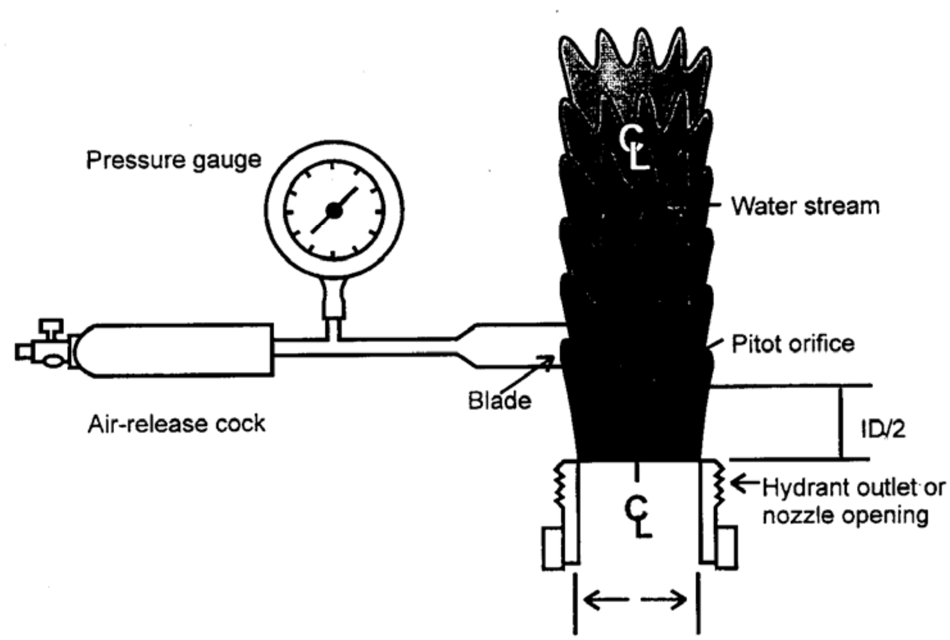
Carefully open the hydrant to the fully open position. Insert the blade of the Pitot tube into the center of the stream. If possible, hold the blade approximately one half the diameter of the stream in front of the outlet for the most accurate reading. The blade should be parallel to the face of the opening. Hold the gauge blade as steady as possible in the stream. The Pitot gauge measures the velocity pressure of the water.

Enter the Pitot pressure on the form. Close the hydrant when all pressure readings are complete.

STEP 4: RECORD READINGS

– Carefully Open Hydrant

– Take And Record Readings By Holding Pitot Tube Steadily In The Stream



Step 5

Read and record residual pressure at pressure hydrant.

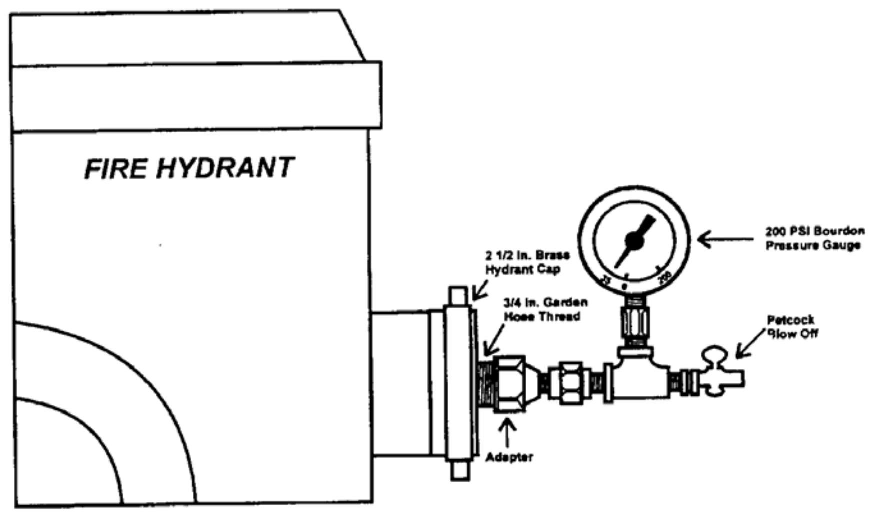
Observe the residual pressure. Measure residual and static pressure with the same gauge on the same hydrant. When water flows from the flow hydrant, the pressure in the main drops to a lower figure. This is called the residual pressure. The more water being discharged, the lower the residual pressure drops. Pressure at the test hydrant should not go below 20 psi.

To get good test results, drop the residual pressure to a point at least between 50 and 75 percent below the static pressure. If opening the single 2-1/2-inch butt does not cause enough drop, open the second butt and measure the flow from both. If necessary, open additional hydrants around the test hydrant. The flow is the sum of all flowing outlets being used.

Enter the residual pressure on the test form. Replace all caps and restore the system to normal. Report any deficiencies noted. Use the data you have collected and recorded to calculate the available fire flow.

STEP 5: RECORD RESIDUAL PRESSURE

- **Record Pressure Hydrant Reading**
- **If Needed, Simultaneously Open Additional Hydrants And Record Data**
- **Pressure Should Not Go Below 20 Psi**



Step 6

Use a discharge table to determine flow. Tables of discharges exist in NFPA 291, the NFPA *Fire Protection Handbook*, and other reference books. Determine the flow by finding the intersection point of the outlet diameter and the measured Pitot pressure. Some tables have a coefficient of 1.0, and the value from the table must be multiplied by the actual coefficient. Other tables are available with the actual coefficients already applied. Check the table carefully. The Pitot pressure is used only to determine the flow through the outlet.

STEP 6: USE TABLE TO DETERMINE FLOW

Distribution System Worksheet

Discharge Table For Circular Outlets
in Gallons per Minute (U.S.)
(Outlet Pressure Measured by Pitot Gauge)

OUTLET PRESSURE LBS.SQ.IN..	OUTLET DIAMETER IN INCHES											
	2 3/8	**2 1/2**	2 5/8	2 3/4	2 7/8	3.0	3 1/8	3 7/8	4.0	4 3/8	4 1/2	4 5/8
1	150	**170**	180	200	220	240	260	400	430	510	540	580
2	210	**240**	260	290	310	340	370	570	610	720	770	810
3	260	**290**	320	350	380	420	450	700	740	890	940	990
4	300	**340**	370	410	440	480	530	810	860	1030	1090	1150
5	340	**380**	410	450	500	540	590	900	960	1150	1220	1290
6	370	**410**	450	500	540	590	640	990	1050	1260	1340	1410
7	400	**440**	490	540	590	640	690	1070	1140	1360	1440	1520
8	430	**480**	520	570	630	680	740	1140	1220	1450	1540	1620
9	450	**500**	550	610	670	730	790	1210	1290	1540	1640	1720
10	480	**530**	580	640	700	760	830	1280	1360	1630	1730	1820
11	500	**560**	610	670	730	800	870	1340	1430	1710	1810	1910
12	520	**580**	640	700	770	840	910	1400	1490	1780	1890	1990
13	550	**610**	670	730	800	870	950	1450	1550	1850	1960	2070
14	570	**630**	690	760	830	900	980	1510	1610	1920	2040	2150
15	590	**650**	720	790	860	940	1020	1560	1660	1990	2110	2220
16	610	**670**	740	810	890	970	1050	1620	1720	2060	2180	2300
17	620	**690**	760	840	910	1000	1080	1660	1770	2120	2240	2370
18	640	**710**	780	860	940	1030	1110	1710	1820	2180	2310	2440
19	660	**730**	810	890	960	1050	1140	1760	1870	2240	2370	2510
20	680	**750**	830	910	990	1080	1170	1800	1920	2290	2430	2570
22	710	**790**	870	950	1040	1130	1230	1890	2020	2400	2550	2700
24	740	**820**	910	1000	1090	1180	1290	1970	2110	2510	2660	2810
26	**770**	**860**	940	1040	1130	1230	1340	2050	2190	2620	2770	2930
28	800	890	980	1070	1170	1280	1390	2130	2280	2720	2880	3040
30	830	920	1010	1110	1210	1320	1430	2210	2350	2820	2980	3150
32	860	950	1050	1150	1260	1370	1480	2280	2430	2910	3080	3250
34	880	980	1080	1180	1290	1410	1530	2350	2510	3000	3170	3350
36	910	1010	1110	1220	1330	1450	1580	2420	2580	3080	3260	3440
38	930	1040	1140	1250	1370	1490	1620	2480	2650	3170	3350	3540
40	960	1060	1170	1290	1400	1530	1660	2550	2720	3250	3440	3630

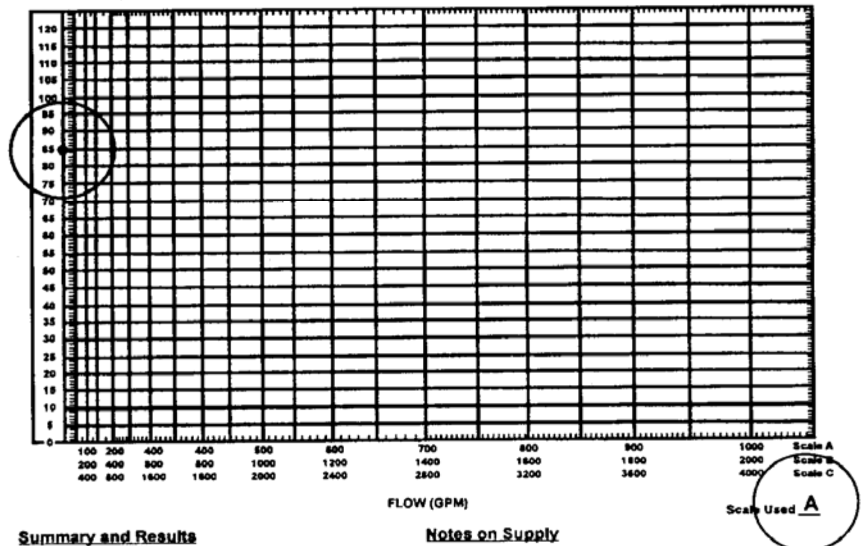
∗Computed with the coefficient C = 0.90, to the nearest 10 gallons per minute.

Step 7

Plot the static pressure on the zero flow line on the left edge of the graph. The graph paper has various flow levels listed across the bottom. The numbers start with zero at the left axis and increase from left to right. Pressures are indicated along the left axis. Zero psi is at the bottom and pressures increase from bottom to top.

STEP 7: RECORD DATA ON FORM

- RECORD ALL DATA IN "HYDRANT GAUGE READING" BOX AND "HYDRANT DISCHARGE DATA" BOX
- INDICATE FLOW ON ZERO FLOW LINE ON LOGARITHMIC CHART.



Post _____ Test No. _____ Date __________

Location of residual hydrant __________

Area _____

Previous Year's Flow___ gpm at ___ psi

Static psi ___ Observers __________

Location Sketch

Hydrant Gauge Readings	
	Pressures in PSI
Hydrant closed (static)	85
Hydrant opened (residual)	35

Hydrant Number	Outlet Diam. inches	Pitot Pressure PSI	Discharge GPM	Remarks
2	2 1/2	26	860	

Total Discharge _______ gpm

Summary and Results

Static pressure ____ psi

Test pressure _____ psi

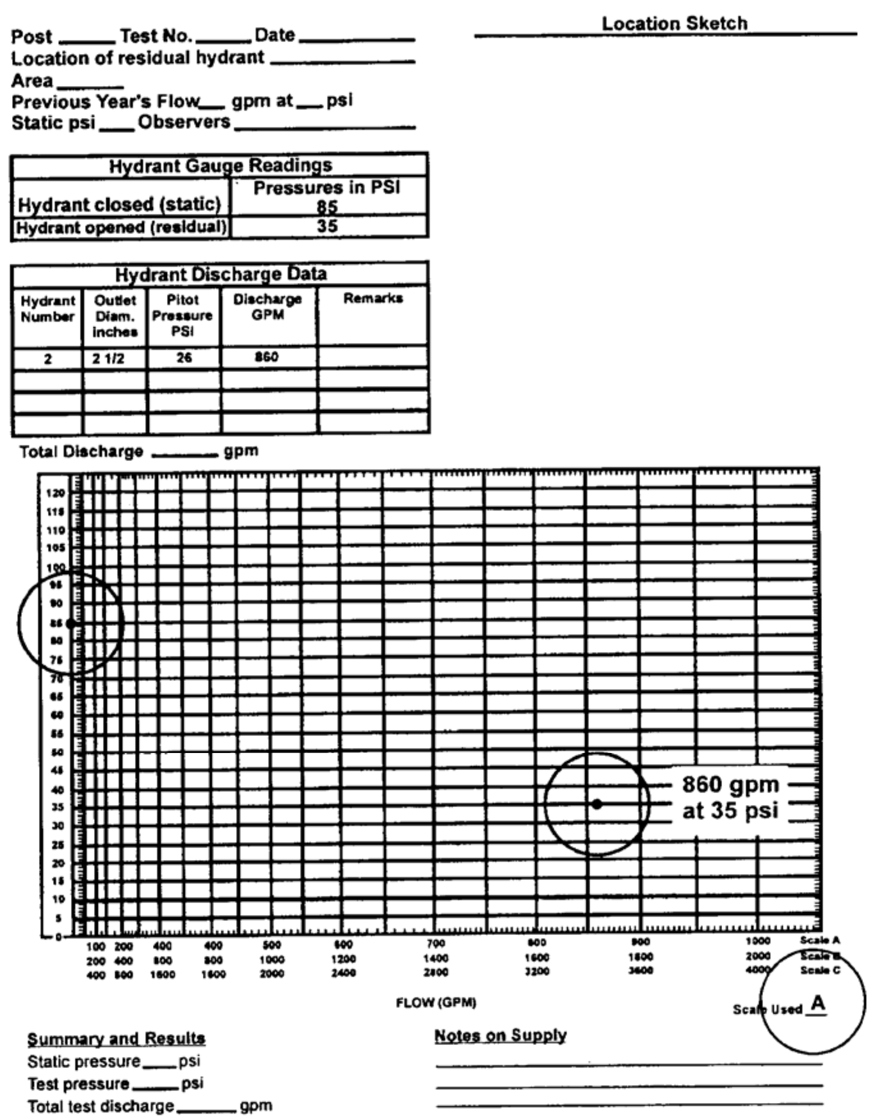
Total test discharge _______ gpm

Notes on Supply

Step 8

If the graph paper has multiple scales on the bottom, select the scale that best matches the flow recorded. Use the flow through the opening and the residual pressure to find the next point. The point is the intersection of the pressure line from the left side and the flow line from the bottom. The multiple scales are used for increased flows. What scale you will use is related directly to having your connecting straight line axis cross the 20 psi pressure line before the line goes off the graph chart as shown in Steps 8 and 9.

STEP 8: RECORD GPS's ON PSI SCALE


Post _____ Test No. _____ Date ___________
Location of residual hydrant ____________
Area ______
Previous Year's Flow___ gpm at ___ psi
Static psi ___ Observers ______________

Location Sketch

Hydrant Gauge Readings	
	Pressures in PSI
Hydrant closed (static)	85
Hydrant opened (residual)	35

Hydrant Discharge Data				
Hydrant Number	Outlet Diam. inches	Pitot Pressure PSI	Discharge GPM	Remarks
2	2 1/2	26	860	

Total Discharge ______ gpm

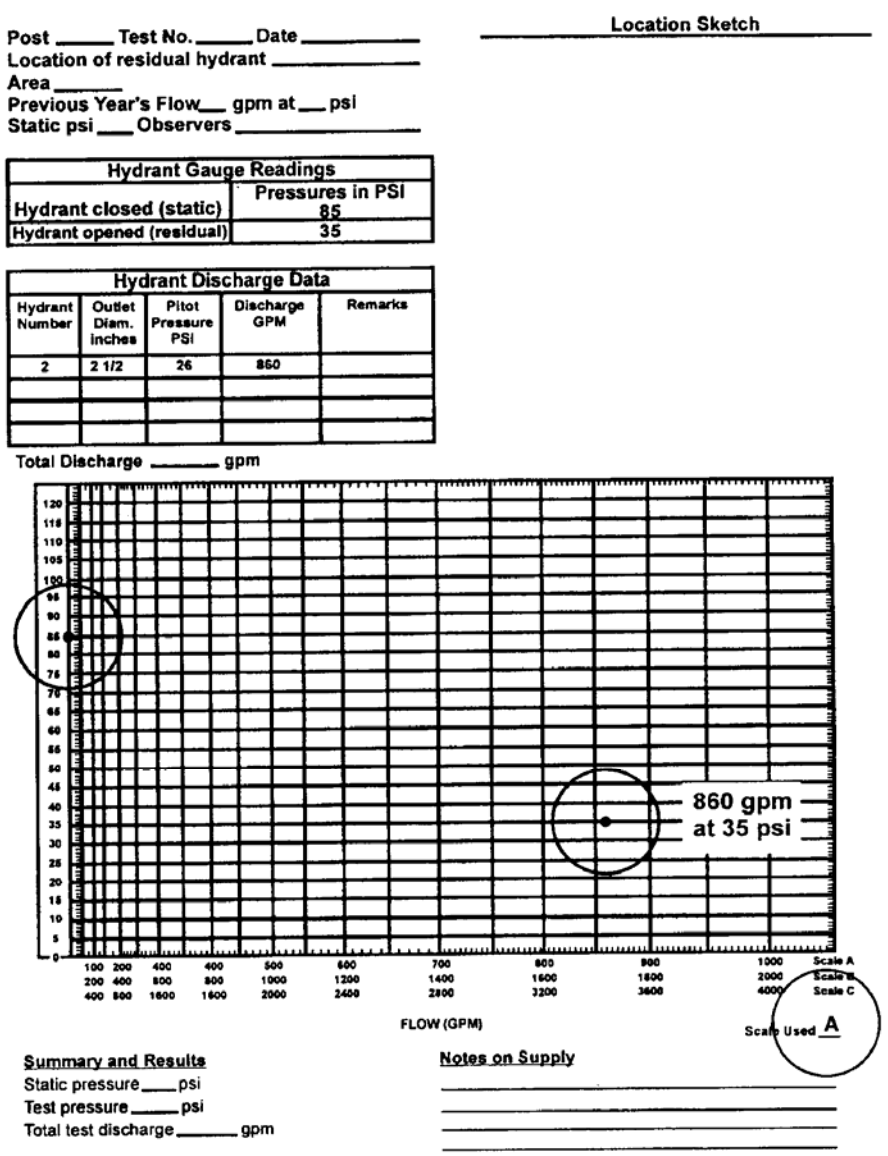
Summary and Results
Static pressure ____ psi
Test pressure _____ psi
Total test discharge ______ gpm

Notes on Supply

Step 9

The graph now has two points: static pressure at zero flow and residual pressure at measured flow. Draw a line from the static point on the left axis through the second point. This line should continue to a point after it crosses the 20-psi line. Read the available fire flow at the point where the line crosses the 20-psi line.

STEP 9: CONNECT POINTS AND EXTRAPOLATE TO 20 PSI



Post _____ Test No. _____ Date ___________
Location of residual hydrant ______________
Area _______
Previous Year's Flow___ gpm at ___ psi
Static psi ___ Observers ________________

Location Sketch

Hydrant Gauge Readings	
	Pressures in PSI
Hydrant closed (static)	85
Hydrant opened (residual)	35

Hydrant Discharge Data				
Hydrant Number	Outlet Diam. inches	Pitot Pressure PSI	Discharge GPM	Remarks
2	2 1/2	26	860	

Total Discharge _______ gpm

Summary and Results
Static pressure ____ psi
Test pressure _____ psi
Total test discharge ______ gpm

Notes on Supply

Water Supply Formula

You can use the actual formula in place of the tables and graphs, but this is done rarely because the tables and charts are easier. This is especially true of the Hazen-Williams formula, which has exponents of 0.54 that are very difficult for most people to use. There actually are tables of numbers raised to the 0.54 power for those who need them. The formulas are set out on the next page.

Here is the formula for discharge through a circular opening:

$$29.83 \times d^2 \times P \times C = \text{gpm}$$

d = the inside diameter of the opening
P = the Pitot pressure
C = the coefficient

Note that, when using smooth-bore nozzles, most fire service calculations assume a coefficient of one.

The Hazen-Williams formula, in some variations, can be used to calculate the flow in the system:

$$\frac{Q^2}{Q^1} \quad \frac{(S-R_2)^{0.54}}{(S-R_1)^{0.54}}$$

$$Q_2 = Q_1 \ \frac{(S-R_2)^{0.54}}{(S-R_1)^{0.54}}$$

Q_2 = the calculated flow at the desired residual pressure, usually 20 psi
Q_1 = the flow determined during the test
S = the static pressure
R_1 = the residual pressure determined during the test
R_2 = the desired residual pressure, usually 20 psi

See the NFPA *Handbook* or other text for further explanation of these formulas.

Because the calculations include some complex mathematical operations, including items raised to the 0.54 power, most people use charts and graphs to simplify the process.

SUMMARY

Mercantile occupancies include stores, shopping centers, supermarkets, and other similar occupancies. Common problems in mercantile occupancies include material handling, seasonal problems, storage of flammable liquids, means of egress problems, and special locking mechanisms. HVAC systems exist in most occupancies and present unique problems for the inspector. HVAC systems are one of the most prevalent causes of smoke spread. Large systems have extensive duct work and can spread smoke, toxic gases, and heat rapidly through the area, and feed fresh oxygen to the fire. Determining fire flow is an important part of the inspection process. There are nine simple steps one can follow to calculate fire flow.

Activity M.1

Identify Types of Mercantile Occupancies and the Associated Hazards

Purpose

To differentiate among the various types of mercantile occupancies.

Directions

1. As a large group, generate a list of mercantile occupancies in your areas.

2. Using the list, discuss some of the things that are unique about different types of mercantile occupancies.

3. You will be divided into small groups.

4. Each small group will be assigned two mercantile occupancies from the list. The group will identify the hazards that can be expected from each occupancy.

Activity M.2

Hazard Identification and Enforcement Notice

Purpose

To familiarize you with researching basic requirements in your code for mercantile occupancies and with writing code-based inspection notations.

Directions

1. Individually, research the specific section in your code that relates to the issue noted.
2. Discuss your findings with the other members of your group.
3. After your group agrees on the proper code section, draft an inspection notation similar to one you would write on an actual inspection form.
4. Select a spokesperson to present the group's findings.
5. You have 30 minutes to complete this activity.

Example

Issue: Stock is stored directly in front of the main electrical panel.

Code Section:
Building Officials & Code Administrators International, Inc. (BOCA) Fire Prevention Code (1999) F-310.3.

Notation:
Move stock stored near main electrical panel to provide a clearance of not less than 30 inches between electrical service equipment and storage.

Worksheet

1. During an inspection of a variety store, you observe that large cartons of merchandise are stacked and stored on the top of display racks. From several locations in the area, you cannot see the exit sign over the side door.

Code Section	Notation
____________________	______________________________
	______________________________
	______________________________
	______________________________
	______________________________

2. When you walk around the outside of the store, you note that there is a large accumulation of trash on the floor of the loading dock at the rear of the store.

Code Section	Notation
____________________	______________________________
	______________________________
	______________________________
	______________________________
	______________________________

3. While inspecting a convenience store, you notice that firecrackers and Roman candles are being sold.

Code Section	Notation
____________________	______________________________
	______________________________
	______________________________
	______________________________
	______________________________

4. During your inspection of a store, you find the rear exit passageway is being used to store merchandise.

Code Section	Notation
____________________	______________________________
	______________________________
	______________________________
	______________________________
	______________________________

5. After you complete your inspection, the owner asks you what the regulations are for decorative materials in his/her store.

Code Section	Notation
____________________	______________________________
	______________________________
	______________________________
	______________________________
	______________________________

Activity M.3

Fire Flow

Purpose

Given certain information, to verify fire flow for a site.

Directions

1. In small groups, follow the process to calculate fire flow, using the worksheet.

2. Using a second set of information, individually calculate fire flow.

3. Use the following data for your calculations:

	Group	Individual
Static pressure	70 psi	80 psi
Residual pressure	30 psi	25 psi
Outlet size	2.5"	2.5"
Pitot reading	18 psi	10 psi
Coefficient	0.9	0.9

Distribution System Worksheet

Use this sheet for your calculations.

Distribution System Worksheet

Discharge Table For Circular Outlets in Gallons per Minute (U.S.)

(Outlet Pressure Measured by Pitot Gauge)

OUTLET DIAMETER IN INCHES

OUTLET PRESSURE LBS.SQ.IN.	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8	3.0	3 1/8	3 7/8	4.0	4 3/8	4 1/2	4 5/8
1	150	170	180	200	220	240	260	400	430	510	540	580
2	210	240	260	290	310	340	370	570	610	720	770	810
3	260	290	320	350	380	420	450	700	740	890	940	990
4	300	340	370	410	440	480	530	810	860	1030	1090	1150
5	340	380	410	450	500	540	590	900	960	1150	1220	1290
6	370	410	450	500	540	590	640	990	1050	1260	1340	1410
7	400	440	490	540	590	640	690	1070	1140	1360	1440	1520
8	430	480	520	570	630	680	740	1140	1220	1450	1540	1620
9	450	500	550	610	670	730	790	1210	1290	1540	1640	1720
10	480	530	580	640	700	760	830	1280	1360	1630	1730	1820
11	500	560	610	670	730	800	870	1340	1430	1710	1810	1910
12	520	580	640	700	770	840	910	1400	1490	1780	1890	1990
13	550	610	670	730	800	870	950	1450	1550	1850	1960	2070
14	570	630	690	760	830	900	980	1510	1610	1920	2040	2150
15	590	650	720	790	860	940	1020	1560	1660	1990	2110	2220
16	610	670	740	810	890	970	1050	1620	1720	2060	2180	2300
17	620	690	760	840	910	1000	1080	1660	1770	2120	2240	2370
18	640	710	780	860	940	1030	1110	1710	1820	2180	2310	2440
19	660	730	810	890	960	1050	1140	1760	1870	2240	2370	2510
20	680	750	830	910	990	1080	1170	1800	1920	2290	2430	2570
22	710	790	870	950	1040	1130	1230	1890	2020	2400	2550	2700
24	740	820	910	1000	1090	1180	1290	1970	2110	2510	2660	2810
26	770	**860**	940	1040	1130	1230	1340	2050	2190	2620	2770	2930
28	800	890	980	1070	1170	1280	1390	2130	2280	2720	2880	3040
30	830	920	1010	1110	1210	1320	1430	2210	2350	2820	2980	3150
32	860	950	1050	1150	1260	1370	1480	2280	2430	2910	3080	3250
34	880	980	1080	1180	1290	1410	1530	2350	2510	3000	3170	3350
36	910	1010	1110	1220	1330	1450	1580	2420	2580	3080	3260	3440
38	930	1040	1140	1250	1370	1490	1620	2480	2650	3170	3350	3540
40	960	1060	1170	1290	1400	1530	1660	2550	2720	3250	3440	3630

* Computed with the coefficient C = 0.90, to the nearest 10 gallons per minute.

Post_______ Test No. _______ Date ____________

Location of residual hydrant ___________________

Area_______

Previous Year's Flow ____ gpm at ____ psi

Static psi _____Observers ___________________

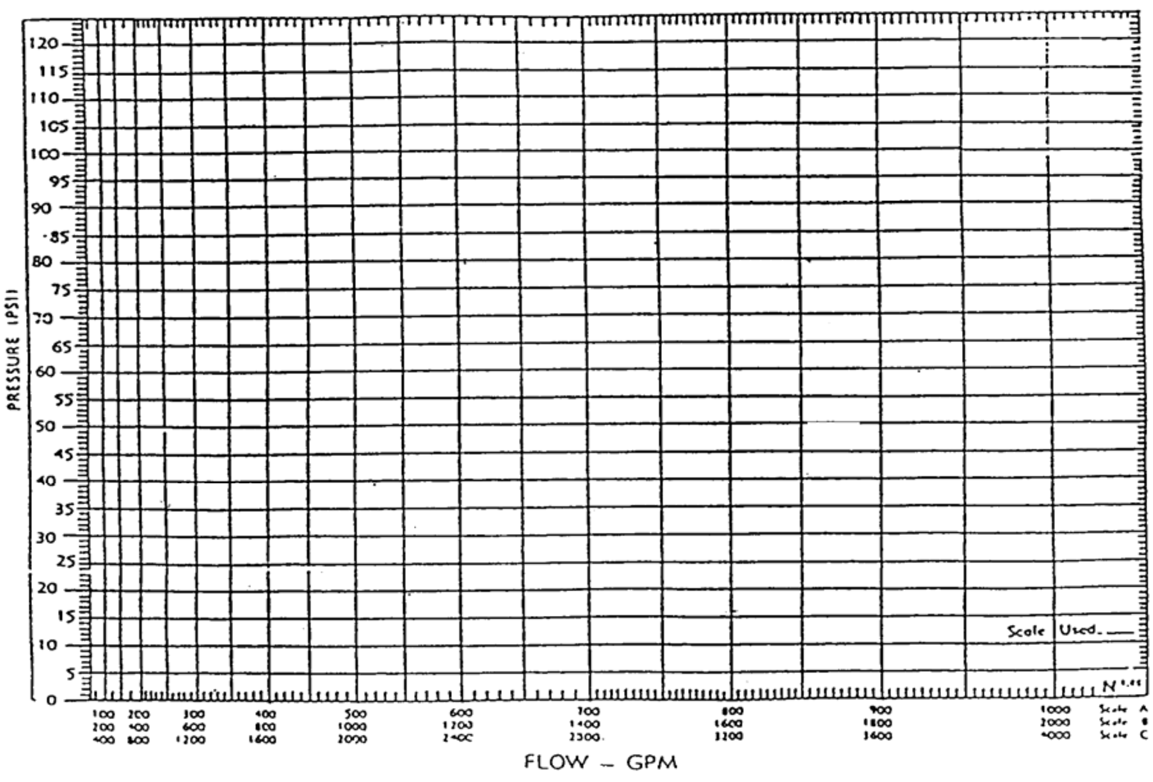
Location Sketch

Hydrant Gauge Readings	
	Pressures in PSI
Hydrants closed (static)	
Hydrant opened (residual)	

Hydrant Discharge Data

Hydrant Number	Outlet Diam. Inches	Pitot Pressure PSI	Discharge GPM	Remarks

Total discharge _______gpm



Summary and Results

Static pressure_____psi

Test pressure______psi

Total test discharge_______gpm

Notes on Supply

____

____

____

____

Activity M.4

Report Writing

Purpose

To formulate code-based findings from an inspection into a properly formatted report document.

Directions

1. Working individually and using the code applicable to your jurisdiction, review the inspection scenario.
2. Complete the attached inspection report form or an inspection report form from your jurisdiction, citing the hazards identified in the scenario.
3. Write a report on the occupancy. Be sure to cite specific code references.
4. You have 60 minutes to complete this activity. You will turn in all completed forms to the instructor.

Scenario

You are a fire inspector sent to inspect the Home-Mart Variety Store located at 826 North Avenue, Emmitsburg, MD. The manager is Jim Creek. This is a large, one-story general merchandise store. As you approach, you note that several fire-lane signs are missing along the front of the building. At the left of the front door, a large shrub has grown in front of the fire department connection. You notice merchandise storage within 12 inches of the electrical service panel in Room 12. One of the side exit doors is locked. The manager removes the lock while you watch.

FIRE-SAFETY SURVEY REPORT

FIRE PREVENTION…
FOR YOUR SAFETY

Building ________________________________ Owner/Mgr. ______________________________
Address ________________________________ Phone __________________________________
________________________________ Type of Occupancy ________________________

☐ New Occupant

The _________________ Fire Department has conducted a fire safety survey of your property. The knowledge gained through this survey will enable the Fire Department to attack and extinguish fire that might occur in the building quickly and efficiently.

During this inspection, conditions affecting fire safety throughout the premises were also noted. It is requested that the items listed below be given your immediate attention in the interest of fire safety.

FIRE HAZARDS FOUND TO EXIST: ☐ NONE OBSERVED THIS INSPECTION

☐ Fire Extinguishers	☐ Housekeeping	☐ Flammable Liquids	☐ Electrical
☐ Trash	☐ Utilities	☐ Fire Protection Equip.	☐ Fire Lanes
☐ Exits	☐ Fire & Smoke Doors	☐ No Smoking Signs	☐ Other

____
____
____
____
____
____
____
____
____

If at any time questions regarding fire safety arise, do not hesitate to contact the Fire Department at ______________. For an emergency call ________________ . In case of fire in your building, call the FIRE EMERGENCY NUMBER.

_________________________ _________________________ _________________________
Property Representative *Reporting Officer* *Date*

Reinspection Due ________ Made By _________________ Date _________ Notified FM # _______

WHITE – Owner/Manager
YELLOW – Station File
PINK – Fire Marshal

FIRE HAZARDS CORRECTED # ________________
FIRE HAZARDS NOT CORRECTED # ___________

10/75

Notice of Violation Page ________ of ________

Building ______________________________ Date ______________________________

Address ______________________________ Owner/Mgr. ______________________________

______________________________ PROPERTY REPRESENTATIVE

______________________________ REPORTING OFFICER

WHITE – Owner/Manager
YELLOW – Station File
PINK – Fire Marshal

FIRE HAZARDS CORRECTED ______________
FIRE HAZARDS NOT CORRECTED ______________

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