Confidence Testing
Fire Hydrants

A Guide to the Maintenance, Testing, and Marking of Private Fire Hydrants

Colorado Springs Fire Department
Office of the Fire Marshal

July 1998

1st Edition

Introduction

The city of Colorado Springs has nearly 12,000 fire hydrants within its city limits. More than a quarter of these are private hydrants. What this means is that the city is responsible for maintaining less than 75% of a critical fire protection system that the Fire Department relies upon to effectively fight fires within its jurisdiction.

How can you tell a private hydrant from a public one? Chances are if the hydrant is not identified by an alpha-numeric code on the bonnet, it is a private hydrant. Also, public hydrants can only be located in the public right-of-way, on the side of public streets, or any other public property. Hydrants located in the middle of commercial parking lots are more than likely private hydrants.

The testing, maintenance, and marking of hydrants is the responsibility of the property owner. It is imperative that this be accomplished by a competent individual or group, therefore we highly recommend the hiring of a contractor knowledgeable in this field. As of January 1, 2000, the maintenance, testing, and inspection of private hydrants may be performed only by an FSC-H licensed contractor or individual. If circumstances warrant, a business may train and certify its own people to undertake this responsibility. Please note that in any case, the property owner assumes all liability not otherwise contractually dictated for the proper operation, maintenance, and marking of its hydrant system(s).

A guide for the fire flow testing and marking of hydrants can be found in the National Fire Protection Association (NFPA) Standard 291: *"Recommended Practice for Fire Flow Testing and Marking of Hydrants."* The maintenance and periodic testing of hydrants is covered in NFPA Standard 25: *"Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protecting Systems."* Specifically, Chapter 4 of this standard addresses private water mains and their appurtenances. Additionally, an outstanding reference guide on this is the American Water Works Association (AWWA) Manual M-17 "Installation, Field Testing and Maintenance of Fire Hydrants."

Scope

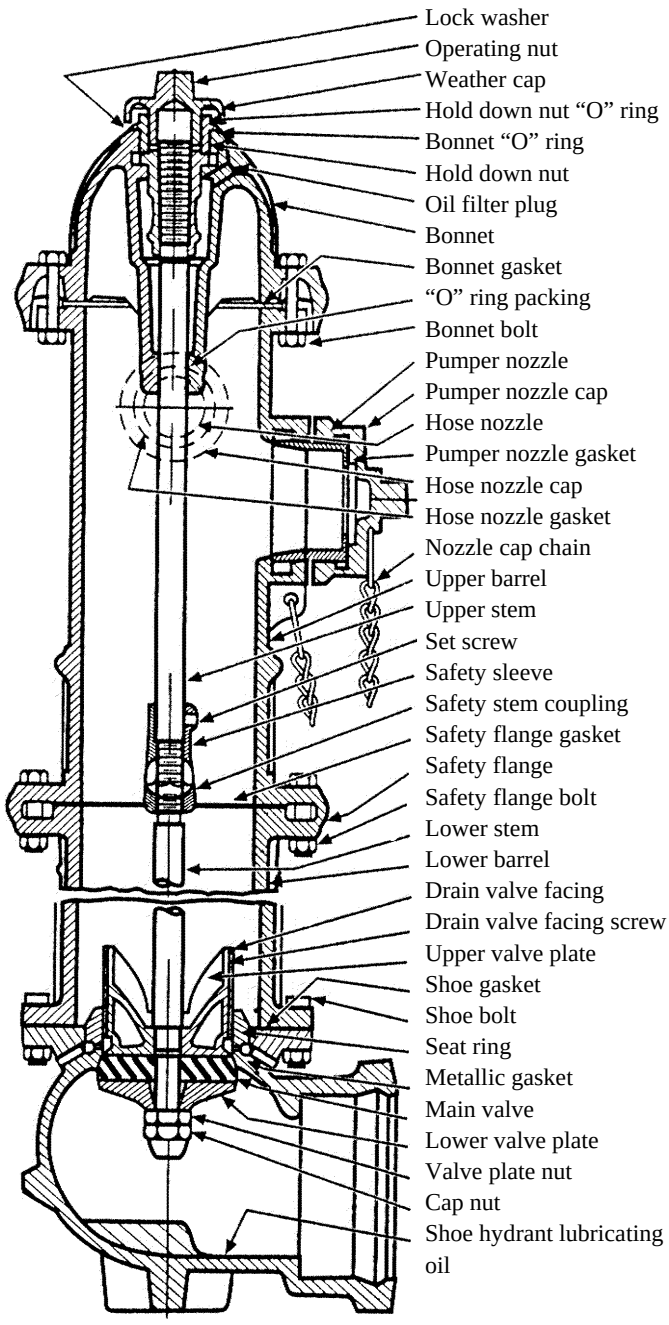
This information packet is intended to aid the informed and competent do-it-yourselfer with the proper maintenance, testing, and marking of private fire hydrants for businesses in the city. In no way will this packet attempt to replace proper training and experience, and therefore, should not be viewed as a training manual, but as a guide to the equipment and expertise required for the proper execution of these functions.

Part I: Regular Maintenance

Fire hydrants spend most of their time unused and ignored, yet they are called upon in a moment's notice to provide fire flow for the protection of a business or home. They are an indispensable facet of the overall fire protection features of a building.

Because of the way land is platted and easements are granted, there exist in excess of 3,000 private hydrants within the city of Colorado Springs.

These hydrants are required for the fire protection of a building, but they are useless unless regularly maintained. Furthermore, they should be painted as described in Part III so that firefighters can quickly identify the system capability.



Anatomy of a Typical Dry Hydrant

All hydrants in this part of the country are *dry hydrants* because of the freezing weather conditions we experience. This means that the barrel of the hydrant stays dry until the hydrant is opened at the Operating nut. This drives the stem to open the valve at the bottom of the barrel. Notice in the detail to the left that the stem is split into two parts with a safety coupling which acts as a breakaway valve in case the hydrant is run over.

As can be seen, a hydrant is an intricate water delivery mechanisms with many moving parts.

In addition to the stem and valve that bring water into the barrel, other important moving parts are the 2½ inch and 4½ inch nozzle caps (identified as hose and pumper nozzle respectively) which keep the nozzles protected from dirt and the elements. The caps can easily lock up due to corrosion, neglect, and sloppy painting

Regularly Scheduled Maintenance

It really doesn't take much to keep a hydrant operating in peak condition. But regular maintenance must be followed. NFPA 25 "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems" is the standard for that should be used for the periodic maintenance and testing of hydrants. .

Chapter 4 indicates that hydrants must be inspected, lubricated, and flow tested ***annually***.

Inspection

This should be done annually or after each use in conjunction with the maintenance and the flow test.

- Check the hydrant's appearance. Remove obstructions around it within a 3 ft radius. Check to see whether the hydrant needs to be raised because of a change in the ground surface grade. If adjustments are needed, schedule the work.
- Inspect the hydrant for leaks, either from the operating nut, nozzle caps, or the drain.
- Remove all nozzle caps and check threads and operating nuts for damage.
- Make repairs as necessary.

Maintenance

In conjunction with regular inspections, the following maintenance should be performed annually.

- Loosen one outlet-nozzle cap to allow air to escape.
- Open the hydrant only a few turns. Allow air to vent from the outlet-nozzle cap.
- Tighten the outlet-nozzle cap. Never use excessive force.
- Open the hydrant fully. Check for ease of operation.
- Check for leakage at flanges, around outlet nozzles, at packing or seals, and around the operating stem. Repair as needed.
- Partially close the hydrant so the drains open and water flows through under pressure for about 10 seconds, flushing the drain outlets.
- Close the hydrant completely. Remove an outlet-nozzle cap and check the operation of the drain valve by placing the palm of one hand over the outlet nozzle. Drainage should be sufficiently rapid to create noticeable suction.
- Remove all outlet nozzle caps, clean the threads, check the condition of the gaskets, and lubricate the threads with a manufacturer approved lubricant. (There are several never-seize compounds available) Check the ease of operation of each cap.
- Check outlet-nozzle-cap chains or cables for free action on each cap. If the chains or cables bind, open the loop around the cap until they move freely. This will keep the chains or cables from kinking when the cap is removed during an emergency.
- Replace the caps. Tighten them, and then back off slightly so they will not be excessively tight. Leave them tight enough to prevent their removal by hand.
- Check the lubrication of operating-nut threads. Lubricate per the manufacturer's recommendations.
- Locate and exercise the auxiliary valve. Leave it in the open position.
- Check the breakaway device for damage.
- If the hydrant is inoperable, bag it with a brightly colored, weather-resistive cover that bears the stenciled warning: "HYDRANT OUT OF SERVICE". Schedule the hydrant for repair.

Flow Tests

There are two different types of flow tests. The first is a simple flushing of the hydrant, which will be covered below. The second is a flow test for the determination of fire flow. This type of test is described in Part II of this packet.

Flushing a hydrant removes any accumulated sediment in the barrel and on the valve. It is recommended that flushing be performed annually along with the regular inspection and maintenance items described above. In any case, these should always be performed prior to flushing.

Circumstances will sometimes not permit flushing; at minimum, perform the regular inspection and maintenance.

To flush a hydrant:

- Contact the Water Resources Department to inform them that a flow test is about to take place. Often, when a large volume of water is moved through an orifice such as a hydrant, sediment in the line will be stirred up and the Water Resources Department will receive complaints about brown water.
- Prepare to flow water from the hydrant. Decide if a diffuser or hose will be necessary to direct the flow of water away from landscaped or other areas. Lay out hose, if necessary. Connect the necessary hardware to the nozzle;
- Open the hydrant **very slowly** until it is fully open;
- Let water flow for a minimum of 3 minutes or until water is clear. Avoid opening more than one hydrant at a time unless you are doing a test as described in Part II. This will minimize the amount of flow created in the main;
- Shut the hydrant down, again very slowly, until the valve is completely shut;
- Remove hardware and replace cap.

Dynamics of Water

When performing any sort of flow test or exercising of hydrants, there are several important concepts that must be understood to avoid causing damage to the hydrants and to the water system in general.

Water Hammer

Water hammer is caused by an abrupt change in the velocity of flowing water. It is most often the result of shutting down a valve too quickly. Imagine driving into a brick wall at 60 mph. The energy of your momentum has to be transferred somewhere. In this case it is shared, though unequally, by you, the car, and the brick wall.

Water is incompressible. It will not absorb ANY of the energy it gives off by being forced to suddenly decelerate. Therefore, the system, pipes, hydrants, ground have to absorb all of the energy.

If a valve is shut down too quickly, the weak link in the system will go first. The weak links are almost always at the flanges.

Brown Water

Brown water is the basic complaint the Water Resources Department receives when people turn on their faucet and see less than clear water coming out. This may be caused by several things. One thing that will almost always cause brown water is a large amount of flow in a water main.

During normal conditions only the center portion of a water main actually flows water. That's because of the friction that the wall of the pipe is exerting on the water. It's less trouble for the center portion to flow than the outer portion.

As the average velocity increases, so will the velocity of the fluid close to the wall of the pipe. As this water moves faster, it begins to kick up all the sediment that usually stays at the bottom of the pipe. This sediment gets stirred up and does not settle back down until the velocity slows down.

However, once the sediment has been kicked up into the center portion of the pipe, it is now in the *main stream* of flow.

Protection from Vehicular Damage

Please refer to the CSFD handout titled "Protection from Vehicular Damage" for help in designing vehicle protection such as bollards for fire hydrants or other devices such as PIVs or fuel tanks.

Part II. Fire Flow Testing

Fire flow testing is the determination of actual flow conditions within a hydrant system. A hydrant system is the system of mains, whether looped or not, capable of providing fire flow to a site. A site may have one or more hydrant systems with different flow and pressure characteristics. Consult a water map or your utility plan to determine how many systems feed your site.

Available fire flow is measured in gallons per minute (gpm) at a residual pressure of 20 psi.

Equipment

To properly test a hydrant system, you will need to following equipment and materials:

Equipment	Quantity
2½" Cap gauges	2
50 ft section of 3" and/or 5" hose*	2 - 4
Allen wrench (check manufacturer for size)	1
Clipboard	1
Diffuser*	1
Hydrant wrench	2
Landscape protection*	-
Paint supplies (spray paint & masking tape)	-
Pitot tube and gauge	1
Record keeping material	-
Ruler to measure inside diameter	1
Scientific calculator	1
Steel brush	1
Thread grease (lubricant) (Check manufacturer for specs)	-
Valve key	1
Water distribution map	1

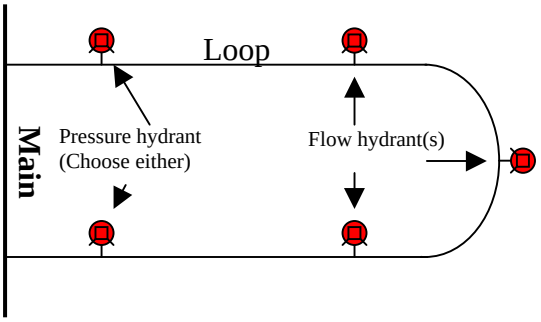
*The diffuser, landscape protection (mat), and hose are optional items that are not absolutely necessary for the testing of hydrants, but are often advantageous to have if you do not want to disturb landscaping. FLOWING WATER WILL TEAR UP GRASS.

NOTE: Additional flow hydrants will require additional equipment. The quantities listed above are minimums.

Setup

- Decide which hydrant will be your *pressure hydrant* and which will be your *flow hydrant(s)*. The pressure hydrant will be used to measure Static pressure and Residual pressure. It should be closer to a feed main than the flow hydrant. See Figure II-1 to the right.
- Decide how many flow hydrants to use. As a rule of thumb, you should flow enough hydrants at the same time such that the residual pressure drops at least 10% from the static pressure.

  For example, you take a static pressure of 140 psi from the cap gage. When you open a hydrant, the pressure drops to 135 psi. You either need to open another hydrant or the steamer (4½ inch) connection.



- Contact the Water Resources Department

Figure II-1: Hydrant flow layout

and inform them that a test is about to take place. Call all three phone numbers on found in Section IV of this packet. Unfortunately, there is not one single number that will notify all the people that need to know water may be flowing.

You may get turned down in your request to flow water during peak flow times of the day (early in the morning until 10 am or after 4 pm in the evening during the summer.)

- Locate and perform the following on the pressure hydrant:
  - Flush as indicated in Part I;
  - Install the cap gauge;

- Open the hydrant slowly and fully;
- Read and record the pressure. This is the Static Pressure.

- Locate and perform the following on the flow hydrant(s):
  - Record the inner diameter of the nozzle which will be flowed;
  - Insert a hand into the nozzle opening and feel the entrance shoulder to determine the nozzle coefficient (0.9 for a smooth rounded shoulder, 0.8 for a square shoulder, and 0.7 for a nozzle that protrudes into the barrel);
  - Install and arrange any hoses or diffusers necessary to minimize effect on traffic or landscaping;

Flow Test

At this point it would be helpful to have one or more assistants and a reliable method of communication such as two-way radios to perform an efficient test.

- Open each flow hydrant slowly and fully. Open one hydrant at a time to avoid a pressure surge;
- Wait for the pressure at the pressure hydrant to stabilize, read and record this pressure. This is the Residual Pressure. Then signal the persons stationed at the flow hydrants to take pitot readings, or go and takes readings yourself. The readings for residual pressure and the pitot readings should really be taken at the same time for an accurate flow.
- To take a pitot reading, hold the pitot gauge approximately ½ of the diameter away from the nozzle in the center line of the nozzle. Read and record this pressure. This is your Pitot or velocity pressure.
- If sediment appears, continue to flow water until the main has been flushed.
- Close each flow hydrant, one at a time, **very slowly**. Closing a hydrant too fast will cause damage to the hydrant or to water mains. Refer to Water Hammer on page 5 for an explanation.
- Perform calculations as described under the Equations section below. If a residual pressure is unusually low, there may be a closed valve which will need to be opened for an accurate flow test.
- Repeat these steps if necessary.
- There may be certain circumstances when there is only one hydrant, and a pressure hydrant cannot be located, or is too far down the line for an accurate measurement. In this case, use on 2½ inch outlet for the pressure readings, and the other 2½ inch or steamer cap for the flow readings. The cap gauge reading may fluctuate more in this case due to turbulence.

Equations

Typically, residual pressures in Colorado Springs are in excess of 50 psi, especially in newly developed part of town. Fire flow, however is measured consistently at 20 psi. In order to get the fire flow in gallons per minute (gpm) at 20 psi, the equations below will need to be performed.

A scientific calculator is useful in performing these equations. A standard calculator may be used to estimate where the 0.54 power is taken as a square root. Basic algebraic skills are required to perform these functions.

The following equations are used to determine fire flow based on the static, residual (flowing), and pitot pressures:

$$Q_r = 29.83 c_d D^2 \sqrt{P_p} \qquad \text{(Eq. 1)}$$

$$Q_f = Q_r \left(\frac{P_s - 20}{P_s - P_r} \right)^{0.54} \qquad \text{(Eq. 2)}$$

where:

Q_r is the residual flow at the pitot pressure measured in gpm

c_d is the friction loss coefficient (usually 0.9 for a smooth 2½" opening)

D is the diameter of the opening in inches

P_p is the pitot pressure in psi

Q_f is the FIRE FLOW in gpm at 20 psi
P_s is the static pressure in psi
P_r is the residual pressure in psi

Example

You perform a hydrant test and gain the following results:
P_s (Static pressure) = 140 psi
P_r (Residual pressure) = 125 psi
P_p (Pitot pressure) = 120 psi
c_d = 0.9 because the inside of the nozzle was smooth.
D = 2.5 inches

- Calculate Q_r (residual flow):

= 29.83 × 0.9 × $(2.5)^2$ × square root of 125
= 29.83 × 0.9 × 6.25 × 11.18
= 1,876 gpm

- Calculate Q_f (fire flow):

$$= 1{,}876 \times \left(\frac{140 - 20}{140 - 125} \right)^{0.54}$$

$$= 1{,}876 \times \left(\frac{120}{15} \right)^{0.54}$$

$= 1{,}876 \times (8)^{0.54}$ (raise 8 to the 0.54 power)
= 1,876 × 3.07375
= 5,766 gpm

That system has the capacity to flow 5,766 gallons per minute at 20 psi residual pressure.

Record Keeping

Refer to Appendix A for forms to use to keep records of these flow tests. Copies of these tests should be sent to the Office of the Fire Marshal and the original kept by the owner of the private property. It is also a good idea to keep copies on site at an appropriate address.

Frequency

It is a requirement of NFPA 25 that inspection, maintenance, and flushing as outlined in Part II of this packet be performed ***annually***.

We recommend that fire flow testing be performed every ***5 years*** to ensure integrity of the system.

Part III. Marking of Hydrants

The marking of hydrants is important for two reasons. First, it immediately tells fire crews the capacity of the fire main system they are hooking into. Second, it shows that the owner is complying with this program.

Historically, fire crews have trusted public hydrants above private ones, because the city hydrants are on a routine maintenance schedule, and, generally, the likelihood of running into problems is lessened.

This contradicts the whole reason for requiring hydrants in the first place.

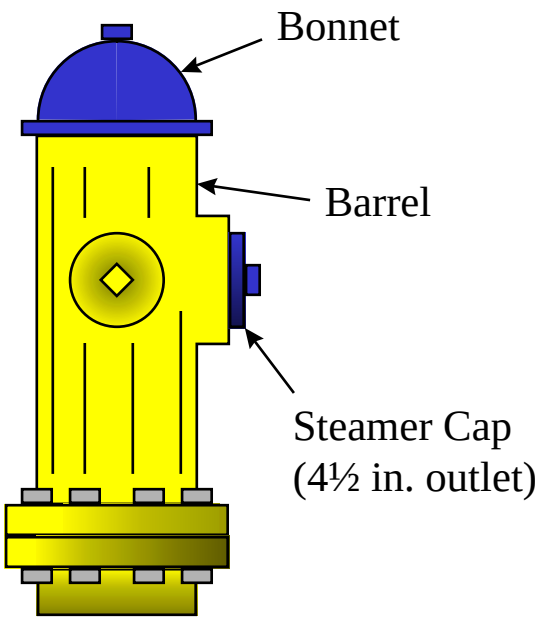
Hydrant Colors - Painting Requirements

The following color designations are based on National Standard[1] as well as a local amendment to that standard. Because Colorado Springs has such excellent water, a new category was created for hydrant systems capable of delivering more than 3,000 gpm.

The Water Resources Department paints all public hydrants a certain color based on the available fire flow measured at 20 psi residual pressure under maximum day demand conditions. The table below shows these designations.

Fire Flows (gpm)	Color	Painted on:
0 - 499	Red	Bonnet
500 - 999	Orange	Bonnet
1,000 - 1,499	Green	Bonnet
1,500 - 3,000	Blue	Bonnet
Above 3,000	Blue	Bonnet & Steamer Cap
-	Yellow	Barrel

Private hydrants are required to be painted to this color scheme depending on actual measured fire flow at 20 psi. The measuring of this flow is described in Part II of this Packet.



Hydrant Paint Scheme Example

For assistance in choosing the actual colors used by the Water Resources Department, we have included the manufacturers and specifications for the paint used on public hydrants.

This table is provided solely for your convenience and is not intended to imply that only these manufacturers' products would be acceptable. Any manufacturer's product that is equivalent in color and quality to these mentioned below would be acceptable for the purpose of hydrant identification.

Color	Manufacturer	Specification
Red	Rustoleum	Safety Red #2163
Orange	Aervoe	Orange #305
Green	Aervoe	Fluor Green #184
Blue	Aervoe	Ford Blue #560
Yellow	Rustoleum	Equipment Yellow #2148

NOTE: It is very rare that you will have to paint a hydrant red or orange. If you calculate a flow of 1,000 gpm or less, recheck your math then inform the Water Resources Department. It may be a closed valve.

[1] NFPA 291, Sec 3-2: Marking of Hydrants

Part IV. References

The following phone numbers will be of valuable use to you in acquiring additional information or in performing the duties outlined in this packet.

Water Resources Department:

- Dispatch – 448-4200
- Construction – 448-4570
- Lab – 448-4560

National Fire Protection Association

(800)344-3555

American Water Works Association

(800)926-7337

Nomenclature

gpm	gallons per minute
psi	pounds force per square inch

Bibliography

Installation, Field Testing, and Maintenance of Fire Hydrants, AWWA Manual M17, Third Edition, American Water Works Association, 666 West Quincy Avenue, Denver, CO 80235

NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 1995 Edition, National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101.

NFPA 291, Recommended Practice for Fire Flow Testing and Marking of Hydrants, 1995 Edition, National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101.

The Fire Protection Handbook, 18th Edition, National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101.

Appendix A

COLORADO SPRINGS FIRE DEPARTMENT

Confidence Testing
Fire Hydrants and Water Supply

Address:_____ Hydrant Location: _____

Business Name:_____ _____

Inspected by:_____ Date Tested: _____

Prior to conducting water flow tests, notify the Water Resources Department: Construction (448-4570), Dispatch (448-4200), and Laboratory (448-4560).

Recorded Pressures and Flows

Static:_____ psi
Residual:_____ psi
Pitot:_____ psi

Diameter:_____ inches
Residual Flow:_____ gpm
Flow at 20 psi:_____ gpm

General

1.	Underground shutoff valves fully operated.	Yes	[ ]	No	[ ]
2.	All vegetation, landscaping, and other obstructions are at least three feet away from hydrants.	Yes	[ ]	No	[ ]
3.	All threaded protective caps are easily removed.	Yes	[ ]	No	[ ]
4.	All threaded connections are undamaged and seals in good condition.	Yes	[ ]	No	[ ]
5.	All threaded connections are lubricated with appropriate lubricant.	Yes	[ ]	No	[ ]
6.	Operating stem nuts are not damaged or stripped.	Yes	[ ]	No	[ ]
7.	Hydrants flushed at full capacity until flowing water is clear.	Yes	[ ]	No	[ ]
8.	When closed, hydrants drain properly, suction can be felt.	Yes	[ ]	No	[ ]
9.	Hydrant was used as part of a fire flow test	Yes	[ ]	No	[ ]
10.	Hydrant is painted appropriate color for fire flow.	Yes	[ ]	No	[ ]

If hydrant must be taken out of service, notify the Fire Department Communications Center (444-7000) and the Water Resources Department Dispatch Center (448-4200).

General Comments

Problems Found:_____

_____

Corrections Made:_____

This is to certify that all fire hydrants and water supply have been inspected and tested for reliability and all necessary corrections have been made.

Signature of tester:

Agency: _____Telephone: _____
This report shall be completed in duplicate. A copy shall be left at the premises for Fire Department inspection and one copy shall be forwarded to:

Colorado Springs Fire Department
Office of the Fire Marshal