FIRE HYDRANT FLOW TESTING – V2

Introduction

This paper was first published and posted on both the FSCS and Academia.edu web sites in 2017 as "*Fire Hydrant Flow Testing – V1*" in response to concerns as to the validity of testing the adequacy of water flow and pressure in Municipal fire mains for fire hydrants.

Notwithstanding that this paper is specifically written in relation to Queensland legislation, legislation in other States and Territories are thought to be similar, if not identical. The technical issues surrounding testing equipment adequacy however can be applied across Australia.

The adequacy concern was related to the misuse of the generally accepted use of the "McCrometer" flow test device and certain examples of misuse were detailed as well as correspondence from the McCrometer manufacturer where the readings did not truly represent the actual flows and pressures in either town main or pump supplied sprinkler and / or hydrant systems.

This paper is now published with an amended name and the edition V2 referenced so as to link it to the original publication. Much of the detail in the original paper is repeated / kept so that this paper can be used in isolation without necessary reference to the original.

The addition of hydraulic calculations for multiple flows through a single hydrant valve and multiple hydrant testing provides additional background to the subject.

Readers should be aware of and refer to the companion paper "*Water Supplies for Fire Services - V6*" published both the FSCS and Academia.edu web sites. That paper provides specific details on the formal determination of water supplies provided through public Municipal Water mains with guidance as to the required method of determining the water flow and pressure from the appropriate water supply "Authority".

This revised paper uses additional data from many past flow tests witnessed by FSCS and clarifies the interpretation of terminology in the latest Standards.

Legislative Requirements

Both "*AS2118.1 – Automatic Fire Sprinkler Systems – Part 1 – General Requirements*" and "*AS 2419.1 – Fire Hydrant Installations – Part 1 – System Design Installation and Commissioning*" detail certain water flows and pressures to satisfy their design requirements.

Note that the publication dates are not cited because the Standards adopted for use by the *National Construction Code - Building Code of Australia* (NCC – **BCA**) vary as and when Standards are revised. Normally the year of publication of a Standard referenced in the BCA and listed under BCA Specification A1.3 -1 Table 1 therein, should be used for design purposes for new buildings. Note that the BCA is revised each year with its adoption always on May 1st.

For existing buildings however, the date of original construction and the Standard referenced in the BCA edition should be used unless the Building Certifier rules otherwise.

Where buildings have been altered or additions made thereto in later years, there is some complexity as to which Standards should be used – indeed that applies to all referenced Codes and Standards used in original construction. FSCS has published a paper entitled "*Alteration of Existing Buildings in Queensland – V4*" where guidance is provided as to the Standards to be used and if new Standards can be retrospective.

Flow Testing

For fire hydrant systems, the water supply is usually sourced directly from a Municipal Water main or a storage tank with associated pumps. The arrangement is dependant on the available flow and pressure in the Municipal water supply, Accordingly to satisfy the system design requirements water pressure and flow data is required such that the pipe reticulation sizes, pump capacity (if used), flow rates and residual pressures at hydrant valves can be calculated.

It is now common for Water Supply Authorities to provide minimum water flow and pressures by means of their network analysis tools, they commit to providing minimum supplies for various building classifications (see the FSCS paper "Water Supply for Fire Services – V6" on both the FSCS and Academia web sites). It is important that for the purposes of designing a hydrant system that these figures should be used and assessed in conjunction with sprinkler system flow requirements if provided.

Previously the assessment of available water supplies for hydrant system design was determined by testing the flow from one or more "street' hydrants and standpipes using a pitot tube or propeller driven flow meter (McCrometer) such as being discussed in this paper. See Figures 1 and 2.

Such tests do not consider the variably of supply pressure and flow as discussed in AS2419.1 in regard to 95% availability and therefore should not be used for design purposes.

Notwithstanding the requirement to use Water Supply Authorities for minimum flows and pressures, there is still a requirement for periodic (maintenance) site flow testing of hydrant systems irrespective of the supply, to confirm the design adequacy of the reticulation system as well as the performance of booster pumps as and when installed.

The data and it source used in the design of hydrant systems should be recorded as required under AS1851 in respect to baseline data retention.

Figure 1 - McCrometer

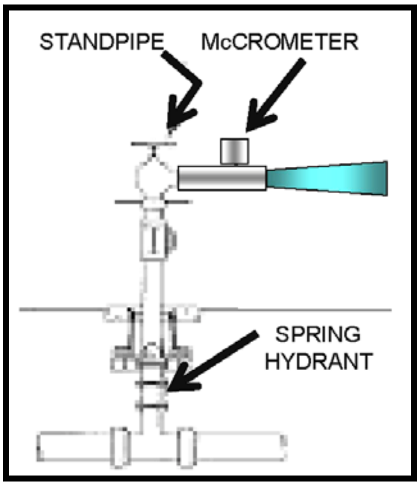

Figure 2 – Street Hydrant and Standpipe

Flow analysis

Where flow and pressure data is either available across a number of iterations, competent Hydraulic Engineers can use this data to confirm or otherwise the validity or adequacy of the data by means of plotting at least three results as follows.

As described in the NFPA Handbook chapter on testing of water supplies, flow data from tests can be plotted on "hydraulic" (semilogarithmic) graph paper, which presents ΔP against $Q^{1.85}$ (where P is pressure and Q is flow) – see Figure 3, is widely used for analysis of water supply systems. The advantage of this graph paper is that where tests have been <u>accurately</u> taken, the resultant graph will be a straight line and therefore if there is a deviation from the straight line, there is indication of potential problems – often of obstructions in the piping or valve(s) being partially closed.

Testing Discrepancies

Tests witnessed using a McCrometer device by FSCS have consistently show residual pressures lower than expected when they are plotted on this graph paper. Whilst, as expected, the static (no flow) pressures are the same, the graph drops off when, as discussed later, the "residual" pressure is measured using a pressure gauge on the McCrometer as shown in Figure 3 compared to when the pressure gauge has a separate connection to the hydrant valve. This difference is discussed later in this paper.

This graph shows flow rates from 0 (zero) to 10 litres per second for two results, the first being with the McCrometer being on the McCrometer and the second with the pressure gauge directly on the hydrant pipe. Notwithstanding the earlier mention that *pressures and flows at different points can be determined,* it should be remembered that in AS2419.1, there is clarification that a fire hydrant has been determined to flow 10l/s. This limitation is because the friction loss in a fire hydrant for greater flows will be greater than that accepted for meeting the performance requirements, calculations later in this paper detail how these losses can be calculated.

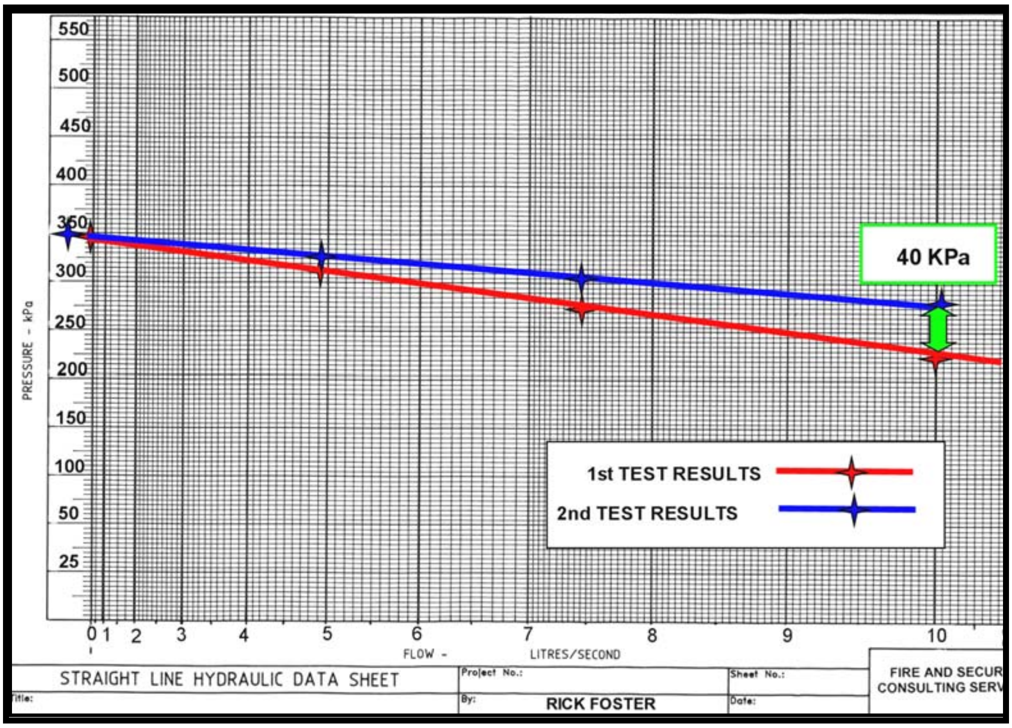

Figure 3 – Comparison of Test Results

Likewise AS2419.1 nominates each booster connection at 10l/s. Ergo for a building requiring 3 hydrants to operate simultaneously, the hydrant flow rate will be 30l/s and the number of booster inlets and associated hydrants shall be 3 (each).

Note that Figure 3 shows the **X** ordinate being flow in litres per second (l/s) and Y ordinate pressure in kilopascals (kPa). The intersection of the "y" ordinate and zero flow represents the static pressure in the system.

Note that in Figure 3, there is a 40 kPa discrepancy in the pressure at 10l/s. These types of results have been common and the errors appear to be in the accuracy of the pressure readings so examination of Figure 3 prompted FSCS to further investigate why the discrepancy was occurring. The results of the investigation were that with the pressure gauge being mounted on the McCrometer barrel, it was in a region of turbulent flow as shown in Figure 4 (a recent Contractor flow test with the McCrometer set up with the pressure gauge connected to a socket on the McCrometer barrel) with the internal McCrometer detail shown in Figure 5. Note that the arrangement shown in Figure 4 does not have an installed test drain but discharges through one or more hose lengths run down the stairs to outside.

This arrangement is commonly used by contractors but is inconsistent with the arrangement shown in the Department of Local Government and Planning (DLGP) "*Fire Hydrant and Sprinkler System Commissioning and Periodic Maintenance Procedure"* Version 1 dated 17th November 2011.as discussed later in this paper.

Examination of past test data indicates that readings from a pressure gauge mounted on the McCrometer barrel (as shown in Figure 4 and at P3 in Figure 5, are always lower than actual and expected pressures.

To confirm (or otherwise) my opinion of turbulent flow issues, FSCS contacted McCrometer in the USA and after several conversations and emails, the following emails were exchanged.

Figure 4 – Typical Observed McCrometer Test Arrangement

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Hello Rick
I reviewed the provided photos of the modified M1104 with our engineering
team and they agree with you.  The placement of the tap is in the region of
the prop would impact the pressure reading.  The expectation is that the
pressure reading is underreporting and may be unstable.  As far as meter
accuracy we do not expect any problems.  I have attached one of our modeling
images for the M1104 that I hope will assist you in illustrating you
concerns to the contractor.  I don't think taking a pressure reading in the
meter housing would be a viable option.
Please let me know if you have any other questions.

Regards,

Sean Herek
Senior Technical Support Representative
McCrometer
951-652-6811 ext 5398
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Sean,
Do you have an agent in Australia, if so, I believe that you should advise
them of this because EVERY McCrometer I have seen here has this tapping and
I suspect that it has been initiated by persons other than the contractors.
Regards
RICK FOSTER RPEQ, FIRE & SECURITY CONSULTING SERVICES
Hello Rick,
I will pass your feedback onto our regional sales manager.  This
modification is not done my McCrometer so I am sure there will be some
interest as to who and why it is added.
Regards, Sean Herek
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Excessive Flow Testing

Whilst the advice from McCrometer confirmed my suspicions, I also needed to investigate how and if results would be affected if a McCrometer was used to determine flows in excess of 10l/s. Note that a standard McCrometer use in Australia has flow readings up to and in excess of 40l/s, therefore users might be tempted to use them for excessive flows.

The obvious area for FSCS to investigate was the friction loss through a single “angle” pattern hydrant as shown in Figure 5 between points “P1” and “P2”. The P2 location being recommended by the DLGP procedures for internal hydrants as detailed later.

The critical issue is where the “residual” pressure is to be measured. Considering that the residual pressure is that in the “hydrant system” FSCS considers that pressure at point ”P2” in Figure 6 above is not ”in” the system but in the device/s connected to the system.

Accordingly the following calculations measure the pressure losses between points “P1” and “P2” for various flows. Note that P3 is the location at which FSCS has typically observed pressure readings being taken by various contractors.

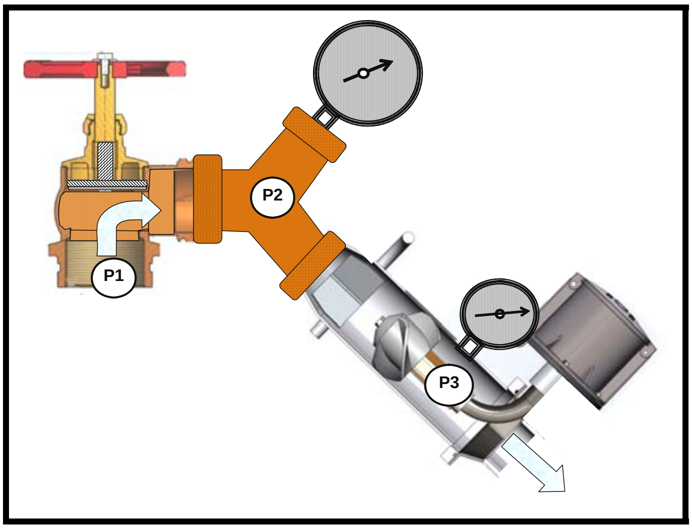

Figure 5 – Hydrant and McCrometer Pressure Locations

Using a hydraulic slide rule as shown at the top of Figure 7, the following calculations were executed:-

- Determining the “equivalent length” of a hydrant “angle” valve – Figure 6
- Determining the friction loss in kPa for flows of 10, 20, 30 and 40 l/s – Figure 7

The results are shown in Figures 6 and 7 below.

ACADS "HYENA" HYDRAULIC PROGRAM EQUIVALENT LENGTH DATA FOR AS2118.1 & NFPA 13 PROGRAMS **(IN FEET)**

										Nominal Fitting Size (mm)			
	mm	15	20	25	32	40	50	65	80	90	100	125	150
Gate Valve	GV	1*	1*	1	1	1	1	1	1	1	2	2	3
Check Valve	CV			5	7	9	11	14	16	19	22	27	32
Globe Valve	LV	16	20	25	34	41	53	61	80	90	101	120	160
Angle Valve	NV	8	11	13	16	21	27	32	40	47	55	60	82
Butterfly Valve	BV						6	7	10	11*	12	9	10
Alarm Valve	AV			0.05	0.2	0.4	1.2	3	8	10	12	15	20
Mushroom Valve	MV										42.1		70.2
Drypipe Valve	DV			0.1	0.2	0.5	1.5	3.5	10	12	18	20	30
Strainer	SR			0.1	0.4	0.75	2.5	6.0	17	20	30	35	40

Figure 6 - Hydrant Valve Equivalent Length

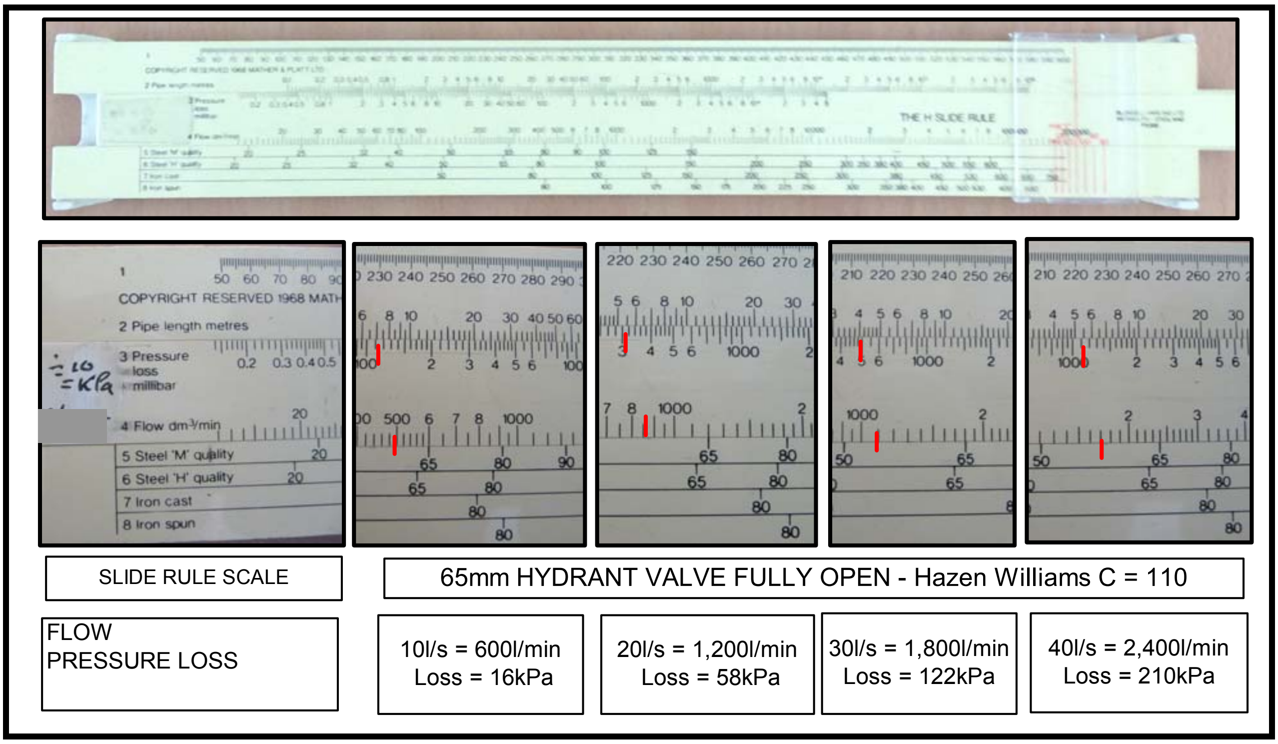

Figure 8 – Hydrant Friction Loss - kPa

The results indicate friction losses of 16kPa, 58kPa, 122kPa and 201kPa through the hydrant valve respectively for the referenced flows.

Whilst the 16kPa loss flow a flow is acceptable, the higher losses for increased flows will certainly result in residual pressures that may fail the required performance criteria. Whilst these figures only address the increased friction loss through the hydrant valve for 20, 30 and 40 l/s, there will also be a significant increase in pressure losses due to turbulent flow in the McCrometer.

Should testing be carried out with the pressure gauge mounted on the McCrometer AND with flows in excess of 10 l/s, the results will no longer be representative of the system performance and very likely result in the system design being failed.

Test Location and Multiple Hydrant Arrangement

Flow tests should be carried out at the highest and most remote point in the system to represent the actual residual flow and pressure. This will also accurately reflect the frictional losses in the pipe reticulation.

Noting as discussed later in the referenced DLGP document and this paper that a McCrometer device should only be use to test a single hydrant at 10 l/s, Figure 9 below shows the arrangement for testing multiple (2) hydrants where the required flow is 20 l/s. Note that in the unlikely scenario where a flow of 30l/s is required, then add a further hydrant to bring the total flow up to 30l/s.

Multiple flow tests from a single hydrant are usually because access to a test drain is not available for multiple hydrants, this arrangement results in increased friction loss through a single hydrant, earlier in this paper the excess friction loss calculations for 10, 20 and 30 l/s are detailed for flow through a single hydrant.

In Figure 9, no pressure gauge is shown connected to the lower hydrant take-off because we are only measuring the residual pressure at the highest hydrant.

However for the arrangement shown in Figure 9 and Figure 10, 16kPa should be added to the uppermost pressure gauge reading, which being the pressure loss through the hydrant valve as discussed later.

Figure 9 also shows how the total friction loss in the system from booster inlet to the most disadvantaged hydrant should be measured, that being the maximum permitted in AS2419.1

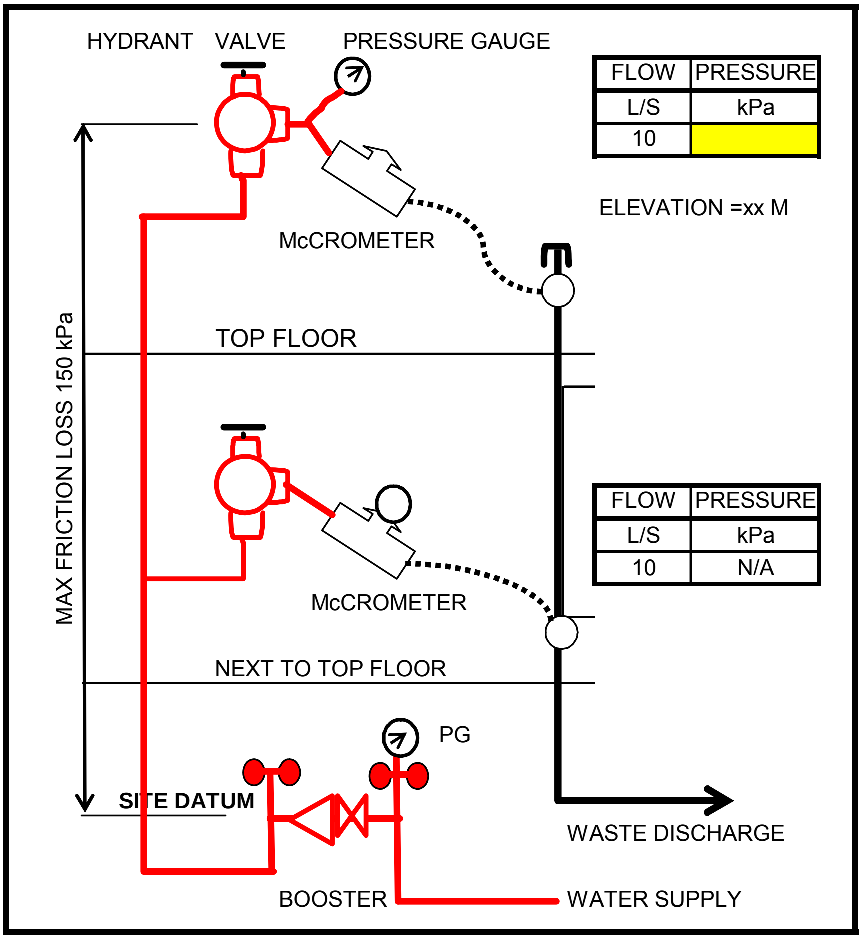

Figure 9 – Multiple Hydrant Testing

If only one test drain is provided (at the highest point) then there are one possible ways of accurately determining system performance acceptance as follows:-

Have the upper McCrometer outlet connected to the single available drain and attach a 65mm hose from the lower hydrant up the stair to a "T' fitting on the drain sharing the discharged water with the upper McCrometer. This will only be satisfactory if the drain line is 150mm nb or greater because there may be excessive back pressure.

Queensland Regulatory Procedures

The Queensland Department of Local Government and Planning (DLGP) "*Fire Hydrant and Sprinkler System Commissioning and Periodic Maintenance Procedure*" Version 1 dated 17th November 2011 is the default testing arrangement in Queensland.

This document details the required arrangement for both external and internal hydrant system tests as follows:-

- For external hydrants, Appendix 1 on Page 11 of the DLGP document reproduced as Figure 10 below shows a twin hydrant where the McCrometer is connected to one hydrant and a blanking cap and pressure gauge connected to the other. The hydrant discharges into open space.

  The pressure reading is the "accurate" static pressure when the hydrant is closed and the residual pressure when flowing.

  This arrangement is typical of external hydrants serving a single level occupancy such as a factory, warehouse or regional shopping centre where external hydrants are permitted to serve both the ground and one storey above the level of access, not having a fire isolated stair.

Note however where that where there are parts of the occupancy of more than one storey and typically with a fire isolated stair, an assessment must be made as to whether external hydrant(s) serving those area(s) require additional flow testing so as to determine if it (they) also meet the residual pressure requirements.

- For internal hydrants, typically located within fire isolated stairs and **sometimes** within the general area of the occupancy, Appendix 1 on Page 12 of the DLGP document reproduced as Figure 11 below shows a single hydrant where a McCrometer is connected to one arm of the "wye" piece and a pressure gauge connected to the other side. The McCrometer outlet discharges into a test drain.
- The pressure reading is only accurate as the static pressure and pressures when flowing need to be corrected by the addition of 16kPa to reflect the pressure drop across the hydrant.

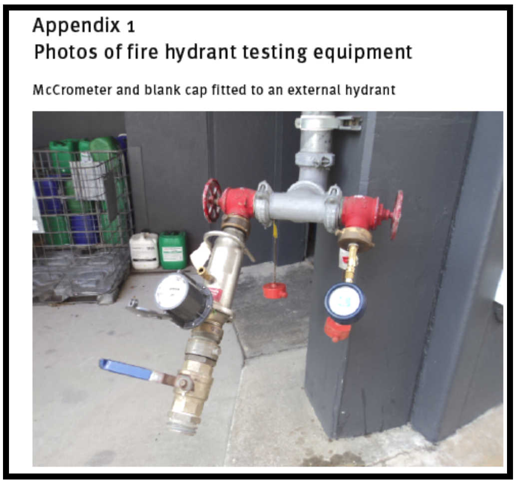

Figure 10 – External Hydrant Test Arrangement

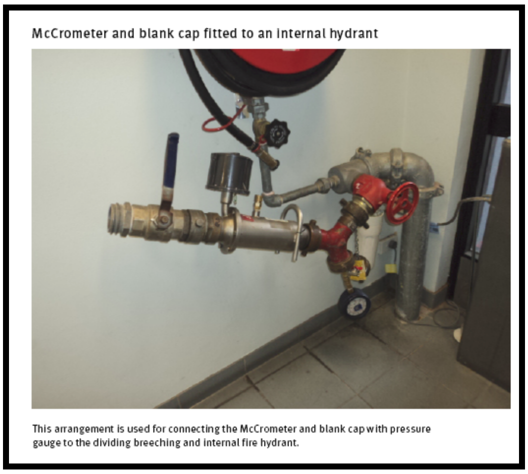

Figure 11 - Internal Hydrant Test Arrangement

I trust that this paper provides useful advice on flow testing.

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Version 2 - 2020