October 27, 2016

Replace Northwest Quadrant Fire Pump and Controller
Northwest Quadrant / Milwaukee Campus
City of Milwaukee

For the: University of Wisconsin

Project Manager: Paul Lippitt

DeForest, WI
(608) 842-0700

Type of Project: Health & Safety

1. Project Description:

The project will create a code compliant fire pump room with new fire pump, jockey pump, and their associated pump controllers. Selective demolition of existing systems and construction of new walls will be required. The existing fire pump will be demolished and piping reconfigured to serve the complex from the new pump room.

The fire pump controller will be designed with a variable frequency drive (VFD) which will limit the system pressure. This will eliminate additional equipment installation, reduce the generator size and utility demand charges, and save maintenance costs on inspection and testing requirements. A code compliant tap of the main electrical service and new normal and emergency power feeders will be installed to serve the fire pump.

Automatic fire sprinkler systems will be installed in the unprotected areas of NWQ-A (Grind Coffee Shop only: 966 SF) and NWQ-B (basement, ground floor, floors 1-5, and floor 8: 86,493 SF), NWQ-C (4,758 SF), and NWQ-D (1,236 SF). In addition, standpipe and automatic sprinkler system repairs will be made to the existing systems within NWQ-B, NWQ-C and NWQ-D. This will include elevator work in NWQ-C to allow for sprinkler system installation.

The fire alarm system will be expanded to support the installation of the fire pump and other miscellaneous fire suppression system modifications made with this project.

2. Authorized Budget and Funding Source:

$184,800 Z070 SP Facilities Repair/Renovation

3. Schedule:

Submission of Bid Documents for Final Review: September 2017
Bid Opening: December 2017
Start of Construction: February 2018
Substantial Completion / Occupancy: January 2019
4. Budget Summary:

<table>
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<th>Per Design</th>
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<td>Construction:</td>
<td>$2,252,700</td>
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<td>Contingency:</td>
<td>$225,300</td>
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<td>A/E Fees:</td>
<td>$180,300</td>
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<td>DFD Mgmt:</td>
<td>$99,200</td>
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<tr>
<td><strong>Total Project Cost:</strong></td>
<td><strong>$2,757,500</strong></td>
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SPECIAL DESIGN AND PLANNING ISSUES

Project History

The original project request included the replacement of the existing fire pump, jockey pump, and their associated controllers. The existing fire pump was aging, but still functional, and the jockey pump and its controller were recently replaced. The fire pump controller, however, was in need of repair. With larger scale remodeling proposed for the 2015-2017 biennium, the decision was reached by the Agency and the Department of Facilities Development to only proceed with the fire pump controller replacement.

The former Columbia St. Mary’s Complex was acquired by the University of Wisconsin-Milwaukee in 2010. The Northwest Quadrant (NWQ) complex was originally constructed in 1919 and since that time has been added onto a total of 16 times and has undergone several renovations in its history. Until 2009, the facilities had been utilized as a hospital until Columbia – St. Mary’s relocated. The buildings have been occupied by various campus departments, some of which have made their permanent homes at NWQ, but largely the building has served as surge space or has remained unoccupied.

With the numerous building additions and various remodeling projects over the years, the project sought to complete a thorough review of the existing fire protection systems to determine how the existing system was configured.

Existing Conditions

The Northwest Quadrant (NWQ) complex comprises of an East Wing (NWQ-A), West Wing (NWQ-B), Clinical Building (NWQ-C), Medical Arts Tower (NWQ-D), Energy Center (NWQ-E), College of Nursing (NWQ-F), and Parking Garage (NWQ-G). This project reviewed NWQ-A, NWQ-B, NWQ-C, NWQ-D, and NWQ-E facilities only.

Figure 1: Northwest Complex – Depiction by Area
The existing fire pump is located on the basement floor of the West Wing (NWQ-B). The current pump is rated for 1,500 GPM at 55 PSI and serves East Wing (NWQ-A), West Wing (NWQ-B), Clinical Building (NWQ-C), Medical Arts Tower (NWQ-D), and Energy Center (NWQ-E). The fire pump supplements the available city water pressure to meet standpipe and sprinkler water requirements in NWQ-A through NWQ-E. The fire pump test header consists of a four-way flush test connection on the north side of NWQ-B. Traditionally for this size of pump, a six-way test connection would be provided as each outlet is capable of a minimum flow of 250 GPM; however, the service records do not indicate that there has been an issue in achieving the required flow under test conditions.

There are two existing water services which supply the fire protection system. An 8” water service enters NWQ-B from Newport Avenue and supplies water to the fire suppression system upstream of the fire pump. This service is equipped with a single detector check which would have met code for backflow prevention at the time of its installation. A double detector check is now required to meet current code. A 6” fire protection service enters the west wing of NWQ-A from a main located in Hartford Avenue. This service is equipped with a double detector check and connects to the fire suppression system serving NWQ-B, NWQ-C, and NWQ-D through a tie valve located in NWQ-A. This connection is downstream of the fire pump. While this service does provide some increased supply and pressure, it cannot be considered a true back-up water service due to its tie location.

There are three two-way flush fire department connections (FDC) located in NWQ-A and NWQ-B. The number of inlets would not meet current code requirements for the flow (GPM) demands of this facility, but did at the original time of installation. These fire department connections are also not appropriately labeled to indicate their use. Fire department connections are located near existing and/or private fire hydrants.

Figure 2: Northwest Quadrant Site Plan
Class I standpipes are located in the stairwells of NWQ-B, NWQ-C, and NWQ-D. There is also a Class III standpipe system in NWQ-B. The standpipe system in NWQ-A is not compliant with current code and has limited Class II and Class III service. Portions of the Class II standpipe system are serviced from the domestic water supply.

It is unclear when the fire pump was first installed, but it appears to have been installed in either 1966 or 1977 when the first phases of NWQ-B or NWQ-D were constructed. Building and fire code required 65 PSI at the most remote hose valves which would have been on the fourth floor at the time. As subsequent building additions were constructed and the most remote hose valve grew further from the pump, the fire pump size was never changed to reflect the increased pressure demand leaving the building out of code compliance. The current code now requires 100 PSI at the most remote hose valves.

![Figure 3: Northwest Quadrant – Years of Construction](As per Quorum Architects, Inc. 2014 Northwest Quadrant Redevelopment Plan – DFD Project No. 11K3C)

The respective buildings are partially sprinklered at this time. NWQ-A and NWQ-B are sprinklered only in select areas while NWQ-C and NWQ-D are nearly fully sprinklered and have limited unsprinklered areas primarily consisting of electrical, mechanical, and elevator equipment rooms which are separated by fire resistive construction. A summary of unsprinklered areas within each building are as follows:

<table>
<thead>
<tr>
<th>BUILDING</th>
<th>TOTAL GSF</th>
<th>UNSPRINKLERED GSF</th>
<th>% UNSPRINKLERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWQ-A</td>
<td>219,190</td>
<td>135,081</td>
<td>62</td>
</tr>
<tr>
<td>NWQ-B</td>
<td>268,119</td>
<td>94,427 **</td>
<td>35</td>
</tr>
<tr>
<td>NWQ-C</td>
<td>146,896</td>
<td>4,758</td>
<td>3</td>
</tr>
<tr>
<td>NWQ-D</td>
<td>152,727</td>
<td>1,236</td>
<td>1</td>
</tr>
<tr>
<td>NWQ-E</td>
<td>9,978</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Staff and students occupy unsprinklered areas of building. Some occupied areas are above the third floor.
In most cases the areas which are not sprinklered are unoccupied; however, it should be noted that in NWQ-B there are unsprinklered areas occupied by both staff and students. NWQ-B is a Group E occupancy and is limited to a height of three stories above grade unless sprinklered. Based upon the actual constructed NWQ-B height, this building is considered a high rise building.

The sprinkler systems in NWQ-C, D, and E are zoned based on their respective fire areas. There is no consistent zoning in the basement, ground and first floors of NWQ-B. The second through eighth floors of NWQ-B are consistently zoned. NWQ-A does not have separate zones where sprinklered. In NWQ-A, there is a common flow switch on the Ground Floor with subsequent flow switches downstream in some areas for indicating sprinkler flow.

During the field survey to determine how the NWQ complex was zoned, the following deficiencies were observed with the standpipe and sprinkler installation. While outside of the original project scope, these items represent life safety concerns and code deficiencies that require attention. Observations are categorized below by floor and also contain some general items. It is important to note that this list should not be considered comprehensive.

General:

1. Many of the existing fire suppression isolation valves are missing tamper switches and subsequent monitoring by the fire alarm system.
2. There are no 2-1/2” hose connections on each side of the wall where horizontal exits are present.
3. Standard spray sprinkler heads which are greater than 50 years old should be replaced with new. Any quick response sprinkler heads older than 25 years should also be replaced with new.
4. Adequate drain provisions for testing of flow switches is not provided.
5. The 1-1/2” hose valves and hoses should be removed and capped in place.
6. Pull cord tamper switches where present in the building should be removed and replaced with new.
7. In Building A, there are 2-1/2” and 4” standpipes which have no 2-1/2” hose valves located in the stairwells. This building contains mostly 1-1/2” hose valves. There is one 2-1/2” hose valve in Stair 2200P.
8. Not all exit stairwells in Building A have standpipes.
9. Inspection, testing, and maintenance requirements as required per NFPA 25 are not current.

Basement:

10. The second water service which enters from Building A does not connect on the pump suction side. This connects to the standpipe system downstream of the pump discharge near the Yellow Elevators.
11. In Film Storage B498, the sprinkler head spacing is spaced for Light Hazard in an area which has compact shelving. Design density should be increased to Ordinary Group 2. The existing light fixtures also obstruct the sprinkler head discharge pattern.
12. Mechanical Room B679, Electrical Room B815B, and a portion of Storage B495 which are not sprinklered. With the exception of these three rooms, the remainder of the NWQ-B basement level is fully sprinklered.
13. There is no flow switch on the main supply downstream of the fire pump. The 8” supply feeds to the building from Mechanical Room B815 also do not have flow switches.
14. The fire pump’s electrical supply is not wired in accordance with NEC Article 695.
Ground Floor:

15. The second water service which enters from Building A does not connect on the pump suction side. This connects to the standpipe system downstream of the pump discharge near the Yellow Elevators.

16. Telephone Room G235, Telephone Equipment G225, and Paint G221 were supplied by a dry pipe system. The valve has been abandoned, but the abandoned sprinkler system has not been reconnected to the existing wet pipe sprinkler main in the area.

17. There is a ½" piped inspector’s test connection located in G240A. The minimum piping size for inspector’s test connections is to be 1" in size.

18. There is sprinkler piping and heads present in Storage G121; however, they are installed out of listing (not within 12" of the ceiling).

19. In the northeast section of Building B, there is a small area supplied by a 3" riser off the standpipe system which has no flow switch.

20. In Stair G300V, there is a 1-1/2" hose valve that was served from the domestic water supply.

First Floor:

21. A 6" sprinkler riser is located in Blood Drawing 1485. There is a flow switch and main drain located downstream of the isolation valve. The main drain is provided at 1-1/4". Per NFPA 13, this drain should be installed as a 2" drain.

22. The dry pendent sprinklers have been removed and capped from the existing freezers and coolers. The freezers and coolers are no longer in use.

23. Corridor 1476, Registration 1476A, Blood Drawing 1485, and Admit Office are located in Building B and supplied by the sprinkler system located in Building D. These systems should be disconnected and supplied from the sprinkler system within Building B so they are continuous with the Building B fire area.

Second Floor:

24. In B Building, the zone control assembly for the 2nd floor is equipped with a 1-1/2" drain on a 4" system supply. This should be increased to a 2" drain per NFPA 13.

25. Building D sprinkler heads were part of a sprinkler head type that was recalled. All sprinkler heads on this floor should be replaced.

26. Mechanical Room 2780 was not sprinklered. This room did not appear to contain electrical switchgear and is recommended to be sprinklered.

27. At the end of Passage 2830, there is a small area which is not sprinklered.

28. The northeast corner of Building A (old stable and maintenance area) has the roof level sprinklered from the existing wet pipe system. This should be removed and replaced by a dry pipe system to mitigate potential for freeze-ups.

29. In Mechanical Room 2269, sprinkler coverage is not provided to meet code minimum spacing.

Third Floor:

30. In B Building, the zone control assembly for the 3rd floor is equipped with a 1-1/4" drain on a 4" system supply. This should be increased to a 2" drain per NFPA 13.

Fourth Floor:

31. In B Building, the zone control assembly for the 4th floor is equipped with a 1-1/4" drain on a 4" system supply. This should be increased to a 2" drain per NFPA 13.
32. There is a 2" main tapped into the existing 1-1/4" drain line (prior to the drain valve). This should be relocated to be tapped into the main.
33. The flow switch in Building B is an older Autocall flow switch. This should be replaced with new.
34. Building C does not have a gauge at the top of the standpipe.

Fifth Floor:

35. In B Building, the zone control assembly for the 5th floor is equipped with a 1-1/4" drain on a 4" system supply. This should be increased to a 2" drain per NFPA 13.
36. Storage 5828 has insufficient sprinkler spacing based on the design density.
37. The 5th floor of Building A was remodeled in recent years. Sprinkler supply was tapped from Building B (exact connection point was not found). The sprinkler system for Building A should originate from Building A so it is continuous with the Building A fire area. A flow switch for this area was not located.
38. The east sections of Building A which are sprinklered do not appear to have a flow switch and monitoring.
39. The refrigerator assembly has been removed from Walk-in Cooler 5371. This area was originally not sprinklered or was provided with a dry pendent head. After cooler removal, sprinkler protection was not added back into this space.

Roof:

40. There are no hose valves provided on the roof per NFPA 14.
Scheduling

The pump and controller replacement is planned for 2018 with project completion in January 2019. The following depicts the anticipated project schedule:

<table>
<thead>
<tr>
<th>TASK NAME</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tr>
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<td>QUARTER 4</td>
<td>QUARTER 1</td>
<td>QUARTER 2</td>
<td>QUARTER 3</td>
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<td></td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
<td>Jan</td>
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<tr>
<td>CLOSE-OUT</td>
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Notes:
1. Durations are based upon the scope presented above and has not accounted for additional project duration due to unforeseen conditions or additional unknown scope items which may become apparent as the project progresses.
2. Schedule is based on average working conditions with construction in occupied areas occurring during evenings/night on a shift basis. All unoccupied area work is planned for day shift.
3. Schedule includes time for contractor shop drawing review and approval. Construction schedule is based upon standard Department of Safety and Professional Services plan review duration, receipt of materials without unreasonable delay, and no lost time due to adverse conditions.

After hours work will be discussed with the Agency and areas where off hours construction is necessary will be noted in the construction documents. Furthermore, phasing and sequencing of work will be discussed with Facilities Management to coordinate with planned events and other projects on campus.
The following is a floor-by-floor tabulation of gross square footage concerning the buildings which are involved in this project.

<table>
<thead>
<tr>
<th>NWQ MAIN COMPLEX</th>
<th>PENTHOUSE</th>
<th>EAST WING</th>
<th>WEST WING</th>
<th>CLINICAL BUILDING</th>
<th>MEDICAL ARTS TOWER</th>
<th>ENERGY CENTER</th>
<th>TOTAL A-E (GSF)</th>
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<td>32,037</td>
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<td>29,117</td>
<td>20,492</td>
<td>154,154</td>
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<tr>
<td>Floor 1</td>
<td>51,374</td>
<td>34,073</td>
<td>28,707</td>
<td>19,602</td>
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<td>Floor 2</td>
<td>35,859</td>
<td>28,184</td>
<td>23,713</td>
<td>11,624</td>
<td>104,770</td>
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<td>Floor 3</td>
<td>28,146</td>
<td>23,113</td>
<td>23,741</td>
<td>12,478</td>
<td>97,868</td>
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<td>Floor 4</td>
<td>25,085</td>
<td>23,094</td>
<td>9,581</td>
<td>12,478</td>
<td>80,628</td>
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<td>Floor 5</td>
<td>25,236</td>
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<td>Floor 7</td>
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<td>Floor 9</td>
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<td>6,213</td>
<td>8,209</td>
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<tr>
<td>Building Total S.F. (All Floors)</td>
<td>219,190</td>
<td>268,119</td>
<td>146,896</td>
<td>152,727</td>
<td>9,978</td>
<td>858,181</td>
<td></td>
</tr>
</tbody>
</table>

The following table describes the floor to floor heights for the existing NWQ complex.

| NWQ MAIN COMPLEX | PENTHOUSE  | EAST WING | WEST WING | CLINICAL BUILDING | MEDICAL ARTS TOWER | ENERGY CENTER | EXISTING FLOOR TO FLOOR HEIGHTS |
|-------------------|------------|-----------|-----------|-------------------|-------------------|---------------|--------------------------------
<p>| Mechanical Penthouse | ---       | ---       | ---       | 16'-9.5&quot;          | ---               | ---           | ---                            |
| Helipad           | 9'-4.5&quot;   | ---       | ---       | ---               | ---               | ---           | ---                            |
| Floor 8           | 18'-4.5&quot;  | ---       | 12'-8&quot;    | ---               | ---               | ---           | ---                            |
| Floor 7           | 15'-2&quot;    | ---       | 12'-8&quot;    | ---               | ---               | ---           | ---                            |
| Floor 6           | 14'-7&quot;    | ---       | 12'-8&quot;    | ---               | ---               | ---           | ---                            |
| Floor 5           | 15'-4&quot;    | 12'-1&quot;    | ---       | 13'-7&quot;            | ---               | ---           | ---                            |</p>
<table>
<thead>
<tr>
<th>Floor Level</th>
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<th>0</th>
<th>0</th>
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</tr>
</thead>
<tbody>
<tr>
<td>FLOOR 4</td>
<td>12'-0&quot;</td>
<td>12'-0&quot;</td>
<td>---</td>
<td>11'-4&quot;</td>
<td>---</td>
</tr>
<tr>
<td>FLOOR 3</td>
<td>12'-2.5&quot;</td>
<td>12'-2.5&quot;</td>
<td>12'-2.5&quot;</td>
<td>11'-4&quot;</td>
<td>---</td>
</tr>
<tr>
<td>FLOOR 2</td>
<td>13'-0.5&quot;</td>
<td>13'-0.5&quot;</td>
<td>11'-5.875&quot;</td>
<td>11'-4&quot;</td>
<td>---</td>
</tr>
<tr>
<td>FLOOR 1</td>
<td>11'-6.75&quot;</td>
<td>11'-6.75&quot;</td>
<td>13'-1.375&quot;</td>
<td>11'-4&quot;</td>
<td>---</td>
</tr>
<tr>
<td>MEZZANINE</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>20'-0&quot;</td>
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<tr>
<td>GROUND FLOOR</td>
<td>9'-6&quot;</td>
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<td>14'-0&quot;</td>
<td>14'-0&quot;</td>
<td>14'-0&quot;</td>
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<td>BASEMENT</td>
<td>---</td>
<td>13'-0&quot;</td>
<td>13'-0&quot;</td>
<td>13'-0&quot;</td>
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</table>
DESIGN CONCEPT / BASIS OF DESIGN

Codes and Standards Impacting This Project


Overall Project Description

The project will create a code compliant fire pump room with new fire pump, jockey pump, and their associated pump controllers. The project will also install automatic sprinkler systems in the unprotected areas of NWQ-A (Grind Coffee Shop only: 966 SF) and NWQ-B (basement, ground floor, floors 1-5, and floor 8: 86,493 SF), NWQ-C (4,758 SF), and NWQ-D (1,236 SF). Other miscellaneous repairs, maintenance items, and deficiencies will be corrected in NWQ-B, NWQ-C, NWQ-D, and NWQ-E. Aside from installing sprinklers in the Grind Coffee Shop, capping the existing 6” water service, and adding standpipe service to two stairwells, no other scope in NWQ-A is planned due to future large scale remodeling. Elevator #17, located in NWQ-C, will receive fire service upgrades including the addition of sprinklers within the pit, hoistway and elevator equipment room, shunt trip protection, and new drainage provisions.

The scope will correct code deficiencies related to the fire suppression systems and will address the repair needs and improve the safety of the existing structure.

Existing Fire Suppression Systems

The existing fire pump is located on the basement floor of the West Wing (NWQ-B) in Mechanical Room B815. The current pump is rated for 1,500 GPM at 55 PSI and serves East Wing (NWQ-A), West Wing (NWQ-B), Clinical Building (NWQ-C), Medical Arts Tower (NWQ-D), and Energy Center (NWQ-E). The fire pump appears to be original to the 1966 NWQ-B or 1977 NWQ-D construction; however, the fire pump controller, jockey pump, and jockey pump controller are newer.

From the fire pump, NWQ-A and NWQ-B share two 8” risers that are designated as standpipe and sprinkler but these risers actually serve both purposes. Each riser is equipped with a tamper switch, but no system flow switch. Similarly in NWQ-C and NWQ-D, there are 6” supplies with tamper switches, but no system flow switches. There is an overall system flow switch on the fire pump suction line.

Class I standpipes are located in the stairwells of NWQ-B, NWQ-C, and NWQ-D. One riser in each of these buildings serves as a combination standpipe/riser with the sprinkler system being fed from this standpipe. Portions of the ground floor sprinkler system in NWQ-B are serviced from the NWQ-C and NWQ-D combination standpipe/risers. There is also a Class III standpipe system in NWQ-B. The standpipe system in NWQ-A is not compliant with current code and has limited Class II and Class III service. Portions of the Class II standpipe system are serviced from the domestic water supply. It is recommended that the Class II and Class III standpipe systems be capped and/or removed and utilize only Class I standpipes throughout the facilities.
The NWQ complex buildings are partially sprinklered. NWQ-A and NWQ-B are sprinklered only in select areas. NWQ-A is largely unoccupied with some areas used for storage. In NWQ-B, there are unsprinklered areas which are occupied by both staff and students. NWQ-B is a Group E occupancy and is limited to a height of three stories above grade unless sprinklered. NWQ-C and NWQ-D are nearly fully sprinklered and have limited unsprinklered areas as previously noted.

The buildings were installed using Schedule 10 and Schedule 40 black steel piping with grooved and threaded fittings most of which are rated for 175 PSI. A 5-year internal inspection on the piping has not been performed recently to be able comment on the existing piping condition.

**New Fire Pump Room**

The pump will be installed in B860 which is adjacent to Mechanical Room B815 where the current pump resides. Installing the pump within the current Mechanical Room B815 is not feasible as there is not sufficient space for installation of both the pump and controller while maintaining the existing system in service. Overall, space is limited in Mechanical Room B815 due to the multitude of other mechanical systems installed to serve the building. Room B860 was selected due to the close proximity to the existing water supply and fire suppression piping. The overall master plan for the NWQ complex included the proposed room as a potential recycling room due to the close proximity to the loading dock. The existing room will be divided to maintain as much space as possible for this function.

A new two-hour rated wall will be constructed to create the fire pump room. A 1-1/2 hour door assembly will be added from Corridor B800B to create a small recycling room and provide access to B870. An exhaust fan will be installed to ventilate the fire pump room. Provisions for intake and exhaust air locations will need to be determined as the design progresses.

Room B860 appears to have served many uses over the years with remnants of the uses remaining from special purpose receptacles to air handling units to shower components. These components will be demolished and new systems installed to meet the new space usage.

**Water Service Modifications**

A flow test was requested from the City of Milwaukee and found to have a total flow of 1,050 GPM at 68 PSI residual (75 PSI static). The existing 6” and 8” water services are adequate to supply the fire suppression system; however, the new 8” water service will receive a new double check detector assembly to become compliant with current code. The new double check detector assembly will be installed opposite the existing water meter and new piping will be routed to the fire pump inlet.

The 6” fire service which enters NWQ-A will be capped at the building entrance to abandon the existing water lateral. The fire department connection near this service entrance will remain. The backflow preventer will be removed and the lateral valve closed leaving the 8” water service to supply the building’s fire protection needs.

**New Fire Pumps and Pump Controllers**

Because all four buildings of the NWQ complex are connected, code permits a single fire pump to serve all buildings. A 200 H.P. (460 Volt, 3-phase) horizontal, split-case fire pump has been selected based upon the preliminary hydraulic calculations performed. The new pump will be rated at 1,250 GPM at 150 PSI (3,550 RPM). The churn pressure of this pumping configuration will be in excess of what the existing piping system and sprinkler heads are rated for. A variable frequency drive (VFD) style fire pump controller with a transfer switch is proposed to limit this pressure. VFD style controllers operate by changing the speed of the pump to raise or lower the output pressure. This allows the system to maintain a constant system pressure or to regulate the pressure to any speed regardless of the pump flow.

A 3 H.P. jockey pump will be pad mounted adjacent to the fire pump to maintain system pressure. The controller for this equipment will be wall mounted within the fire pump room.
The new fire pump has been selected based upon four 2-1/2" hose valves on the 7th floor of NWQ-B plus a fifth 2-1/2" hose valve on the 8th floor of NWQ-B as the design condition. The VFD controller will be configured to provide 65 PSI at the hydraulically most remote valve to meet code at the time of its installation; however, the pump will have the capacity to provide 100 PSI in the future as remodeling occurs and the fire suppression systems are brought into compliance with code.

**Fire Protection System Piping Modifications**

All new piping will be installed as black steel, with the exception of the lead-in to the double check detector assembly which will be Schedule 10, Type 304 stainless steel with grooved fittings. Black steel piping in sizes 2-1/2" and larger will be installed using Schedule 10 piping. All piping 2” and smaller will be Schedule 40.

New piping will be routed from the double check detector assembly to the inlet of the fire pump. This will be routed in a manner to maintain the existing fire pump in service. New fire pump bypass piping will be installed within the fire pump room. The pump outlet will be routed back into Mechanical Room B815 and reconnected to the existing pump outlet, test header, and fire department connection. As a consideration, a distribution header could be created to provide valved, zoned outlets for connection of NWQ-A, NWQ-B, NWQ-C, and NWQ-D systems should it be desired.

Piping in the basement level will be removed and replaced with larger piping where necessary to improve hydraulic performance. This will be done to decrease the size of the fire pump which will also reduce the corresponding electrical connections to the new pump.

In NWQ-B, the existing sprinkler mains will be modified to create consistent zoning on the basement, ground and first floors. Currently, areas of these floors are being served out of NWQ-C and NWQ-D. Piping will be re-routed to serve NWQ-B from within Building B’s fire area.

Modifications to the existing standpipe system will also be made as part of the project. In NWQ-B, all 1-1/2“ hose valves will be removed and capped. Roof mounted hose valves will be installed in NWQ-B, NWQ-C and NWQ-D. In addition, all gauges will be replaced at the top of the standpipes throughout these buildings.

Class I standpipe service will be added to two stairwells in NWQ-A near the white and blue elevators. Supply for the new standpipes will be from an existing 5" main located on the Ground Floor of NWQ-A (G250). A water flow switch and butterfly valve with tamper switch will be provided on each standpipe. Hose valves will be located on the intermediate landing for fire service. All Class II and Class III hose valves will be removed from service in NWQ-A.

**Automatic Sprinkler Systems**

Automatic sprinkler systems will be provided and/or expanded into the unsprinklered areas of NWQ-B, NWQ-C, and NWQ-D. New connections to the existing riser/standpipe will be made where needed to install the sprinkler system into the unsprinklered areas. To allow for installation, the existing ceiling tiles will be removed, the hole cut to allow for the sprinkler drop within the tile, and the tiles reinstalled.

In Building A, there is a 4” line that comes up in the chase behind the coffee shop that is available for connection. This line will be tapped and a new floor control assembly with water flow switch and tamper switch installed.

A breakdown of the areas to receive automatic sprinklers is as follows:
In addition to sprinklering the remainder of NWQ-B, NWQ-C, and NWQ-D, all standard spray sprinklers in NWQ-B (Basement through 5th Floor) and quick response sprinklers in NWQ-D (5th Floor through 9th Floor) will be replaced with new quick response sprinkler heads per NFPA 25. Also, sprinkler heads on the 2nd Floor of NWQ-D will be replaced with new as the installed sprinklers are part of a manufacturer’s recall.

Sprinkler head spacing in Film Storage B498 and Storage 5828 will be modified to be code compliant with its hazard design density. Piping will be rerouted and/or modified to accommodate the increased design density.

The project scope will also include providing code compliant main drains and adequate drainage provisions for flow switch testing.

**Elevators**

The complex currently has seven banks of elevators and four single elevators which are identified by color and number. In 2014, a Multi-Building Elevator Renovation Upgrade (DFD Project 12A1A) was completed which modernized the green, yellow, and orange elevators providing them with fire service, sprinkler systems, and shunt trip protection.

There are several elevators which are out-of-service or have future plans to be decommissioned. Currently, the blue, white and brown elevators are locked-out of service. The 2014 Northwest Quadrant Redevelopment Plan calls for both the blue and white elevators to be decommissioned, as well as the black elevator which is used as a staff elevator. Elevator upgrades to the brown elevators are planned as part of a larger HVAC Systems Upgrades and Horizontal IT Cabling project in NWQ-C & NWQ-D in the future; however, their future is unclear due to the close proximity of the red elevators.

This leaves the red and purple elevators to evaluate. Elevators #12, 13, and 14 (red) are traction type elevators with a penthouse equipment room. While Wisconsin is currently on the 2007 edition of NFPA 13, the pending state adoption of the 2015 International Building Codes references the 2013 edition of NFPA 13. The 2013 edition (NFPA 13 - 8.15.5.3) permits the elimination of automatic fire sprinklers from the elevator machine room, hoistway and pit in traction style elevators. Dependent upon when this code is adopted, along with any Wisconsin modifications, petition for modification or variance may be required, but based upon initial review, these elevators can remain unsprinklered.

Elevator #17 (purple) is a hydraulic style elevator located in NWQ-C and serves Floors B-1. The elevator is provided with Phase 1 and Phase 2 fire service and is believed to be 1989-1990 code compliant. The machine room and hoistway are not sprinklered at this time. The project will install automatic sprinklers within these spaces, provide shunt trip protection, and will address code required fire service upgrades associated with sprinklering. At this time, it is unclear if the existing hoistway is provided with a code compliant drain and sump; however, the project will review this and replace/upgrade the drainage within the elevator pit should it be necessary.
Figure 4: Northwest Quadrant – Elevator Identification
(As per Quorum Architects, Inc. 2014 Northwest Quadrant Redevelopment Plan – DFD Project No. 11K3C)
Electrical

Electrical work will be provided as necessary to support the demolition of the existing fire pumps and installation of the new fire pump. The current fire pump is serviced by a 200 Amp disconnect switch and a 225 Amp enclosed circuit breaker fed from a tap of the bus within USS-P2. These components are located within Electrical B815B. This installation does not meet Article 695.3 (Power Supplies) of the National Electric Code. The current fire pump is supplied with emergency power through two sections of distribution equipment, a tap within a pull box located in NWQ-A, and an enclosed circuit breaker prior to the transfer switch (ATS-MAF). This transfer switch is dedicated to the fire pump, but is not UL Listed for fire pump service. It is the desire of the project to bring the installation up to current code and provide a more reliable source of power for the fire pump.

The design proposes to tap the secondary terminals of the transformer and install a service entrance rated, enclosed circuit breaker to serve the fire pump. Due to the existing equipment configuration and need to maintain the fire pump in service during construction, there is not space within Electrical B815B to install this equipment. It is proposed to locate the enclosed switch in the adjacent Mechanical Room B815. The space vacated by the single detector check valve would provide for the front access clearance needed for the equipment. New conduit and feeders will be installed from the enclosed circuit breaker to service the new fire pump and controller.

The complex is served by three, paralleled 600kW, 480-Volt diesel generators located in NWQ-E. The emergency power distribution is configured to meet Article 517 of the National Electric Code for health care requirements and is not segregated into NEC 700, 701, and 702 loads. From the available spaces within the distribution section of the paralleling gear located in NWQ-E, we would propose to install a new fused switch and route new conduit and feeders to the transfer switch within the fire pump controller.

The new feeders from Mechanical Room B815 and NWQ-E will be 2-hour rated feeders per NEC Article 695.14 (Control Wiring).

The existing jockey pump disconnect will be reused and new conduit and feeders routed to the new jockey pump and controller located within B860.

The Elevator #17 (purple) will be provided with a new fusible disconnect switch with shunt trip capability and voltage monitoring, and fire safety signal interface.

Fire Alarm

The project involves the installation and replacement of new tamper switches and flow switches as it relates to the installation and modifications to the existing fire suppression system. In addition, monitoring of the new fire pump controller per NFPA 20 will be provided. These devices and equipment will be furnished and installed by the Fire Protection Contractor. The Fire Alarm Contractor will be responsible for providing monitor modules, programming and connecting these modules to the existing fire alarm control panel(s).

Smoke and heat detection will be added to Elevator #17’s hoistway and elevator equipment room. Interconnection for fire alarm shunt trip will also be provided. The existing smoke and heat detection of Elevators #12, 13, and 14 will be further reviewed and detection installed in order to apply the provisions of NFPA 13 (2013).

The existing fire alarm system was installed by Johnson Controls (JCI 3030 intelligent addressable two-way voice system). This system was installed as part of DFD Project 12B1R which created a Fire Command Center in NWQ-B, Room 1470. All new devices will be compatible with the existing equipment. UWM Electricians have confirmed that space is available on the signaling line circuit (SLC) loop for additional devices.
## DESIGN REPORT BUDGET DETAIL

### OCTOBER 27, 2016
NORTHWEST QUADRANT FIRE PUMP AND CONTROLLER
UNIVERSITY OF WISCONSIN MILWAUKEE
MILWAUKEE, WISCONSIN

**Project Number:** 14J1O

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EXISTING DRAWINGS

Fire Protection Field Survey Drawings
Partial Electrical One-Line Drawing
Standpipe System Riser Diagram
UWM Campus Planning NWQ Ground Floor Space Plan

FIRE SUPPRESSION EQUIPMENT

Fire Pump
Fire Pump Controller
Variable Speed Fire Pump Controller Slideshow – Master Control Systems, Inc.

MISCELLANEOUS

City of Milwaukee Flow Test
Site Photos
AURORA® MODEL 481 PUMPS

SINGLE-STAGE FIRE SERVICE

Section 912 Page 201

Date AUGUST 2014

Supersedes Section 912 Page 201
Dated JUNE 2014

NOTES
1. All dimensions are in inches (mm).
2. Dimensions may vary ± 3/8" (10).
3. Not for construction purposes unless certified.

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PUMP SIZE

DISCH MODEL 481 PUMPS

AND DISCHARGE

OPT. 250# SUCTION FLANGE

PUMPS

SUCTION FLANGES

DISCH FLANGE

OPT. 125# SUCTION FLANGE

OPT. 125# DISCHARGE FLANGE

OPT. 250# DISCHARGE FLANGE

FIREFIGHTER PUMP CUTSHEET

Master Control Systems, Inc.

Variable Speed
Fire Pump Controllers

Meets NFPA 20 - 2013

UL/FM Listed and Approved for fire protections
Why Variable Speed?

- Huge Sprinkler System and Standpipe Cost Savings can be obtained while increasing the reliability of the system!
  - Eliminates Pressure Reducing Valves (PRVs)
  - Eliminates related NFPA 25 inspections and testing
  - Eliminates break tanks (saves cost and space)
  - Reduces high pressure piping
  - Reduces pipe sizing
  - Reduces the gen-set size
  - Reduces utility demand charges
  - Can add a water supply safety factor for future growth without affecting the design.
Ok, what does it look like?

Model ECV-150-46-XG4

Listed and Approved For Fire Protection
So how does it work?

**ENGINERING PRINCIPLES**

- By changing the speed of the pump, the output pressure can be raised or lowered accordingly to maintain a constant system pressure.
- For a centrifugal pump, the pressure varies by the square of the speed. For Example, if a pump produces 100 psi at rated speed, it will produce 64 psi at 80% speed.
The water supply curve (blue) and the fire pump curve (red) add together to make the system supply curve (yellow).

As you can see, the pressure on the system under low flow conditions far exceeds the standard 175 psi ratings of most components.
Engineering principles

- So by controlling the speed you can regulate the pressure to any value under the 100% speed system curve, regardless of flow.
- Thus, the design point can be very close to the maximum system pressure allowed.
But is it Reliable? Yes!

Our design is totally redundant.

The variable speed drive is automatically isolated and bypassed by the traditional fire pump controller if needed.
Load and Line VFD Isolation

- Load isolation is added to disconnect the motor from the VFD before connecting it to the traditional fire pump controller.
- Line isolation is added to increase the life of the VFD as well as to reduce the exposure to service entrance line transients.
5% Line Reactance for VFD

- Reduces RMS line currents.
- Reduces effects of line transients.
- Reduces electrical line noise.
VFD Line Side Fusing

- Fusing is added in the VFD power path to protect the traditional fire pump controller circuit breaker from tripping due to a fault in the VFD power path.
- This fusing is bypassed in the traditional fire pump controller power path.
So How Does it Operate?

- The controller is started when the pressure drops below the “start pressure”, just like with an ordinary fire pump controller.
- Once started, the VFD powers up and begins regulating the motor speed to maintain the “set pressure”. If the VFD “Ready” signal is not received in 5 seconds, the VFD will be bypassed.
- If the system pressure is not high enough to exceed the “reset pressure”, the controller will bypass the VFD within 15s.
- If the system pressure drops below the “bypass pressure” while running for more than 15s, the VFD is bypassed.
- Once bypassed, the controller will continue running in the bypass mode until manually reset.
The jockey reset must be above the VFD set pressure to send the VFD to its minimum speed before auto stop can occur. Note: Unlike normal VFDs, we don’t slow down the fire pump to see if water flow exists. This would drop the pressure on a fire hose during a fire.

VFD set pressure must be above the fire pump controller reset to turn off the VFD failure timers.

The VFD running bypass should be set below 65% of the set pressure and higher than the max. static suction pressure.

### Pump Room Settings

- **180**: Bypass Relief Valve (max. psi)
- **175**: Jockey Reset
- **170**: VFD Set Pressure
- **165**: Jockey Start
- **160**: Fire Reset
- **155**: Fire Start
- **115**: VFD Running Bypass Reset
- **100**: VFD Running Bypass Trip
If your building is over 75’ tall it’s classified as a High Rise building by NFPA 14.

Most jurisdictions will require a class 1 standpipe system and an automatic sprinkler system.
Standpipe System

- Now with the variable speed controller, you can raise the maximum height or zone to 150 feet without the use of PRV’s.
  - 175 psi under any conditions
    - 100 psi FD requirement
    - 10 psi riser friction loss (0.067 psi/ft)
  ======
  65 psi x 2.31 ft/psi = 150 feet.

- Finally a realistic PRV free building!
When a combined sprinkler and standpipe system is used, the sprinkler system is subject to the same pressure as the standpipe system.

Before variable speed controllers, PRV’s were used to also keep the sprinkler system pressure to 175 psi or below.
Let’s calculate a 12-story, 144 foot, large footprint, high rise building with 12 feet per floor.

It will have:
- 4 stairways
- 2 sprinkler design areas per floor.
High Rise Calculations

- With 4 stairways, the required gpm will be 500 for the 1st and 250 for the others. This adds up to a total of 1250 gpm. For a combined system, only 1000 gpm is needed.
- Ideally, the pump pressure is based on the elevation of the building, plus 100 psi on the roof for the Fire Department connection less the residual pressure of the water source. However, the friction loss of the standpipe and the backflow preventer must also be added.
- So if the elevation pressure is 63 psi and the residual pressure is 30 psi, the ideal pump pressure is 133 psi. However, we need to add 3 psi for the standpipe loss and 10 psi for the backflow preventer so the nearest pump size will be 1000 gpm at 150 psi.
Residual Calculations – 144 feet

12 Story High Rise
Class I Standpipe
12 feet per floor

Residual Calculation

30 psi
Backflow Preventer 10 psi
170 psi
Fire Pump 150 psi
170 psi

5 psi friction loss
(6 inch riser)

103 psi
2 1/2" Fire Department Hose Valve Connections
Static Conditions

- This looks good so why do we need variable speed if the maximum pressure is 170 psi?
- Because of the high static or low flow fire conditions.
  - Static water source higher
  - No drop in backflow preventer
  - Pump running at shutoff is higher
  - No friction loss in pipes
In this case, the pump adds 30 psi at shutoff. Note: The max shutoff pressure per NFPA-20 is 140% which could add as much as 62 psi.

- The city supply adds 30 psi from residual to static.
- The backflow preventer adds 10 psi from residual to static.
- Adding these to the residual design pressure of 170 will produce a total static system pressure of 240 psi.
Static Calculations – 144 feet

Pressures are too high on all 12 floors.
Add PRV’s, Pressure Regulating Valves, high pressure fittings, and drain risers from the 12th floor down. This amounts to:

- 48 Fire Department PRV’s (12 per stairway x 4)
- 4 Three inch drain risers (1 per stairway)
- 24 Floor Control PRV’s (1 per sprinkler design area x 2)
- 24 Relief valves and piping for the sprinkler PRV’s
12 Story Conventional Design Solution

All 12 floors require PRVs.
12 Story Conventional Design Detail

- Fire Department PRV’s typically require:
  - Input Pressure Gauge
  - Monitor Switch
  - 2 ½” Cap and Chain
- 3” drain riser (not shown)
- NFPA 25 Requires:
  - Quarterly Inspections
  - Annual partial flow test
  - 5-year full flow test
Sprinkler Control PRV’s typically require:
- Input pressure gauge
- Output pressure gauge
- Small relief valve
- Flow switch
- Tamper switch
- Connection to 3 inch drain riser (not shown)

NFPA 25 Requires:
- Quarterly Inspections
- Annual partial flow test
- 5-year full flow test
### 12 Story Conventional Design - Owner Costs

- **PRV’s, labor and related costs**  
  ($857 /FD PRV x 48, $940/ FC PRV & Accy’s x 24)  
  **$63,696**
- **3” Drain risers** (2 x $30/ft x 144 + 2 x $15/ft x 144)  
  **$12,960**
- **Extra design and management time** ($100/hr x 40hr)  
  **$ 4,000**
- **Initial PRV testing** (72 x 1.0hr x $100)  
  **$ 7,200**
- **NFPA 25 costs for life of building (20 years)**  
  - **Qtrly Inspect** (3 x 24 x .25hr x $100/hr x 20)  
    **$36,000**  
  - **Annual Test** (72 x .5hr x $100/hr x 16)  
    **$57,600**  
  - **5-Year Full Flow** (72 x 1.0hr x $100 x 4)  
    **$28,800**  
  - **PRV repair costs** (72 x 5% x $940 x 20)  
    **$67,680**  
  ===========  
  **$277,936**

Note: Average annual testing cost is $12,888.
Note: Most of this testing is done on overtime, but this is not included.
Conventional Design Problems

- PRV’s are always closed under normal conditions and must open when a fire occurs.
- They must be inspected quarterly and tested annually in accordance with NFPA 25.
- Most use non-adjustable PRV’s to reduce costs; however, each valve must be factory set for the exact location in the building and installed accordingly.
- High swings in suction pressure will still eliminate it’s use. Check the static and residual curves to be sure.
New 12 Story ECV Solution – 144 feet

With Master’s model ECVRT, variable speed transfer switch fire pump controller, the pressure at the output of the fire pump to precisely controlled to 170 psi under all flow conditions.
12 Story ECV Design - Owner Costs

- Variable Speed Upgrade (150 hp, 460 v) $62,900
- Bypass Relief Valve (6 inch) $ 6,000

Total: $68,900

- Potential Gen-set savings ($300/kw*150 kw) $45,000

Saves the owner $209,036 to $254,036 over the conventional design approach and eliminates PRV’s!
ECV Job Videos

Starting with no flow
(Set Pressure = 175)

Starting with 3 hoses
(Set Pressure = 170)
ECV Job Photos
ECV Photos – cont’d
ECV Photos – cont’d
Variable Speed Application Guidelines

- The motor should meet the NEMA design B, code G requirements and be suitable for inverter duty applications.
- The maximum pump horsepower should not exceed the motor nameplate horsepower. The service factor should not be used.
- A bypass relief valve is required to handle system overpressures that may occur when the manual operator is used or the VFD is bypassed.
Variable Frequency Drives with 5% input line reactance provides the best form of motor starting for the gen-set.

The starting current drawn by the VFD is typically 125-150% of the motor FLA while still producing 100% starting torque.

The bypass starting current can be based on a voltage drop greater than 15% per NFPA 20-9.4.3
More about the Gen-Set

- Because the variable speed controller starts at low frequencies, the rated full load torque of the motor can always be supplied. This always allows the motor to accelerate to full speed, unlike wye-delta starting.
- NFPA 20 requires that the voltage drop shall not exceed 15% during starting or 5% during running. This typically requires the gen-set to be 2-3 times larger than normal.
- However, since the VFD is typically 125-150% of motor FLA, the gen-set may be smaller.
Gen-set Sizing Example

- Based on a typical application for a 150 hp motor utilizing soft starting, a gen-set manufacture’s sizing program would select a 300 kW gen-set.
- For the same application, the program would select a 150 kW gen-set when using a variable frequency drive.
- This saves 150 kWs and **cuts the gen-set size in half!**
- But before we pocket this savings, let’s check the bypass mode.
As standard, the bypass mode uses full voltage starting. This may be fine for large gen-sets, but…

For tightly sized gen-sets, reduced voltage primary reactors or soft starters are available.

With the Master primary reactor bypass, the gen-set sizing is the same as with the VFD!
  - This is based on our ability to hold in at 65% voltage with a primary reactor bypass circuit so the gen-set can be sized for a 30% gen-set voltage dip during starting (see the 2010 version of NFPA 20, paragraph 9.4.3).
  - Note: typical soft starters are only rated for a minimum operating voltage of 85% of the nominal line so they cannot take advantage of paragraph 9.4.3.
ECVRT with Transfer Switch

- Left bay is the FPC Section
- Middle bay is the Tsw Section
- Right bay is the VFD Section.
The Variable Speed Advantage

- Creates a PRV free building.
- Eliminates NFPA 25 testing of PRVs.
- Eliminates break tanks.
- Eliminates the drain riser required by NFPA 14.
- Requires fewer high pressure fittings.
- Allows smaller pipe sizes.
- Reduces the gen-set size.
- Reduces utility demand charges.
- Can design in a safety factor for future water supply changes.
- And the best part of all, you have a redundant, more reliable system for better fire protection and life safety!
Thank you!

And remember, there is a difference...

MASTER, The intelligent choice
FLOW TEST INFORMATION

<table>
<thead>
<tr>
<th>Date of Test</th>
<th>April 9, 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow_Hydrant(s)</td>
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<tr>
<td>Size of Nozzle</td>
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</tr>
<tr>
<td>Hydrant_1</td>
<td>E/S OF N FREDERICK AV, 1ST HYDRANT N/O E NEWPORT AV</td>
</tr>
<tr>
<td>Hose Monster</td>
<td></td>
</tr>
<tr>
<td>Residual_Hydrant</td>
<td></td>
</tr>
<tr>
<td>NEC OF E NEWPORT AV &amp; N FREDERICK AV</td>
<td>Elev 97</td>
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<tr>
<th>Results</th>
<th>Velocity</th>
<th>Nozzle_C</th>
<th>Flow</th>
<th>Total Flow (gpm)</th>
<th>Pressures (psi)</th>
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<td>Pressure</td>
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<td>0.548</td>
<td>1050</td>
<td>1,050</td>
<td>75</td>
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</tbody>
</table>

Notes:
1) The flow coefficient for MWW Hydrants is 0.9, the above test results have been adjusted per AWWA and NFPA recommended values when a pumper nozzle is used and measurement is with a pitot rod.
2) The flow coefficient for the Hose Monster is from the Manufacturer.
3) The elevation shown is referenced to the City of Milwaukee Datum (Add 580.603 for NGVD)
4) The flow information is only valid for the date indicated. The distribution system is subject to many variables, which may affect hydrant test results. (i.e. system demand, weather conditions, system maintenance) Therefore, the test results should only be treated as information, as it is impossible to predict exactly what pressures are available in the field.

Milwaukee Water Works
Pressure & Flow Request Line
watflowtest@milwaukee.gov
Fax: (414) 286-2085

http://city.milwaukee.gov/water
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<td>Hydrant_1</td>
<td>Hose Monster</td>
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### Residual_Hydrant

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## Results

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<thead>
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<th>Flow</th>
<th>Total Flow (gpm)</th>
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<td>1,050</td>
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SITE VISIT PHOTOGRAPHS
NORTHWEST QUADRANT FIRE PUMP AND CONTROLLER
UNIVERSITY OF WISCONSIN MILWAUKEE
MILWAUKEE, WISCONSIN

Project Number: 14J1O

Electrical Room B815B – Looking North

Electrical Room B815B – Looking South

Mechanical Room B815 – Existing Fire Pump
SITE VISIT PHOTOGRAPHS
NORTHWEST QUADRANT FIRE PUMP AND CONTROLLER
UNIVERSITY OF WISCONSIN MILWAUKEE
MILWAUKEE, WISCONSIN

Project Number: 14J10

Mechanical Room B815 – Existing Fire Pump

Room B860 – Looking Southeast

Room B860 – Looking East
SITE VISIT PHOTOGRAPHS
NORTHWEST QUADRANT FIRE PUMP AND CONTROLLER
UNIVERSITY OF WISCONSIN MILWAUKEE
MILWAUKEE, WISCONSIN

Project Number: 14J1O

Room B860 – Looking Northeast