Study of Multipurpose Piping System Circulation

Abstract
A demonstration was conducted to confirm the Uponor multipurpose residential fire sprinkler system (brand name AquaSAFE™) does not trap water in the piping system and therefore poses no stagnant-water health risks. Because the crosslinked polyethylene (PEX) tubing (brand name Uponor AquaPEX®) in the multipurpose system is translucent, it allowed a visual demonstration of red-colored water circulating through the system and then being flushed with fresh, clear water when plumbing fixtures were opened. The results showed after flowing plumbing fixtures, the pipe sections with colored water quickly became diluted, then clear, with no colored stagnant water remaining in the system.

Introduction
"A Multipurpose piping system is a piping system intended to serve both domestic and fire protection needs." (NFPA 13D, 2010 Edition)

Multipurpose systems have been recognized by the National Fire Protection Association (NFPA) 13D *Standard for the Installation of Sprinkler Systems in One- and Two-family Dwellings and Manufactured Homes* since the 1996 Edition. The 2009 International Residential Code (IRC) also recognizes multipurpose systems and lists them in the body as well as the plumbing section of the code (IRC, 2009 edition, section P2904).

Both the NFPA 13D Standard and the IRC explain the design and installation of multipurpose systems, however neither illustrates how the flow of water occurs within the system when plumbing fixtures are used. This study focuses on the circulation of water within specific sections of a looped-design multipurpose piping system, including loops, sub-loops, dead ends and sidewall sprinkler arm overs.

The system being tested was installed by Lawrence Plumbing on Corey Drive in Gibsonia, Penn., Sept. 27 through Oct. 1, 2010. An Uponor Fire Sprinkler System Technical Field Representative conducted the colored-water flow test on Oct. 1, 2010 with several witnesses in attendance, including representatives from the Richland Water Authority, the West View Water Authority, the Shaler Water Authority, the Fox Chapel Water Authority, the City of Pittsburgh Water and the Allegheny County Health Department.

Methods and Materials

Job Site
This study featured an existing housing project called Willow Ridge to reflect normal installation conditions. The jobsite was a *Broadmore* model located on Corey Drive in Gibsonia, Penn. The wood-frame construction home featured three levels with three bedrooms, two and one-half bathrooms and approximately 2,100 finished square feet, including the basement (see Appendix A for floor plan). The underground consisted of a single, 100-foot 1" incoming copper water supply from the street to a ¾" Sensus® SR II® water meter. The existing street pressure was 90 psi, which required a 1½" pressure-reducing valve (PRV) on the incoming water supply along with a 1" dual check valve.

Multipurpose Fire Sprinkler Design
The AquaSAFE looped multipurpose sprinkler system design in the *Broadmore* unit was created by a NICET-certified (National Institute for Certification in Engineering Technology) Uponor designer (see Appendix A: Sprinkler Layout). The designer performed hydraulic calculations through HydraCALC™ (a software program by Hydratec, Inc.), which is a widely recognized design software program for the fire sprinkler industry (see Appendix B: Hydraulic Calculations). Sprinkler location and spacing methods were based on NFPA 13D, 2010 Edition; Reliable® Automatic Sprinkler Company Installation Guidelines; and the IRC, 2009 Edition.

Multipurpose Fire Sprinkler System Installation
Lawrence Plumbing installed the multipurpose residential fire sprinkler system according to the sprinkler layout provided by Uponor (see Appendix A: Sprinkler Layout), as well as in accordance with all applicable codes, standards and manufacturer's guidelines. The system was designed and installed using 1" Uponor AquaPEX tubing. Since the project was at rough-in stage, there were no plumbing fixtures installed. To simulate cold-water plumbing fixture flow, cold-water supply lines for the expected fixtures were integrated at appropriate locations and control valves were installed on the ½" Uponor AquaPEX supply lines that extended to tub drains or exterior windows. A successful flow test was conducted and documented by Uponor to verify the system met the minimum required flow rates (see Appendix C: Flow Test Verification Form).

Colored-water Flow Test
With a complete and operable multipurpose residential fire sprinkler system in place, the system was completely filled with colored water. A 30-gallon, atmospheric storage tank and a reserve 30-gallon container were filled with colored water and attached to a 25 psi at 4 gallons per minute (gpm) jet pump to fill the multipurpose residential fire sprinkler system from the basement to the top floor (see Figure 1: Storage Tank and Jet Pump). A ½" Uponor AquaPEX line was attached to the end of a flow test kit on the top floor to relieve back pressure and prevent pump damage while filling the system.

Figure 1: Storage Tank and Jet Pump

It took approximately 13 minutes to fill the system with colored water on all three levels of the home. During the filling process there was a noticeable amount of air within the system which seemed to slow the colored water from flowing into specific areas. It was very noticeable at high points within the system where the tubing runs crossed over the vaulted ceiling and down to the flat ceiling (see Figure 2: Tubing Elevation Change Air Pocket and Appendix D: Elevation Drops from Vaulted to Flat Ceilings).

Additionally, air collected at the end of one of the sub-loops on the main floor with colored water present on either side of the air pocket (see Figure 3: Sub-loop Air Pocket).

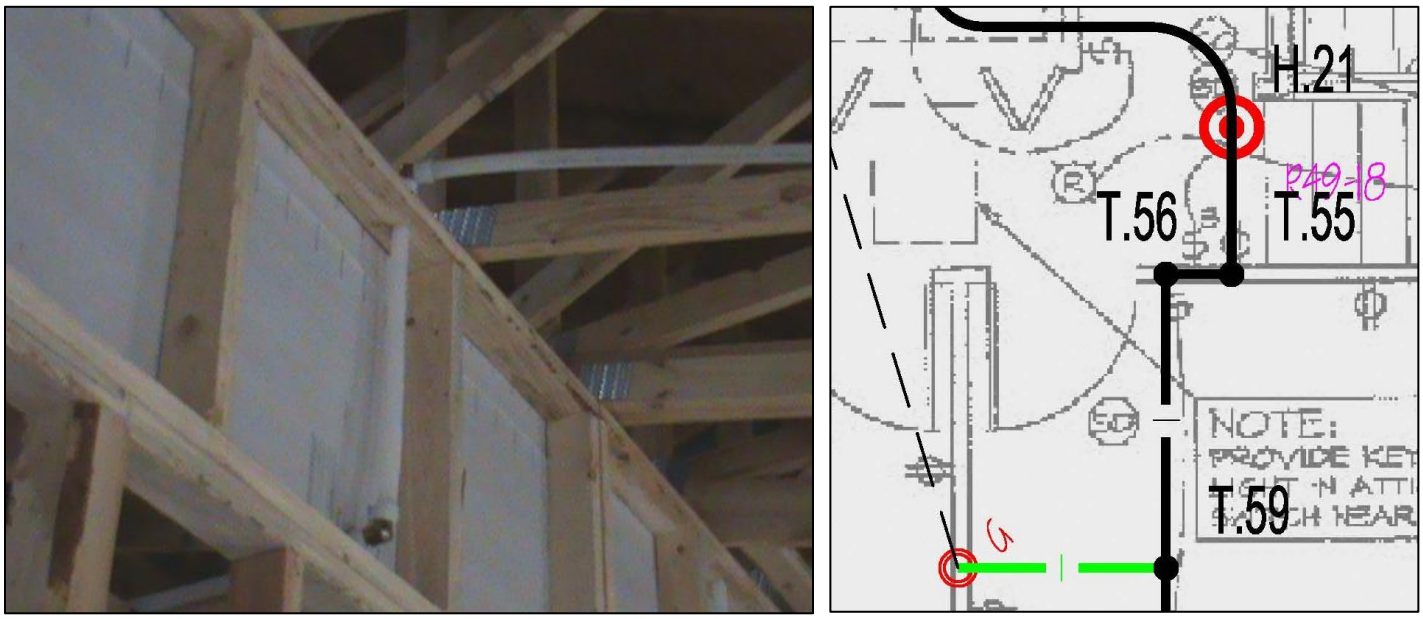


Figure 2: Tubing Elevation Change Air Pocket

Figure 3: Sub-loop Air Pocket

Once the system was filled to capacity (including colored water and air pockets), city water was reestablished through a variety of cold-water fixtures from all three levels of the home in different sequences to pressurize the system. Evaluation of the flow and circulation of water within the system was conducted through observation of the initial dilution and final evacuation of the colored water.

In all cases, areas with air pockets did not trap any colored water; however, one section of tubing in the top-floor laundry room did circulate slower (see Figure 4: Circulation Area in Laundry Room). The colored water in this area changed from vibrant red to light pink in 10 minutes during the flow test.

Additionally, the basement had an 18", dead-end drop for future connection to the hot-water heater. The colored water in this dead-end section of tubing was vibrant red when the system was filled but also returned to clear, fresh water during the circulation testing. Water flow from just a few plumbing fixtures at city pressure eliminated the trapped air in the system.

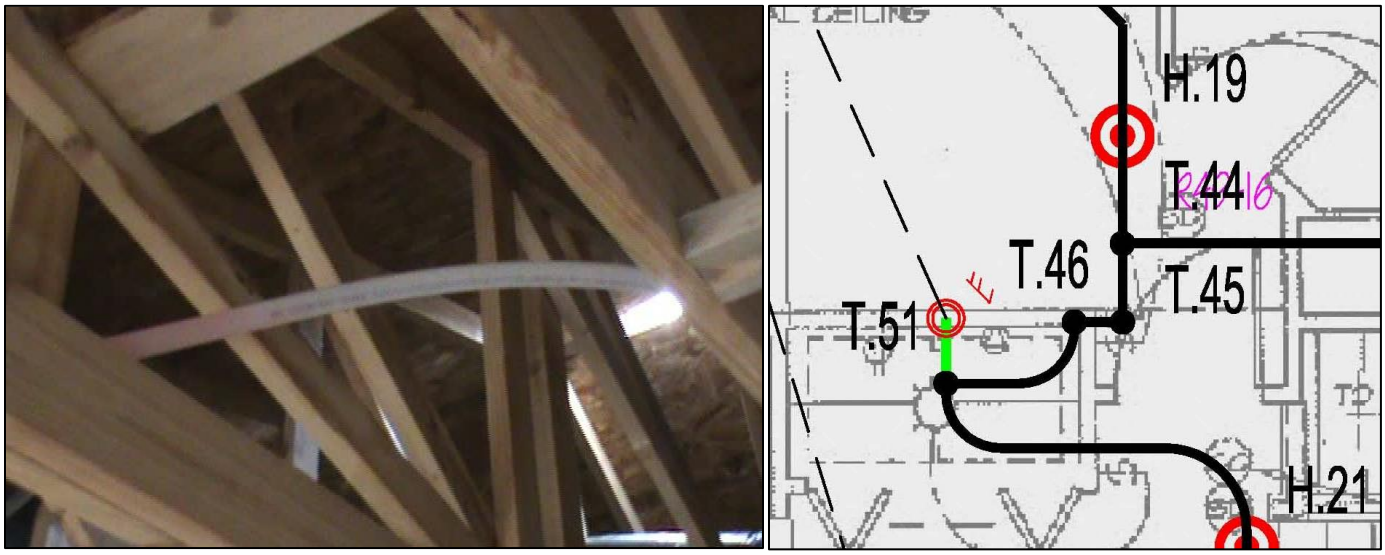
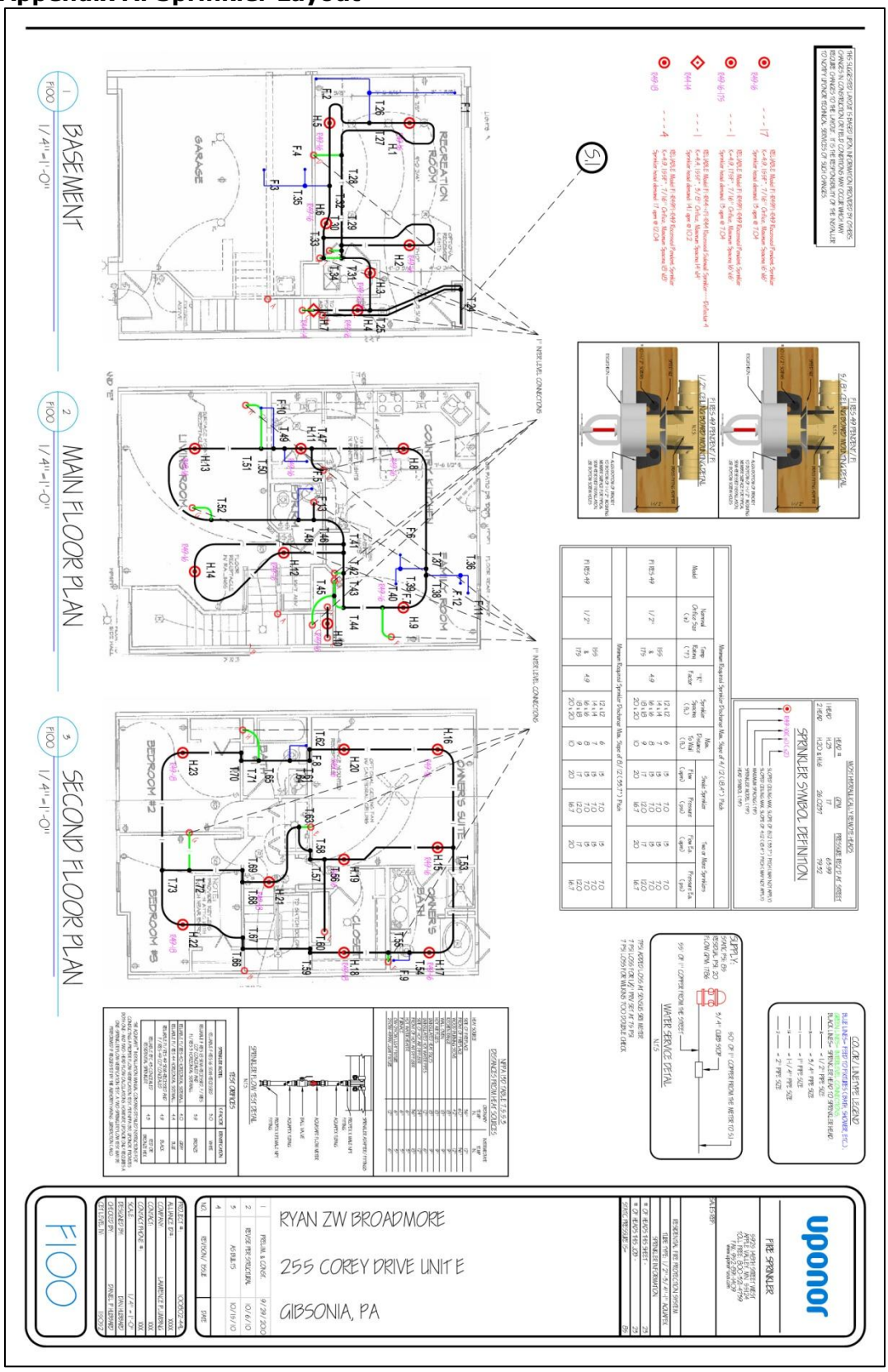


Figure 4: Circulation Area in Laundry Room

Conclusion

The AquaSAFE Looped Multipurpose System is a combined fire sprinkler and plumbing solution that provides non-stagnant potable water to plumbing fixtures and residential fire sprinklers. Cold-water plumbing connections supplied from the fire sprinkler loops ensure circulation throughout the system when plumbing fixtures are used. By filling the system with colored water and flowing fixtures, the system verified its non-stagnant status through the evacuation of colored water from all sections of tubing.

Appendix A: Sprinkler Layout



Appendix B: Hydraulic Calculations

AQUASAFE® Fire Safety System

Uponor
5925 148th Street West

Apple Valley, MN 55124
800-321-4739

Job Name	:	RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)
Drawing	:	RESIDENTIAL
Location	:	255 COREY DRIVE UNIT E GIBSONIA PA
Remote Area	:	1
Contract	:	100802-44L
Data File	:	Ryan ZW Broadmore.wx2

Computer Programs by Hydratec Inc. Route 111 Windham N.H. USA 03087

HYDRAULIC DESIGN INFORMATION SHEET

Name - RYAN ZW BROADMORE Date - 9/29/2010
Location - GIBSONIA PA
Building - RESIDENTIAL System No. - 1
Contractor - LAWRENCE PLUMBING Contract No. - 100802-44L
Calculated By - DAN HUBBARD Drawing No. - 1
Construction: (X) Combustible ( ) Non-Combustible Ceiling Height VARIES
OCCUPANCY - RESIDENTIAL

SYSTEM DESIGN

Type of Calculation: ( )NFPA 13 Residential ( )NFPA 13R (X)NFPA 13D
Number of Sprinklers Flowing: ( )1 (X)2 ( )4 ( )
( )Other
( )Specific Ruling Made by Date

Listed Flow at Start Point - 13 Gpm System Type
Listed Pres. at Start Point - 7.04 Psi (X) Wet ( ) Dry
MAXIMUM LISTED SPACING 16 x 16 ( ) Deluge ( ) PreAction
Domestic Flow Added - 0 Gpm Sprinkler or Nozzle
Additional Flow Added - Gpm Make RELIABLE Model F1-R49
Elevation at Highest Outlet - 132 Feet Size 7/16 K-Factor 4.9
Note: Temperature Rating 155

Calculation Summary: Gpm Required 26.0237 Psi Required 79.32 At Ref Pt STR
C-Factor Used: Overhead 150 Underground 150

WATER SUPPLY

Water Flow Test:
Date of Test - x
Time of Test - x
Static (Psi) - 85
Residual (Psi) - 20
Flow (Gpm) - 1786
Elevation - 100

Pump Data:
Rated Cap.
@ Psi
Elev.
Other

Tank or Reservoir:
Cap.
Elev.

Well
Proof Flow Gpm

PLANS

Location: x

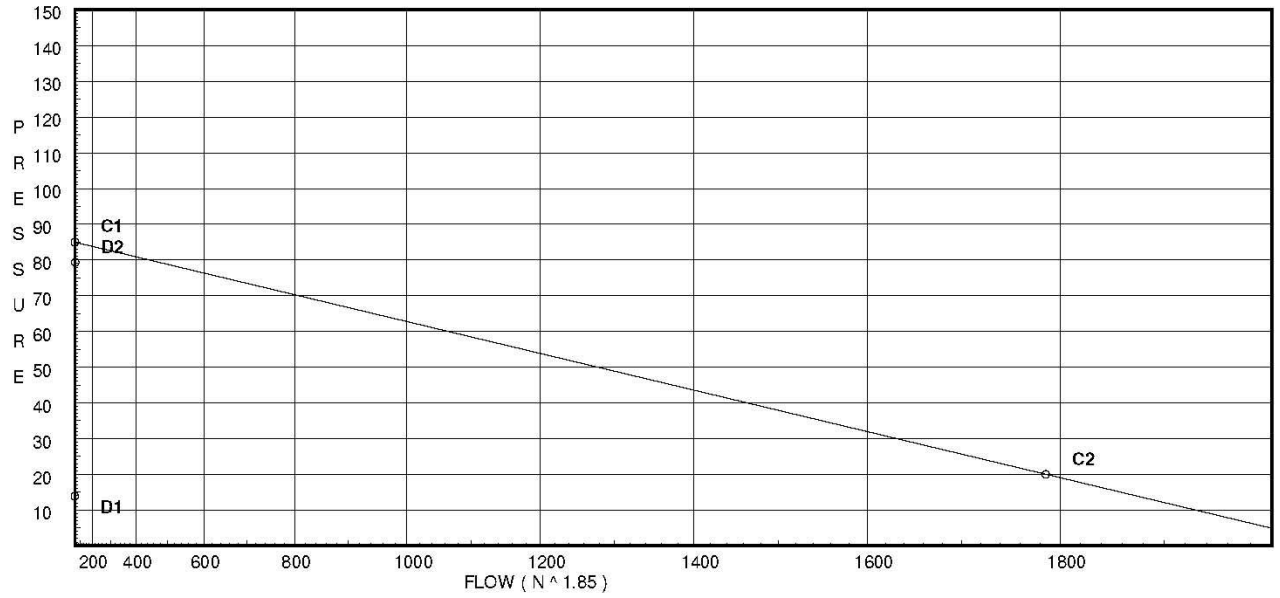
Source of Information: x

Water Supply Curve (C)

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

City Water Supply:
C1 - Static Pressure : 85
C2 - Residual Pressure: 20
C2 - Residual Flow : 1786

Demand:
D1 - Elevation : 13.859
D2 - System Flow : 26.0237
D2 - System Pressure : 79.320
Hose (Adj City) : _____
Hose (Demand) : _____
D3 - System Demand : 26.0237
Safety Margin : 5.653



Computer Programs by Hydratec Inc. Route 111 Windham N.H. USA 03087

Fittings Used Summary

Fitting Legend Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
E	90' Standard Elbow	2	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
G	Generic Gate Valve	1	1	1	1	1	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
T	90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121
Tc	Copper Tee-Branch	1.5	2	2	3	3.5	5	6	7.5	9	10.5	13	15	0	0	0	0	0	0	0	0
Tcs	Copper Cplg/Tee-Run	0.5	0.5	0.5	1	1	1	1.5	1.5	2	2	2.5	3	0	0	0	0	0	0	0	0
U	UnAdjusted Fitting	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Uel	Aquapex 90 Elbow	3	3	6	9.8	12.06	12.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utb	Aquapex Tee - Branch	2	3	6	9.08	12.88	13.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utr	Aquapex Tee - Run	1	2	2	1.64	2.39	2.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Units Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

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Flow Summary - NFPA 2007

SUPPLY ANALYSIS

Node at Source	Static Pressure	Residual Pressure	Flow	Available Pressure	Total Demand	Required Pressure
STR	85.0	20	1786.0	84.974	26.02	79.32

NODE ANALYSIS

Node Tag	Elevation	Node Type	Pressure at Node	Discharge at Node	Notes
H.20	132.0	4.9	7.04	13.0	
T.50	132.0		7.36		
T.49	132.0		7.92		
T.52	132.0		9.04		
T.40	118.0		16.2		
H.11	118.0		16.37		
T.39	118.0		16.46		
T.26	108.0		21.28		
T.27	108.0		21.36		
H.2	108.0		21.38		
T.30	108.0		21.4		
T.31	108.0		21.46		
T.29	108.0		21.54		
H.3	108.0		22.12		
T.25	108.0		23.12		
T.24	108.0		25.76		
S.1	101.0		33.86		
MTR	100.0		53.66		
STR	100.0		79.32		
H.16	132.0	4.9	7.06	13.02	
T.42	132.0		8.93		
H.17	132.0		9.44		
T.43	132.0		9.66		
T.32	118.0		16.54		
T.36	118.0		16.79		
T.37	118.0		17.07		
H.7	108.0		22.38		
H.4	108.0		22.68		
H.15	132.0		9.3		
H.19	132.0		9.83		
T.44	132.0		9.98		
H.10	118.0		16.39		
T.57	132.0		9.07		
T.58	132.0		9.19		
H.23	132.0		9.41		
T.60	132.0		9.68		
T.59	132.0		9.86		
T.41	118.0		16.2		
T.38	118.0		16.3		
T.33	118.0		16.55		
T.34	118.0		16.62		
T.35	118.0		16.74		

NODE ANALYSIS (cont.)

Node Tag	*Elevation*	*Node Type*	*Pressure at Node*	*Discharge at Node*	*Notes*
T.28	108.0		21.37		
H.18	132.0		9.66		
T.47	132.0		9.66		
T.48	132.0		9.66		
T.53	132.0		9.67		
T.54	132.0		9.67		
H.22	132.0		9.68		
T.56	132.0		9.89		
T.55	132.0		9.97		
H.21	132.0		9.98		
T.51	132.0		10.02		
T.45	132.0		9.98		
T.46	132.0		9.99		
H.13	118.0		16.2		
H.8	118.0		16.49		
H.9	118.0		16.54		
H.14	118.0		16.58		
H.12	118.0		16.6		
H.1	108.0		21.32		
H.5	108.0		21.36		
H.6	108.0		21.39		

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

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Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
H.20	11.47	0.862		0.0	4.000	7.040		K Factor = 4.90
to		150.0		0.0	0.0	0.0		
T.50	11.47	0.0802		0.0	4.000	0.321		Vel = 6.31
T.50	0.0	0.862	1Uel	3.0	1.000	7.361		
to		150.0		0.0	6.000	0.0		
T.49	11.47	0.0800		0.0	7.000	0.560		Vel = 6.31
T.49	0.0	0.862	1Uel	3.0	6.000	7.921		
to		150.0	1Utr	2.0	8.000	0.0		
T.52	11.47	0.0801		0.0	14.000	1.122		Vel = 6.31
T.52	-4.79	0.862	2Utb	6.0	25.000	9.043		
to		150.0		0.0	12.000	6.063		
T.40	6.68	0.0295		0.0	37.000	1.090		Vel = 3.67
T.40	-0.02	0.862	1Utr	2.0	4.000	16.196		
to		150.0		0.0	2.000	0.0		
H.11	6.66	0.0293		0.0	6.000	0.176		Vel = 3.66
H.11	0.0	0.862	1Utr	2.0	1.000	16.372		
to		150.0		0.0	2.000	0.0		
T.39	6.66	0.0293		0.0	3.000	0.088		Vel = 3.66
T.39	-1.70	0.862	2Utb	6.0	17.000	16.460		
to		150.0		0.0	12.000	4.331		
T.26	4.96	0.0170		0.0	29.000	0.492		Vel = 2.73
T.26	-1.95	0.862	1Utr	2.0	10.000	21.283		
to		150.0		0.0	2.000	0.0		
T.27	3.01	0.0068		0.0	12.000	0.081		Vel = 1.65
T.27	-1.83	0.862	1Utr	2.0	7.000	21.364		
to		150.0	1Utb	3.0	8.000	0.0		
H.2	1.18	0.0012		0.0	15.000	0.018		Vel = 0.65
H.2	0.0	0.862	1Utb	3.0	10.000	21.382		
to		150.0		0.0	6.000	0.0		
T.30	1.18	0.0012		0.0	16.000	0.019		Vel = 0.65
T.30	1.94	0.862	1Utb	3.0	2.000	21.401		
to		150.0		0.0	6.000	0.0		
T.31	3.12	0.0072		0.0	8.000	0.058		Vel = 1.72
T.31	2.49	0.862	1Utr	2.0	2.000	21.459		
to		150.0		0.0	2.000	0.0		
T.29	5.61	0.0213		0.0	4.000	0.085		Vel = 3.08
T.29	6.06	0.862	1Utr	2.0	5.000	21.544		
to		150.0		0.0	2.000	0.0		
H.3	11.67	0.0827		0.0	7.000	0.579		Vel = 6.42
H.3	0.0	0.862	1Utr	2.0	4.000	22.123		
to		150.0	1Utb	3.0	8.000	0.0		
T.25	11.67	0.0827		0.0	12.000	0.992		Vel = 6.42
T.25	8.15	0.862		0.0	12.000	23.115		
to		150.0		0.0	0.0	0.0		
T.24	19.82	0.2204		0.0	12.000	2.645		Vel = 10.90
T.24	6.20	0.862	1T	7.528	9.000	25.760		
to		150.0	1Utr	2.0	4.904	3.032		
S.1	26.02	0.3646		0.0	13.904	5.070		Vel = 14.30

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

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Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
S.1	0.0	0.995	2E	4.673	50.000	33.862		
to		150.0	1U	1.0	18.173	7.433		* Fixed loss = 7
MTR	26.02	0.1813	6Tc	12.0	68.173	12.360		Vel = 10.74
			1Tcs	0.5				
MTR	0.0	0.995	1E	2.336	55.000	53.655		
to		150.0	1T	5.841	9.345	14.000		* Fixed loss = 14
STR	26.02	0.1813	1G	1.168	64.345	11.665		Vel = 10.74
	0.0							
	26.02					79.320		K Factor = 2.92
H.20	1.53	0.862	1Utr	2.0	10.000	7.040		
to		150.0		0.0	2.000	0.0		
H.16	1.53	0.0019		0.0	12.000	0.023		Vel = 0.84
H.16	13.02	0.862	1Utr	2.0	13.000	7.063		K Factor = 4.90
to		150.0		0.0	2.000	0.0		
T.42	14.55	0.1244		0.0	15.000	1.866		Vel = 8.00
T.42	-7.60	0.862	1Utr	2.0	14.000	8.929		
to		150.0		0.0	2.000	0.0		
H.17	6.95	0.0317		0.0	16.000	0.507		Vel = 3.82
H.17	0.0	0.862	1Utr	2.0	5.000	9.436		
to		150.0		0.0	2.000	0.0		
T.43	6.95	0.0317		0.0	7.000	0.222		Vel = 3.82
T.43	-0.64	0.862	2Utb	6.0	19.000	9.658		
to		150.0		0.0	12.000	6.063		
T.32	6.31	0.0265		0.0	31.000	0.823		Vel = 3.47
T.32	1.70	0.862	1Utr	2.0	4.000	16.544		
to		150.0		0.0	2.000	0.0		
T.36	8.01	0.0413		0.0	6.000	0.248		Vel = 4.40
T.36	2.64	0.862	1Utr	2.0	2.000	16.792		
to		150.0		0.0	2.000	0.0		
T.37	10.65	0.0698		0.0	4.000	0.279		Vel = 5.85
T.37	-2.49	0.862	1Utb	3.0	17.000	17.071		
to		150.0		0.0	6.000	4.331		
H.7	8.16	0.0427		0.0	23.000	0.981		Vel = 4.49
H.7	0.0	0.862	1Utr	2.0	5.000	22.383		
to		150.0		0.0	2.000	0.0		
H.4	8.16	0.0426		0.0	7.000	0.298		Vel = 4.49
H.4	0.0	0.671	1Utr	2.0	1.000	22.681		
to		150.0		0.0	2.000	0.0		
T.25	8.16	0.1447		0.0	3.000	0.434		Vel = 7.40
	0.0							
	8.16					23.115		K Factor = 1.70
T.42	7.60	0.862	1Utr	2.0	2.000	8.929		
to		150.0	1Utb	3.0	8.000	0.0		
H.15	7.6	0.0375		0.0	10.000	0.375		Vel = 4.18
H.15	0.0	0.862	1Utr	2.0	12.000	9.304		
to		150.0		0.0	2.000	0.0		
H.19	7.6	0.0374		0.0	14.000	0.524		Vel = 4.18
H.19	0.0	0.862	1Utr	2.0	2.000	9.828		
to		150.0		0.0	2.000	0.0		
T.44	7.6	0.0372		0.0	4.000	0.149		Vel = 4.18

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
T.44	-1.40	0.671	1Utb	3.0	24.000	9.977		
to		150.0		0.0	3.000	6.063		
H.10	6.2	0.0869		0.0	27.000	2.347		Vel = 5.63
H.10	0.0	0.671	1Utr	2.0	30.000	18.387		
to		150.0	1Utb	3.0	5.000	4.331		
T.24	6.2	0.0869		0.0	35.000	3.042		Vel = 5.63
	0.0							
	6.20					25.760		K Factor = 1.22
T.52	4.80	0.862		0.0	2.000	9.043		
to		150.0		0.0	0.0	0.0		
T.57	4.8	0.0160		0.0	2.000	0.032		Vel = 2.64
T.57	0.0	0.862	1Uel	3.0	1.000	9.075		
to		150.0		0.0	6.000	0.0		
T.58	4.8	0.0160		0.0	7.000	0.112		Vel = 2.64
T.58	0.0	0.862	1Utr	2.0	6.000	9.187		
to		150.0	1Uel	3.0	8.000	0.0		
H.23	4.8	0.0159		0.0	14.000	0.223		Vel = 2.64
H.23	0.0	0.862	1Utr	2.0	15.000	9.410		
to		150.0		0.0	2.000	0.0		
T.60	4.8	0.0159		0.0	17.000	0.271		Vel = 2.64
T.60	0.63	0.862	1Utb	3.0	3.000	9.681		
to		150.0		0.0	6.000	0.0		
T.59	5.43	0.0201		0.0	9.000	0.181		Vel = 2.99
T.59	-2.09	0.862	2Utb	6.0	21.000	9.862		
to		150.0		0.0	12.000	6.063		
T.41	3.34	0.0082		0.0	33.000	0.271		Vel = 1.84
T.41	0.02	0.862	1Utr	2.0	11.000	16.196		
to		150.0		0.0	2.000	0.0		
T.38	3.36	0.0083		0.0	13.000	0.108		Vel = 1.85
T.38	3.49	0.862	1Utr	2.0	6.000	16.304		
to		150.0		0.0	2.000	0.0		
T.33	6.85	0.0308		0.0	8.000	0.246		Vel = 3.77
T.33	-1.19	0.862	1Utr	2.0	1.000	16.550		
to		150.0		0.0	2.000	0.0		
T.34	5.66	0.0220		0.0	3.000	0.066		Vel = 3.11
T.34	1.19	0.862	1Utr	2.0	2.000	16.616		
to		150.0		0.0	2.000	0.0		
T.35	6.85	0.0308		0.0	4.000	0.123		Vel = 3.77
T.35	-2.63	0.862	2Utb	6.0	12.000	16.739		
to		150.0		0.0	12.000	4.331		
T.28	4.22	0.0126		0.0	24.000	0.302		Vel = 2.32
T.28	1.83	0.862	1Utb	3.0	1.000	21.372		
to		150.0		0.0	6.000	0.0		
T.29	6.05	0.0246		0.0	7.000	0.172		Vel = 3.33
	0.0							
	6.05					21.544		K Factor = 1.30
T.43	0.64	0.862	1Utr	2.0	5.000	9.658		
to		150.0		0.0	2.000	0.0		
H.18	0.64	0.0004		0.0	7.000	0.003		Vel = 0.35

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
H.18	0.0	0.862		0.0	4.000	9.661		
to		150.0		0.0	0.0	0.0		
T.47	0.64	0.0002		0.0	4.000	0.001		Vel = 0.35
T.47	0.0	0.862	1Uel	3.0	1.000	9.662		
to		150.0		0.0	6.000	0.0		
T.48	0.64	0.0004		0.0	7.000	0.003		Vel = 0.35
T.48	0.0	0.862	1Uel	3.0	7.000	9.665		
to		150.0		0.0	6.000	0.0		
T.53	0.64	0.0004		0.0	13.000	0.005		Vel = 0.35
T.53	0.0	0.862	1Uel	3.0	1.000	9.670		
to		150.0		0.0	6.000	0.0		
T.54	0.64	0.0003		0.0	7.000	0.002		Vel = 0.35
T.54	0.0	0.862	1Utr	2.0	8.000	9.672		
to		150.0	1Uel	3.0	8.000	0.0		
H.22	0.64	0.0004		0.0	16.000	0.006		Vel = 0.35
H.22	0.0	0.862		0.0	8.000	9.678		
to		150.0		0.0	0.0	0.0		
T.60	0.64	0.0004		0.0	8.000	0.003		Vel = 0.35
	0.0							
	0.64					9.681		K Factor = 0.21
T.59	2.08	0.862	1Utr	2.0	6.000	9.862		
to		150.0		0.0	2.000	0.0		
T.56	2.08	0.0035		0.0	8.000	0.028		Vel = 1.14
T.56	0.0	0.671	2Uel	6.0	1.000	9.890		
to		150.0		0.0	6.000	0.0		
T.55	2.08	0.0116		0.0	7.000	0.081		Vel = 1.89
T.55	0.0	0.862		0.0	3.000	9.971		
to		150.0		0.0	0.0	0.0		
H.21	2.08	0.0033		0.0	3.000	0.010		Vel = 1.14
H.21	0.0	0.862	1Utr	2.0	9.000	9.981		
to		150.0		0.0	2.000	0.0		
T.51	2.08	0.0034		0.0	11.000	0.037		Vel = 1.14
T.51	1.41	0.862	1Utb	3.0	17.000	10.018		
to		150.0	1Utr	2.0	8.000	6.063		
T.38	3.49	0.0089		0.0	25.000	0.223		Vel = 1.92
	0.0							
	3.49					16.304		K Factor = 0.86
T.44	1.40	0.862		0.0	2.000	9.977		
to		150.0		0.0	0.0	0.0		
T.45	1.4	0.0020		0.0	2.000	0.004		Vel = 0.77
T.45	0.0	0.862	1Uel	3.0	1.000	9.981		
to		150.0		0.0	6.000	0.0		
T.46	1.4	0.0016		0.0	7.000	0.011		Vel = 0.77
T.46	0.0	0.862	1Uel	3.0	4.000	9.992		
to		150.0	1Utb	3.0	12.000	0.0		
T.51	1.4	0.0016		0.0	16.000	0.026		Vel = 0.77
	0.0							
	1.40					10.018		K Factor = 0.44

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
T.40	0.02	0.862	1Utr	2.0	7.000	16.196		
to		150.0		0.0	2.000	0.0		
H.13	0.02	0.0		0.0	9.000	0.0		Vel = 0.01
H.13	0.0	0.862		0.0	10.000	16.196		
to		150.0		0.0	0.0	0.0		
T.41	0.02	0.0		0.0	10.000	0.0		Vel = 0.01
	0.0							
	0.02					16.196		K Factor = 0
T.39	1.70	0.862	1Utr	2.0	10.000	16.460		
to		150.0		0.0	2.000	0.0		
H.8	1.7	0.0023		0.0	12.000	0.028		Vel = 0.93
H.8	0.0	0.862	1Utr	2.0	18.000	16.488		
to		150.0		0.0	2.000	0.0		
H.9	1.7	0.0024		0.0	20.000	0.047		Vel = 0.93
H.9	0.0	0.862	1Utr	2.0	2.000	16.535		
to		150.0		0.0	2.000	0.0		
T.32	1.7	0.0022		0.0	4.000	0.009		Vel = 0.93
	0.0							
	1.70					16.544		K Factor = 0.42
T.33	1.19	0.862	1Utr	2.0	19.000	16.550		
to		150.0	1Utb	3.0	8.000	0.0		
H.14	1.19	0.0012		0.0	27.000	0.033		Vel = 0.65
H.14	0.0	0.862		0.0	12.000	16.583		
to		150.0		0.0	0.0	0.0		
H.12	1.19	0.0012		0.0	12.000	0.015		Vel = 0.65
H.12	0.0	0.862	1Utr	2.0	7.000	16.598		
to		150.0	1Utb	3.0	8.000	0.0		
T.34	1.19	0.0012		0.0	15.000	0.018		Vel = 0.65
	0.0							
	1.19					16.616		K Factor = 0.29
T.35	2.63	0.862	1Utb	3.0	4.000	16.739		
to		150.0		0.0	6.000	0.0		
T.36	2.63	0.0053		0.0	10.000	0.053		Vel = 1.45
	0.0							
	2.63					16.792		K Factor = 0.64
T.26	1.95	0.862	1Utr	2.0	11.000	21.283		
to		150.0		0.0	2.000	0.0		
H.1	1.95	0.0030		0.0	13.000	0.039		Vel = 1.07
H.1	0.0	0.862	1Utr	2.0	9.000	21.322		
to		150.0		0.0	2.000	0.0		
H.5	1.95	0.0031		0.0	11.000	0.034		Vel = 1.07
H.5	0.0	0.862		0.0	11.000	21.356		
to		150.0		0.0	0.0	0.0		
H.6	1.95	0.0030		0.0	11.000	0.033		Vel = 1.07
H.6	0.0	0.862	1Utr	2.0	2.000	21.389		
to		150.0		0.0	2.000	0.0		
T.30	1.95	0.0030		0.0	4.000	0.012		Vel = 1.07

Final Calculations - Hazen-Williams

Uponor
RYAN ZW BROADMORE - Two Head Calculation (H.20 & H.16)

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Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	*******	Notes	******
	0.0									
	1.95					21.401		K Factor = 0.42		
T.27	1.84	0.862	1Utr	2.0	1.000	21.364				
to		150.0		0.0	2.000	0.0				
T.28	1.84	0.0027		0.0	3.000	0.008		Vel = 1.01		
	0.0									
	1.84					21.372		K Factor = 0.40		
T.37	2.49	0.862		0.0	12.000	17.071				
to		150.0		0.0	0.0	4.331				
T.31	2.49	0.0048		0.0	12.000	0.057		Vel = 1.37		
	0.0									
	2.49					21.459		K Factor = 0.54		

Appendix C: Flow Test Verification Form

uponor

FIRE SAFETY SYSTEMS

AQUASAFE™ FLOW TEST VERIFICATION

FORM

AquaSAFE™ Flow Test Verification Form

Alliance Member ID: LEVEL 2 COMPLETED # T.B.D

Company Name: Lawrence Plumbing

Contact: Jason Lawrence

Phone: _____

Fax: _____

Job Name: WILLOW RIDGE

Project Number: 100802-45L

Job Address: 255 corey drive (Unit E)

City: Gibsonia

State, ZIP: PA

For designs not provided by Uponor, complete the following information.

Designer's Name: NA

Company: NA

Phone: NA

Fax: NA

Is the warning sign permanently attached close to the main shutoff valve? ☑ Yes ☐ No

Was this system required by code? ☑ Yes ☐ No

Important: Installing contractor must submit this completed form. Failure to do so nullifies the system warranty. E-mail or fax completed form to the Uponor Fire Safety Design Department at technical.services@uponor.com or 952.997.1731. For questions, contact Uponor Technical Services at 888.594.7726 or technical.services@uponor.com.

Color of test orifice used: black (4.9 k)

Static pressure (not flowing) reading at incoming water supply into home or at main shutoff: _____ psi after PRV

Residual pressure (flowing) reading at incoming water supply into home or at main shutoff: _____

What time of day was the flow test taken? _____

Flow test method used? ☑ Bucket ☐ Flow Meter

Flow test gpm: 26 gpm

How many gallons of water did the design predict as required? 26 (13 per sprinkler)

Did the test meet or exceed design flow? ☑ Yes ☐ No

Which sprinkler did you flow? Number: H.16,H.20

Location of head: Master Bedroom

Date left in service with all valves open: _____

Test Witnessed and Verified by:

Name	Signature	Occupation	Date
Dan Jones		Plumber	11/8/10
MARK Kraswski		INSPECTOR	11/15/10

Additional Explanations and Notes _____

Uponor, Inc.
5925 148th Street West
Apple Valley, MN 55124 USA

Tel: 800.321.4739
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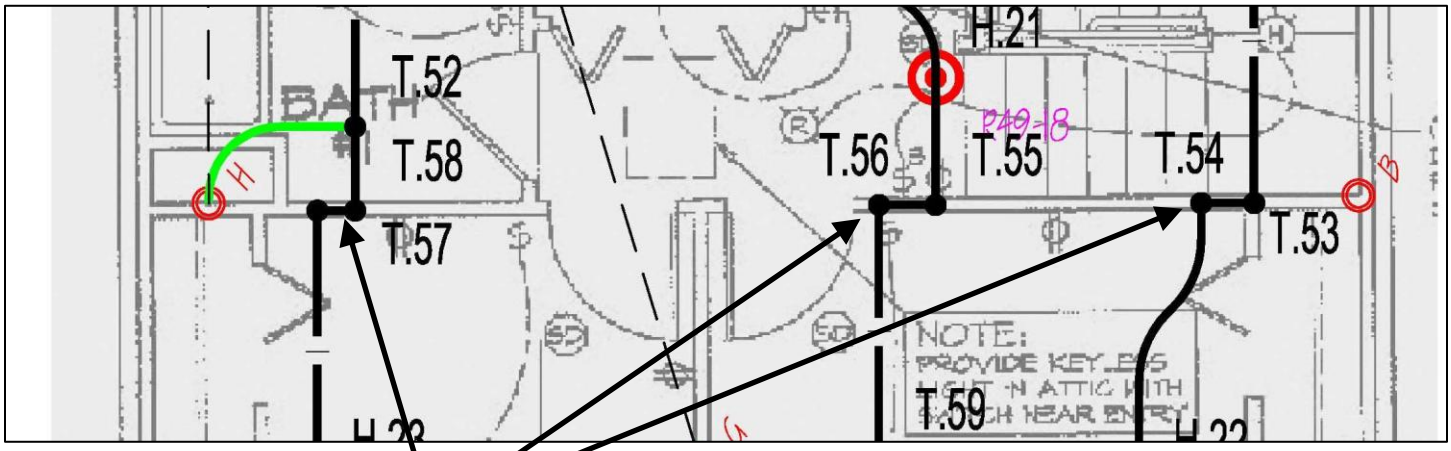
Appendix D: Elevation Drops from Vaulted to Flat Ceilings



Elevation drops from vaulted to flat ceilings (second floor)