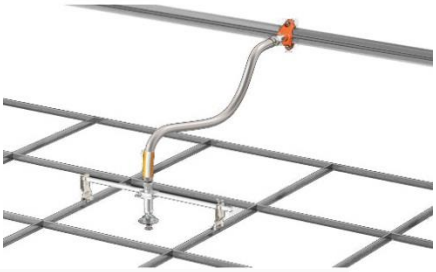


FLEXIBLE SPRINKLER RETROFIT ANALYZER

Review & Hydraulic Validation

Abstract

This report outlines many of the concerns around adding flexible drops in existing systems, while also explaining the math. It also reviews calculations performed with hydraulic sprinkler software to validate the results of the CSA Retrofit Analyzer Excel file.

Evaluation performed by:
Scott Lacey, PE, CSP, SFPE

CSA

Images randomly selected from the internet to represent subject of report. This report is not supported by, nor does it indorse any particular product or brand.

Report Date: 11/1/2017
Rev 1: 1/17/2018

Lacey Fire Protection Engineering, LLC

Compliance Services and Assessments, LC (CSA) is a national fire protection installer assessment company. CSA evaluates fire protection installers to their knowledge of codes, safety requirements, and the application of such criteria. Most NFPA standards and building / fire codes require installers to be knowledgeable and qualified in the services they provide. CSA evaluates installers to the applicable codes based on what service they are providing. This process provides an assurance to the AHJ's that these installers have demonstrated a solid understanding of code requirements and the ability to use the referenced documents in their daily activities. While other national programs are focused around designer qualifications, CSA is specifically focused around the tasks of installers. Installers are required to re-test every three years to demonstrate knowledge with the ever changing codes. More information can be found at www.CSAexams.com or by email at info@CSAexams.com. The Excel file is available at the CSA website under the Contractor Information and AHJ Information links.

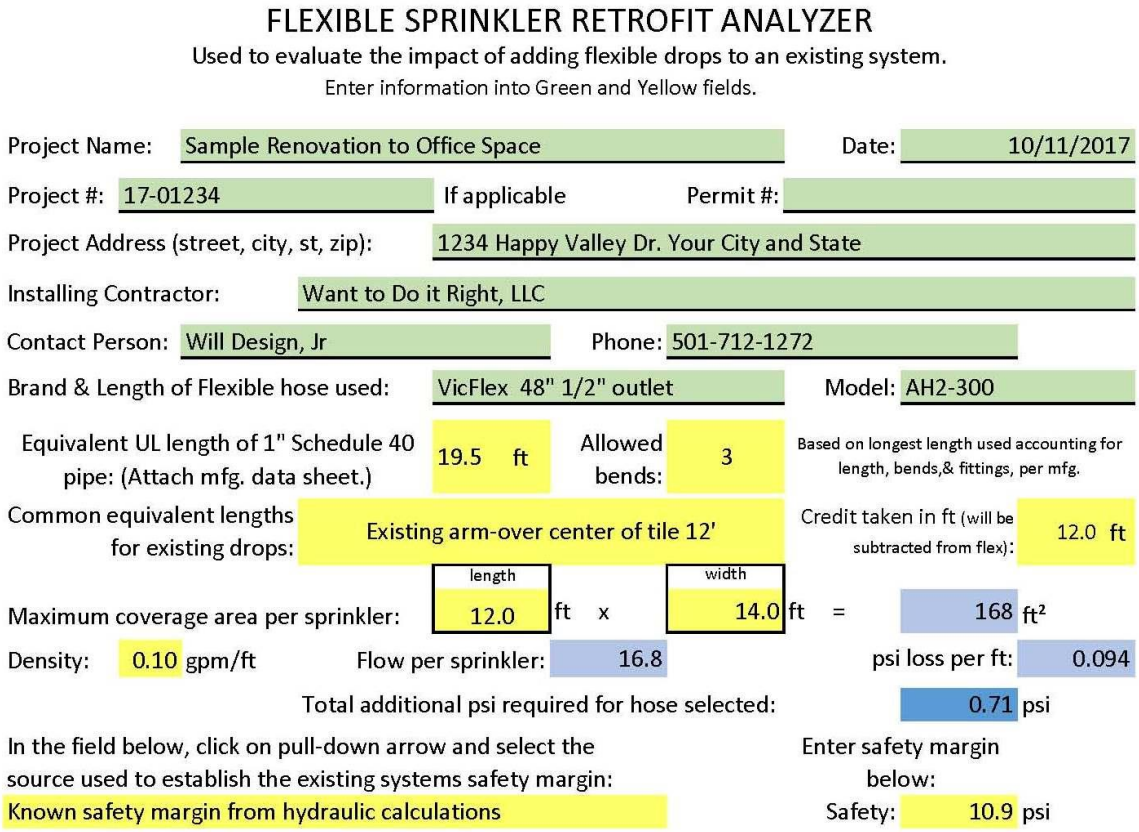
Lacey Fire Protection Engineering, LLC is an Arkansas based engineering firm dedicated to fire protection and life safety. Company President Scott Lacey has an extensive background including municipal / industrial firefighting, code enforcement as an AHJ, system design, and extensive commissioning with field conditions. In addition to designing an extensive number of suppression systems, Mr. Lacey has an extensive background in fire alarm and mass notifications systems for industrial and military clients. More information can be found at www.LaceyFPE.com.

Hydraulic software used in evaluation:
HydraCAD 54
HydraCALC 50
HydraCAD and HydraCALC are Trademark products of Hydratec, Incorporated.

Representation of particular products within this report does not endorse any particular product. Such use is to identify that not all products are the same, and that each product must be evaluated independently. The intent of this report is to provide validation of the Analyzer Report only, and not validate any particular flexible product. Not all products on the market have been evaluated or identified.

WHAT IS THE FLEXIBLE SPRINKLER RETROFIT ANALYZER

A free Excel-based worksheet that provides a professional report for use by code enforcers in evaluating flexible drops added to existing systems. Originally developed for alumni of the Oklahoma State University School of Fire Protection and Safety to better serve their customers in the sprinkler industry, it has been made freely available to anyone who can benefit. It can be downloaded from www.CSAexams.com. Updates and revisions will also be posted to the CSA web site. A lookup by brand version is also available.



FLEXIBLE SPRINKLER RETROFIT ANALYZER

Used to evaluate the impact of adding flexible drops to an existing system.

Enter information into Green and Yellow fields.

Project Name:	Sample Renovation to Office Space	Date:	10/11/2017
Project #:	17-01234 If applicable	Permit #:	
Project Address (street, city, st, zip):	1234 Happy Valley Dr. Your City and State		
Installing Contractor:	Want to Do it Right, LLC		
Contact Person:	Will Design, Jr	Phone:	501-712-1272
Brand & Length of Flexible hose used:	VicFlex 48" 1/2" outlet	Model:	AH2-300
Equivalent UL length of 1" Schedule 40 pipe: (Attach mfg. data sheet.)	19.5 ft	Allowed bends:	3
Based on longest length used accounting for length, bends,& fittings, per mfg.			
Common equivalent lengths for existing drops:	Existing arm-over center of tile 12'	Credit taken in ft (will be subtracted from flex):	12.0 ft
Maximum coverage area per sprinkler:	length 12.0 ft x width 14.0 ft =	168	ft²
Density:	0.10 gpm/ft	Flow per sprinkler:	16.8
psi loss per ft:	0.094		
Total additional psi required for hose selected:		0.71	psi
In the field below, click on pull-down arrow and select the source used to establish the existing systems safety margin:		Enter safety margin below:	
Known safety margin from hydraulic calculations		Safety:	10.9 psi

Figure 1: Sample Section of Report (actual form may vary)

Over the years, flexible sprinkler drops have become more common, likely based on competition and lower costs. However, some of the flexible drops can demand a higher system pressure than previously installed schedule 40 pipe drops. Older systems, or even recently installed systems may not have hydraulically accounted for this higher pressure demand. As a result, incorporating these drops into such systems could negatively impact the performance of the system. There are some brands that have very little impact on system pressure. However, there are some brands that have a considerable impact on the required pressure. How is the Authority Having Jurisdiction (AHJ) supposed to know what the impact will be when approached by the contractor?

In an abundance of caution, code authorities frequently require contractors to provide new hydraulic calculations of the existing sprinkler system. If the contractor has the original calculations, has the same software, and the versions are compatible, than it may not be too difficult to re-calculate the system.

However, this simple approach is frequently not the case due to the following challenges:

- The original system was designed by a different contractor and the calculations are not available.
- The original system was calculated by a different designer in the same company and the original files cannot be located.
- The computer with the old calculations crashed and the company did not have an organized and backed up digital file system.
- Software has changed or has been upgraded and is no longer compatible.
- Many other reasons.

Without the original design files, calculation files, and proper software, portions of the system must be re-calculated from scratch. If accurate as-built drawings in pdf or hard copy are available, then the system can be re-created from scratch without climbing above ceilings. This may take a full day's work depending on available information.

Without drawings of the existing system, a detailed evaluation is required to re-design critical aspects of the system for calculations. In most cases the entire system will not have to be redesigned. However the area in question and the entire supply path serving the space must be traced back to the riser. This involves getting above the ceiling to evaluate pipe sizes, get measurements, identify elevation changes, elbows, offsets, and various other conditions. This may or may not be possible during working hours, or prior to bidding a project. This may be additionally challenged when the sprinkler piping passes through / over another tenant spaces or area that are not readily accessible or contractor welcomed to evaluate the system. This can be extremely difficult in buildings with many tenants. It can be very costly and time consuming taking days to weeks to get access and evaluate the entire system serving the particular space being renovated.

When in reality, the use of flexible sprinkler drops may have NO impact on a system, or can easily have less than 2 psi impact depending on the brand and length of the flexible drop to be used vs. the existing sprinkler drops to be changed.

The purpose of the Flexible Sprinkler Retrofit Analyzer is to help contractors and jurisdictions evaluate and document the impact of such a retrofit project. Using this tool, the code authority can feel confident in what the impact will be, without burdening every contractor of every project by performing new calculations for systems that may not be impacted.

The AHJ has a responsibility to ensure protection, while also being sensitive to the needs, costs, and project schedules of their customers. CSA has tried to help the AHJ and their customers by developing the tool.

UNDERSTANDING THE IMPACT

It is important to understand how incorporating flexible drops into a system impacts the pressure demand on the system.

First, the addition of flexible drops is not accumulative. This means that adding 50 flexible sprinkler drops does not negatively impact the system any more than a single flexible drop. Let's say that a flexible drop has a 2 psi pressure loss. This means that the pressure in the branch line where the flexible drop connects, must have a pressure that is 2 psi higher than the minimum required head pressure. Thus, assuming all the flex drops are the same (2 psi loss), than the additional 2 psi in the branch line is now available to all the other flexible drop connections. So, as long as you achieve the needed pressure for the remote (worst case) drop, all the others will have at least the same, and even higher pressures as you get closer to the source. The additional flow closer to source is discussed later.

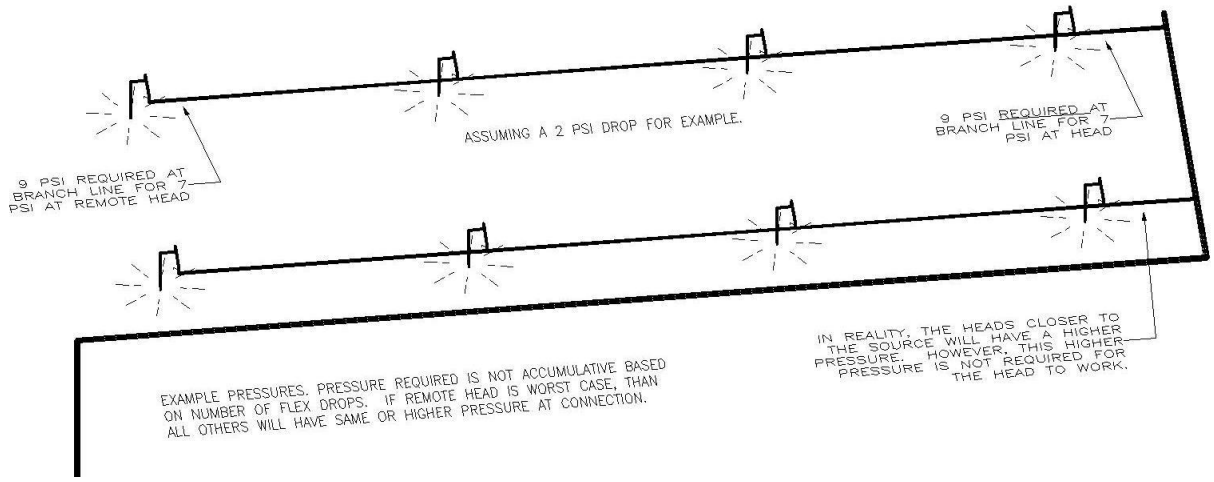


Figure 2: Pressure Needed for One is Same for All. Flex Pressures are not Accumulative.

Second, the reason that flexible drops can impact a system is due to the corrugated nature of the tubbing / hose used in the flex drop. Schedule 40 pipe typically used on sprinkler drops is relatively smooth pipe with relatively smooth elbows. As a result, there is not a lot of resistance on the flow of water through the pipe. However, flexible sprinkler drops vary in corrugation, or ripples, allowing for the ability to bend. This corrugation creates turbulent flow resulting in pressure loss. Each time the tubing is bent creates additional turbulent flow. The more turbulent the flow, the higher pressure that is required to flow the same amount of water in gallons per minute.

Figure 3: Corrugated Sprinkler Tubbing / Hose

Now, if you want to get technical, it is true that sprinklers closer to the source will have a higher pressure drop between the branch line and head while also flowing a higher gallon per minute (or gpm density). This is the result of a higher pressure closer to the source than at the furthest remote head. It is important to understand that this closer drop does not need a higher pressure to achieve the required density, it just happens to have a higher pressure being closer to the source, thus resulting in a higher flow. This higher flow will indicate a higher pressure demand in the calcs. For example lets say the remote head is flowing 20 gpm for a density of 0.1 over 200 ft^2. Yet, the head closest to the source is flowing 27 gpm over a 200 ft^2 area per head. Because the demand does not require 27 gpm, the higher pressure and thus drop is not necessary to achieve the minimum required density.

Note that the analyzer assumes the existing system was sized to support the density evaluated. Meaning, if the original system was designed for a density of 0.1 gpm/ft^2, than the analyzer CANNOT be used to evaluate a new density of 0.15 gpm/ft^2. The density used in the analyzer must be the same or lower than the original design criteria for proper pipe sizing and water supply.

EQUIVALENT SCHEDULE 40 PIPE LENGTH

Let's look at equivalent pipe length as it relates to the flexible hose. A 5 foot length of schedule 40 pipe has an equivalent length of 5 feet. Pretty simple. Now, a standard 1 inch elbow has the equivalent friction loss of 2 feet of pipe. Thus, if you have 2 elbows and 5 feet of pipe, you would have an equivalent length of 9 feet of pipe (5' + 2' + 2' = 9'). Because 1 inch pipe is the normal, and minimum pipe size allowed, in a sprinkler drop, flexible drops are evaluated to result in an equivalent length of schedule 40 1-inch pipe. Basically, the friction loss through a section of flexible drop is calculated backwards to an equivalent length of schedule 40 pipe. This evaluation is based on a correlating number of bends, such as 3. So a 48 inch flexible drop allowed to have 3 bends has been determined to have the same pressure loss as a 24 foot section of straight pipe (as an example). Another brand of flex, or a different evaluation may say that the same 48 inch flexible drop with 4 bends would have an equivalent loss of 30 feet of pipe. The number of bends and the equivalent length will vary by each brand, length, sprinkler outlet size, outlet orientation, and other factors. Thus, there is no one-size fits-all. This is why the Retrofit Analyzer requires the worst case drop by brand, length, and bends to be evaluated. This is also why AHJ's get concerned when flex drops are added to previously calculated systems without new evaluation.

OK, it gets a little more complicated. The typical value used is based on Underwriters Laboratories (UL) evaluation procedures. The UL criteria allows for a smaller radius (tighter) bend. UL is nearly always the value recognized by jurisdictions as it is a minimum value most in favor of the client (owner/contractor). This follows the same principle generally applied by NFPA standards as code minimums. Factory Mutual (FM) on the other hand, has different criteria. Factory Mutual is a large insurance carrier who

establishes criteria more focused on limiting property loss (smaller $ payouts) than code minimum which could result in a higher $$ loss in controlling the fire. As such, FM requires a larger radius in its bends (wider bend) and also applies a higher value for equivalent pipe length (more conservative). Thus a product with a UL equivalent length of 24 feet may have a FM equivalent of 34 feet. So when looking at manufacturers data, it is important to verify the criteria used, and the number of bends allowed. Some brands may have values indicated for 3, 4, 5 and even 8 bends. However, it is generally not practical to have 8 bends in a 4 foot flex drop. This is another reason why the Retrofit Analyzer requires the contractor to identify how many bends they will use based on the equivalent pipe length calculated. We caution the AHJ to NOT require the highest value on the table. This unnecessarily punishes the manufacturer for providing data on more bends, rather than being realistic and letting the installer identify the maximum number of bends they will use. The field inspector should be using the Retrofit Analyzer Report to verify installed conditions to the agreement submitted by the contractor via the report.

CREDIT FOR EXISTING SPRINKLER DROPS

When evaluating the impact of adding a flexible drop, it is important to also account for friction loss of the existing sprinkler drop to be replaced. There are different ways that an existing drop may supply sprinklers. It could be a simple 1 foot drop straight down from the branch line to the ceiling grid (not common and not center of tile). It may be a shell system with sprinklers directly on the branch lines now to be dropped to a new suspended ceiling. It could also be a common center of tile arm-over which would incorporate 4 elbows and 5 feet of straight pipe resulting in an equivalent length of 12 feet of schedule 40 pipe.

If the new flexible drop has an equivalent length of 15 feet, and the existing center of tile arm-over equals 12 feet, than there is only a 3 foot impact by adding the new drop.

Because of such consideration, the CSA Retrofit Analyzer allows credit for the existing sprinkler drops, but does not require this credit, such as build-out of shell spaces.

SAFETY MARGINS IN EXISTING SYSTEMS

Most systems will have margins of safety. Use them! Now, that said, there are some things to keep in mind.

NFPA 13 requires that fire flow values used in calculations for all systems account for fluctuations such as seasonal water usage, future growth such as in undeveloped areas, domestic flows, and other such changes. There are many times that such fluctuations may not be appropriately considered, or at least not clearly identified between actual fire flow results and fire flow values used in calculations.

It is not uncommon for good designers to incorporate a margin of safety in their hydraulic designs. This margin may be 5 psi or even 20 psi. This margin is to account for

fluctuations in seasonal water pressure, future renovations, future build-out of shell spaces, and/or just good design practice. However, there are also designers who will put it to the line with no margin of safety. Although this is not good practice, fortunately there are a number of safety factors already built into the NFPA 13 calculation process. It is more likely we would lose a building due to changes in fuel load, than due to a margin of safety.

Many jurisdictions will require minimum margins of safety in calculations. This is commonly 5, 10, 15, or even 20 psi. Again, this may be for various reasons including seasonal fluctuation, future growth and demand on the water system, future renovations, or other factors. Such minimums are also frequently required by insurance companies, federal projects, or owners. When evaluating the impact of flexible drops we would suggest that these jurisdictions requiring such margins of safety consider allowing these, or a portion of these, margins for such renovations. Again, a common reason for the margin of safety was to account for future changes such as renovations. Adding flexible drops is a renovation that should be allowed to utilize some of this margin of safety. Example, if the AHJ has a standard policy of requiring a 10 psi margin of safety, than they could allow up to 3 psi to be used for renovations such as incorporating flexible drops.

The CSA Retrofit Analyzer requires that a margin of safety be entered when evaluating the impact of adding flexible drops. There is a pull down menu allowing the source of this margin of safety. This could be based on previous calculations for that area, a flat psi margin required by the AHJ, or a psi margin allowed by the AHJ for renovation work, such as the 3 psi discussed above. Again, a value is required for the margin of safety, so users need to identify the source.

Notes in the report identify that pipe schedule systems will require hydraulic calculations and the Analyzer should not be used on pipe schedule systems. This is because it has been found that many pipe schedule systems may not pass current criteria nor have the same water pressures when originally installed.

VALIDATION OF CALCULATIONS

To validate the effectiveness of the Flexible Sprinkler Retrofit Analyzer Excel file, we prepared a sample light hazard remote area in HydraCAD which was calculated using HydraCALC. The sample area had the following parameters for evaluation:

- A light hazard density of 0.1 gpm per square feet over a 12’ x 14’ (168 ft^2) area.
- Eight operating sprinklers protecting an area of 1,344 ft^2.
- A 4 inch underground supply that is 50’ long from source to riser and incorporates a PIV and “T” at point of connection.
- A 2.5 inch riser with alarm valve, gate valve, and fixed 6 psi for backflow loss.
- A 2.5 inch supply main from riser to remote area that is 150 feet long.
- Two branch lines serving 4 heads each.

Table 1 provides the results between calculations of the CSA Retrofit Analyzer Excel file, and HydraCALC hydraulic sprinkler software. The values presented are pressure loss in psi between the branch line and the sprinkler head based on sprinkler drop utilized. The simple arm-over had an equivalent length of 8.1 feet. The center of tile arm-over had an equivalent length of 12.8 feet. Each of the flexible drops had an actual length of 48 inches.

Table 1: Comparison of Calculation Method – Pressure Loss in PSI (equ. length in ft)

			These columns represent the additional psi per drop adding flex over an existing Center of Tile Arm-over		
Method of Calculation	Simple Arm-over	Existing Center of Tile Arm-over	Victaulic VicFlex	FlexHead	Viking SprinkFlex
HydraCALC	0.77 (8.1)	1.22 (12.8)	0.71 (19.5)	1.13 (24)	4.15 (56)
Retrofit Analyzer	---	---	0.71 (19.5)	1.13 (24)	4.15 (56)
Comparison			Same values	Same values	Same values

As indicated in Table 1, the values from both HydraCALC and the Retrofit Analyzer are the same, which would be expected since they both use Hazen Williams as the key equation with the same variables.

It is therefore concluded that the Flexible Sprinkler Retrofit Analyzer Excel sheet provides an effective means of evaluating the impact of adding flexible sprinkler drops to an existing hydraulically calculated system having an appropriate margin of safety.

SUPPORTING DATA

The hydraulic calculations from HydraCALC, drawing views from HydraCAD, and the corresponding Retrofit Analyzer reports are included within this report as part of the validation results. These documents start on page 10.

CONCLUSION

The CSA Flexible Sprinkler Retrofit Analyzer presented values representative of detailed hydraulic analysis of the sample configuration. Both methods utilize the Hazen Williams formula, evaluate the same minimum required flow per head, and over the same distance of pipe. Review of the overall systems margin of safety was within the analyzers results. However, considering time and $$, the retrofit analyzer was considerably quicker and less expensive to reach the same conclusion. The report provides for a clean and professional summary of what is proposed for an over-the-counter permit, while also providing critical information for the field inspection.

VICTAULIC VICFLEX EXAMPLE

FLEXIBLE SPRINKLER RETROFIT ANALYZER

Used to evaluate the impact of adding flexible drops to an existing system.

Enter information into Green and Yellow fields.

Project Name: Sample Renovation to Office Space Date: 10/11/2017

Project #: 17-01234 If applicable Permit #:

Project Address (street, city, st, zip): 1234 Happy Valley Dr. Your City and State

Installing Contractor: Want to Do it Right, LLC

Contact Person: Will Design, Jr Phone: 501-712-1272

Brand & Length of Flexible hose used: VicFlex 48" 1/2" outlet Model: AH2-300

Equivalent UL length of 1" Schedule 40 pipe: (Attach mfg. data sheet.) 19.5 ft Allowed bends: 3 Based on longest length used accounting for length, bends,& fittings, per mfg.

Common equivalent lengths for existing drops: Existing arm-over center of tile 12' Credit taken in ft (will be subtracted from flex): 12.0 ft

Maximum coverage area per sprinkler: length 12.0 ft x width 14.0 ft = 168 ft²

Density: 0.10 gpm/ft Flow per sprinkler: 16.8 psi loss per ft: 0.094

Total additional psi required for hose selected: 0.71 psi

In the field below, click on pull-down arrow and select the source used to establish the existing systems safety margin:

Known safety margin from hydraulic calculations

Enter safety margin below:

Safety: 10.9 psi

Note: When using existing hydraulic calculations, they must be relevant for the same zone/riser and the same floors remote area.

Some jurisdictions may allow a default value for hydraulic systems.

If calculations were used for establishing safety factor, provide information below and attach copy of calculations.

Date of the calculations: 10/11/2017 Name of project calculated: Example by Lacey FPE

Based on the information provided for the flexible hose indicated: **SAFETY MARGIN IS ACCEPTABLE** ←Results

Warnings (if applicable):

I hereby attest that the information represented in this form is accurate and represents the worst case conditions for the flexible drops to be used in the project indicated.

Contractor Signature: _____ Date: _____

Accepted by: _____ Date: _____

Notes:

Actual calculations indicated that center of tile arm-over pipe with 2' of movement had pressure loss of 1.31 psi, while 48" flexible drop (same movement) had pressure loss of 1.44 psi. A difference of 0.13 psi.

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Lacey Fire Protection Eng. LLC
PO Box 723
Greenbrier, AR 72058
(501) 679-1753

Job Name	:	48 Inch Long VicFlex Equal to 19.5' Schedule 40 1"
Building	:	
Location	:	
System	:	
Contract	:	
Data File	:	48vicflex Area 1.WXF

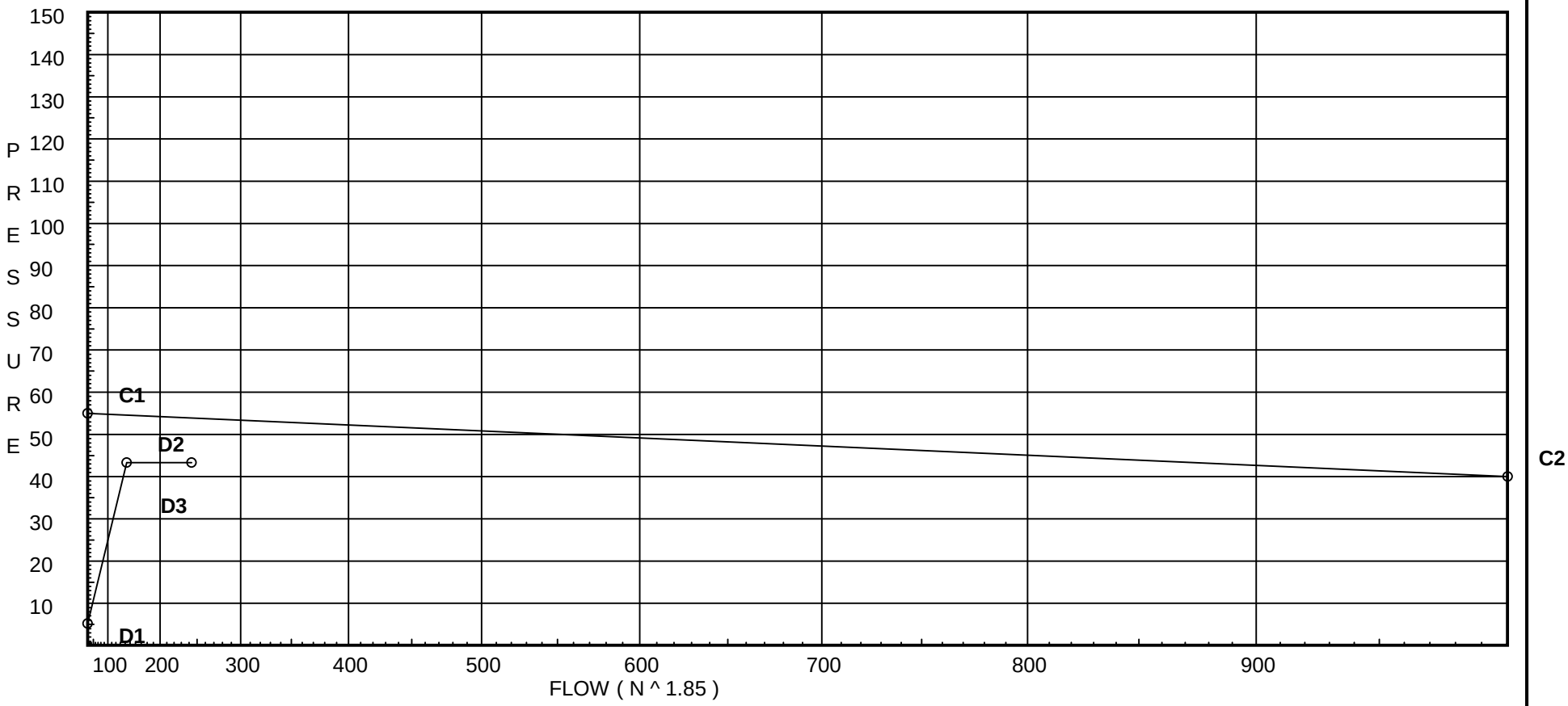
Water Supply Curve C

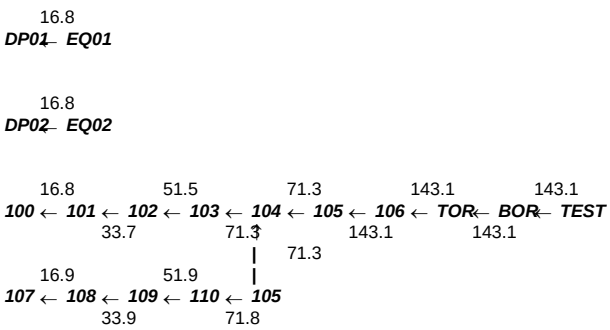
Lacey Fire Protection Eng. LLC
48 Inch Long VicFlex Equal to 19.5' Schedule 40 1"

Date 10/11/2017

City Water Supply:
- C1 - Static Pressure : 55
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

Demand:
- D1 - Elevation : 5.197
- D2 - System Flow : 143.133
- D2 - System Pressure : 43.318
- Hose (Demand) : 100
- D3 - System Demand : 243.133
- Safety Margin : 10.586




16.8
DP01
EQ01
16.8
DP02
EQ02
16.8
51.5
71.3
143.1
143.1
100
101
102
103
104
105
106
TOR
BOR
TEST
33.7
71.3
143.1
143.1
71.3
16.9
51.9
107
108
109
110
105
33.9
71.8

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
A	Alarm Rel E1 & E3							7.7	21.5		17		27	29							
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Units Summary

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

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ01	12.0		10.16	na				
DP02	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ02	12.0		10.44	na				
100	12.0	K = K @ EQ01	10.16	na	16.8			
101	12.0	K = K @ EQ02	10.51	na	16.85			
102	12.0	K = K @ EQ02	11.76	na	17.83			
103	12.0	K = K @ EQ02	14.52	na	19.81			
104	12.0		16.59	na				
105	12.0		16.84	na				
106	12.0		17.16	na				
TOR	12.0		29.6	na				
BOR	-4.0		44.81	na				
TEST	0.0		43.32	na	100.0			
107	12.0	K = K @ EQ01	10.32	na	16.93			
108	12.0	K = K @ EQ02	10.67	na	16.98			
109	12.0	K = K @ EQ02	11.95	na	17.97			
110	12.0	K = K @ EQ02	14.74	na	19.96			

The maximum velocity is 11.32 and it occurs in the pipe between nodes 110 and 105

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
DP01	16.80	1.049	E	2.0	19.500	9.000		K Factor = 5.60
to		120.0		0.0	2.000	-0.866		
EQ01	16.8	0.0942		0.0	21.500	2.026		Vel = 6.24
	0.0							
	16.80					10.160		K Factor = 5.27
DP02	16.80	1.049	T	5.0	19.500	9.000		K Factor = 5.60
to		120.0		0.0	5.000	-0.866		
EQ02	16.8	0.0942		0.0	24.500	2.309		Vel = 6.24
	0.0							
	16.80					10.443		K Factor = 5.20
100	16.80	1.38		0.0	14.000	10.16		
to		120.0		0.0	0.0	0.0		
101	16.8	0.0248		0.0	14.000	0.34		
101	16.85	1.38		0.0	14.000	10.50		
to		120.0		0.0	0.0	0.0		
102	33.65	0.0896		0.0	14.000	1.25		
102	17.83	1.38		0.0	14.000	11.76		
to		120.0		0.0	0.0	0.0		
103	51.48	0.1968		0.0	14.000	2.75		
103	19.81	1.61	T	8.0	4.210	14.51		
to		120.0		0.0	8.000	0.0		
104	71.29	0.1696		0.0	12.210	2.07		
104	0.0	2.469		0.0	12.000	16.588		
to		120.0		0.0	0.0	0.0		
105	71.29	0.0212		0.0	12.000	0.254		Vel = 4.78
105	71.84	2.469		0.0	4.140	16.842		
to		120.0		0.0	0.0	0.0		
106	143.13	0.0768		0.0	4.140	0.318		Vel = 9.59
106	0.0	2.469	2E	12.0	150.000	17.160		
to		120.0		0.0	12.000	0.0		
TOR	143.13	0.0768		0.0	162.000	12.436		Vel = 9.59
TOR	0.0	2.469	E	6.0	16.000	29.596		
to		120.0	A	7.7	13.700	12.930		* * Fixed Loss = 6
BOR	143.13	0.0768		0.0	29.700	2.280		Vel = 9.59
BOR	0.0	4.1		0.0	50.000	44.806		
to		140.0		0.0	0.0	-1.732		
TEST	143.13	0.0049		0.0	50.000	0.244		Vel = 3.48
	100.00							Qa = 100.00
	243.13					43.318		K Factor = 36.94
107	16.93	1.38		0.0	14.000	10.321		K Factor @ node EQ01
to		120.0		0.0	0.0	0.0		
108	16.93	0.0251		0.0	14.000	0.352		Vel = 3.63
108	16.99	1.38		0.0	14.000	10.673		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
109	33.92	0.0909		0.0	14.000	1.273		Vel = 7.28
109	17.96	1.38		0.0	14.000	11.946		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
110	51.88	0.1996		0.0	14.000	2.795		Vel = 11.13

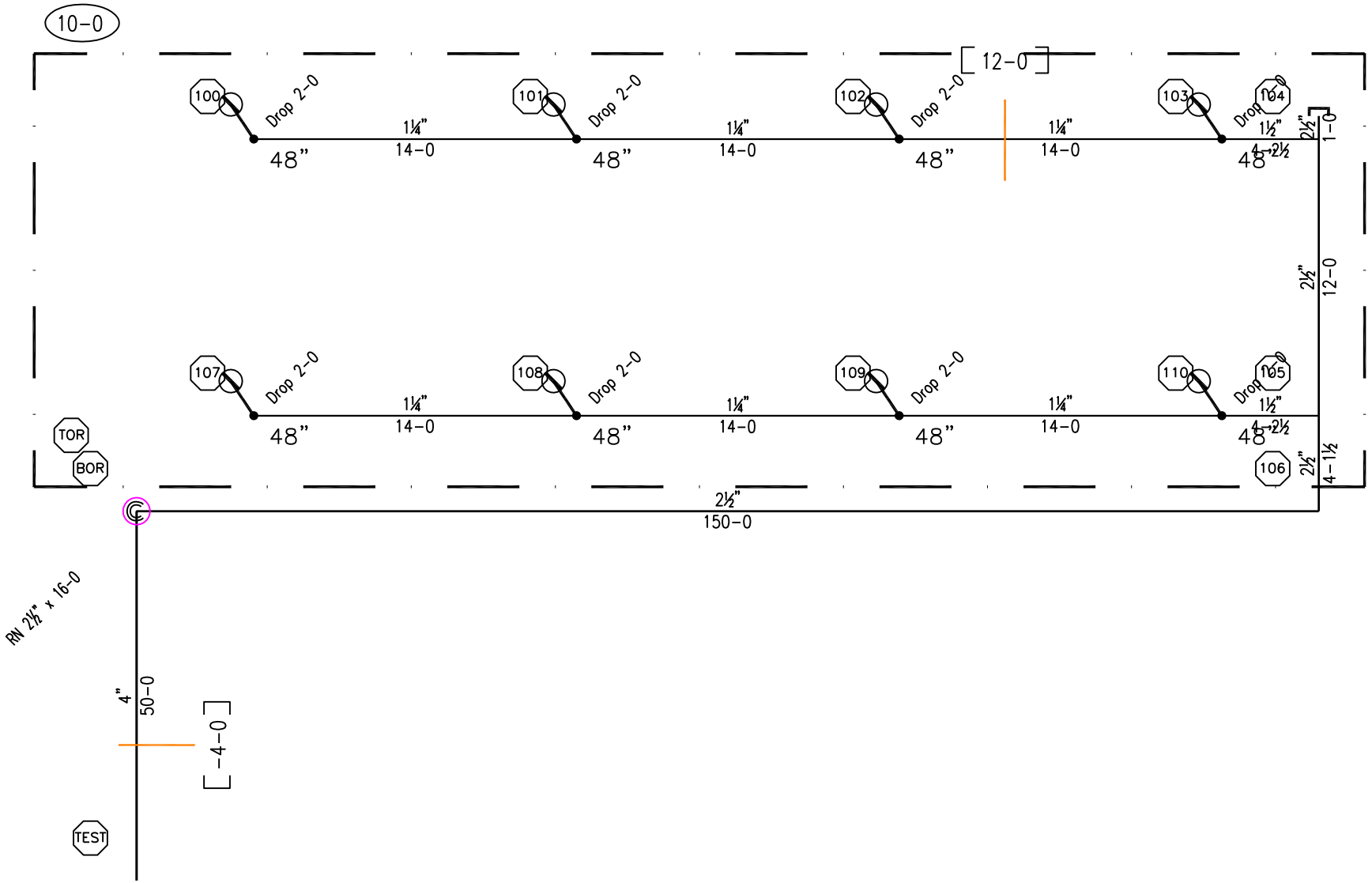
Using this pressure per foot. We do not account for the "T" fitting of 5' or the elevation gain as both of these would also apply to the regular sprinkler drop. Thus 19.5' equivalent flex minus the 12' existing equivalent drop results in a new equivalent of 7.5' x 0.0942 = 0.71 psi more than a center of tile drop.

Final Calculations - Hazen-Williams

Lacey Fire Protection Eng. LLC
48 Inch Long VicFlex Equal to 19.5' Schedule 40 1"

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
110	19.96	1.61	T	8.0	4.210	14.741		K Factor @ node EQ02
to		120.0		0.0	8.000	0.0		
105	71.84	0.1721		0.0	12.210	2.101		Vel = 11.32
	0.0							
	71.84					16.842		K Factor = 17.51

48 INCH VICFLEX



FLEXIBLE SPRINKLER RETROFIT ANALYZER

Used to evaluate the impact of adding flexible drops to an existing system.

Enter information into Green and Yellow fields.

Project Name: Sample Renovation to Office Space Date: 10/11/2017

Project #: 17-01234 If applicable Permit #:

Project Address (street, city, st, zip): 1234 Happy Valley Dr. Your City and State

Installing Contractor: Want to Do it Right, LLC

Contact Person: Will Design, Jr Phone: 501-712-1272

Brand & Length of Flexible hose used: FLEXHEAD 48" 1/2" Out Model: 2048

Equivalent UL length of 1" Schedule 40 pipe: (Attach mfg. data sheet.) 24.0 ft Allowed bends: 4 Based on longest length used accounting for length, bends,& fittings, per mfg.

Common equivalent lengths for existing drops: Existing arm-over center of tile 12' Credit taken in ft (will be subtracted from flex): 12.0 ft

Maximum coverage area per sprinkler: length 12.0 ft x width 14.0 ft = 168 ft²

Density: 0.10 gpm/ft Flow per sprinkler: 16.8 psi loss per ft: 0.094

Total additional psi required for hose selected: 1.13 psi

In the field below, click on pull-down arrow and select the source used to establish the existing systems safety margin:

Known safety margin from hydraulic calculations

Note: When using existing hydraulic calculations, they must be relevant for the same zone/riser and the same floors remote area.

Enter safety margin below:

Safety: 10.9 psi

Some jurisdictions may allow a default value for hydraulic systems.

If calculations were used for establishing safety factor, provide information below and attach copy of calculations.

Date of the calculations: 10/11/2017 Name of project calculated: Example by Lacey FPE

Based on the information provided for the flexible hose indicated: **SAFETY MARGIN IS ACCEPTABLE** ←Results

Warnings (if applicable):

I hereby attest that the information represented in this form is accurate and represents the worst case conditions for the flexible drops to be used in the project indicated.

Contractor Signature: _____ Date: _____

Accepted by: _____ Date: _____

Notes:

Actual calculations indicated that center of tile arm-over pipe with 2' of movement had pressure loss of 1.31 psi, while 48" flexible drop (same movement+) had pressure loss of 1.87 psi. A difference of 0.5 psi.

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Job Name	:	48 Inch Long FlexHead Equal to 24' Schedule 40 1"
Building	:	
Location	:	
System	:	
Contract	:	
Data File	:	48SprinkFlex Area 1.WXF

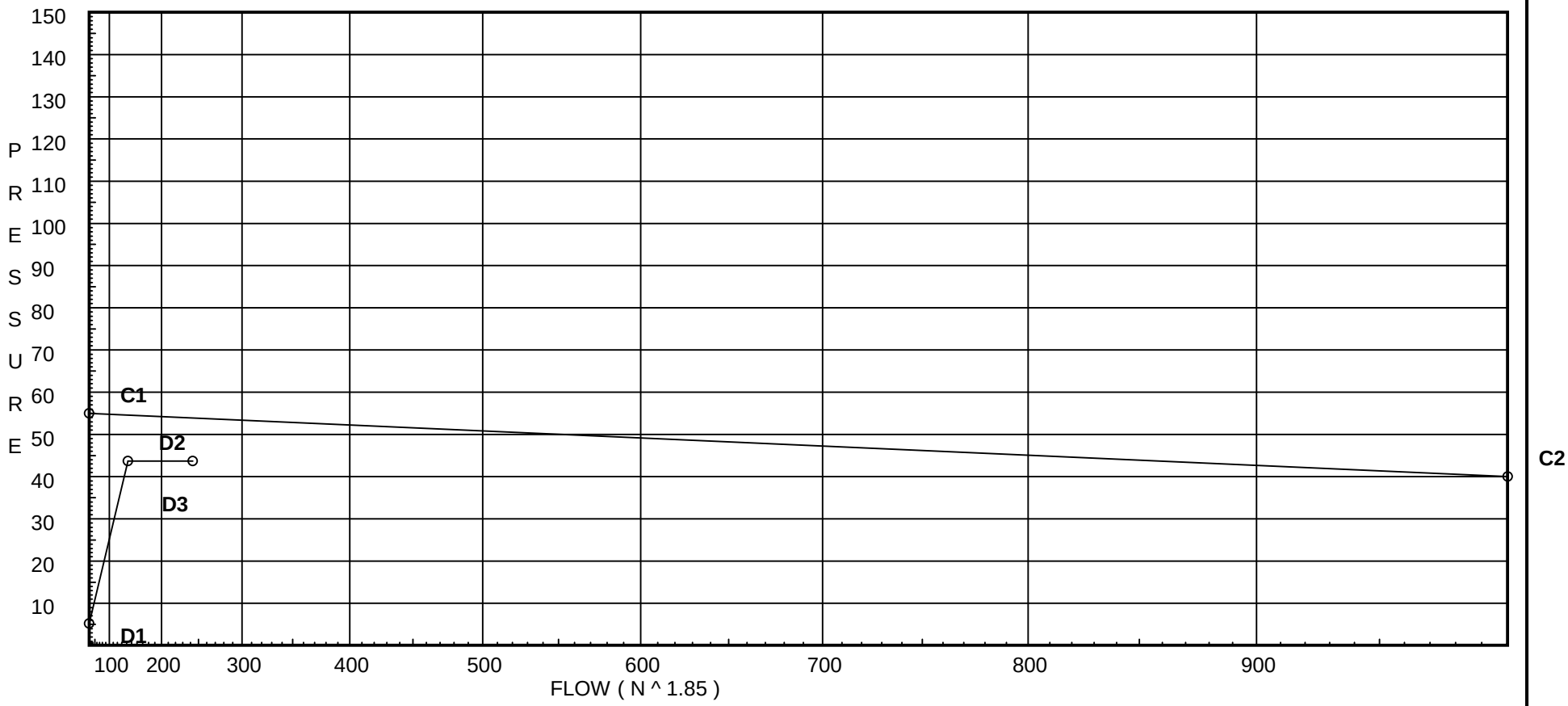
Water Supply Curve C

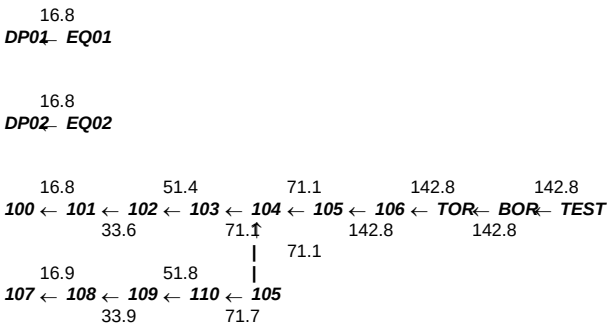
Lacey Fire Protection Eng. LLC
48 Inch Long FlexHead Equal to 24' Schedule 40 1"

Page 1
Date 10/11/2017

City Water Supply:
- C1 - Static Pressure : 55
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

Demand:
- D1 - Elevation : 5.197
- D2 - System Flow : 142.81
- D2 - System Pressure : 43.665
- Hose (Demand) : 100
- D3 - System Demand : 242.81
- Safety Margin : 10.242




16.8
DP01
EQ01
16.8
DP02
EQ02
16.8
51.4
71.1
142.8
142.8
100
101
102
103
104
105
106
TOR
BOR
TEST
33.6
71.1
142.8
142.8
71.1
16.9
51.8
107
108
109
110
105
33.9
71.7

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
A	Alarm Rel E1 & E3							7.7	21.5		17		27	29							
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Units Summary

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

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ01	12.0		10.58	na				
DP02	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ02	12.0		10.87	na				
100	12.0	K = K @ EQ01	10.58	na	16.8			
101	12.0	K = K @ EQ02	10.93	na	16.85			
102	12.0	K = K @ EQ02	12.19	na	17.79			
103	12.0	K = K @ EQ02	14.94	na	19.7			
104	12.0		17.0	na				
105	12.0		17.25	na				
106	12.0		17.57	na				
TOR	12.0		29.95	na				
BOR	-4.0		45.15	na				
TEST	0.0		43.66	na	100.0			
107	12.0	K = K @ EQ01	10.75	na	16.93			
108	12.0	K = K @ EQ02	11.1	na	16.98			
109	12.0	K = K @ EQ02	12.37	na	17.92			
110	12.0	K = K @ EQ02	15.16	na	19.84			

The maximum velocity is 11.29 and it occurs in the pipe between nodes 110 and 105

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
DP01	16.80	1.049	E	2.0	24.000	9.000		K Factor = 5.60
to		120.0		0.0	2.000	-0.866		
EQ01	16.8	0.0942		0.0	26.000	2.450		Vel = 6.24
	0.0							
	16.80					10.584		K Factor = 5.16
DP02	16.80	1.049	T	5.0	24.000	9.000		K Factor = 5.60
to		120.0		0.0	5.000	-0.866		
EQ02	16.8	0.0942		0.0	29.000	2.733		Vel = 6.24
	0.0							
	16.80					10.867		
100	16.80	1.38		0.0	14.000	10.584		
to		120.0		0.0	0.0	0.0		
101	16.8	0.0248		0.0	14.000	0.347		
101	16.85	1.38		0.0	14.000	10.931		
to		120.0		0.0	0.0	0.0		
102	33.65	0.0896		0.0	14.000	1.255		
102	17.79	1.38		0.0	14.000	12.186		
to		120.0		0.0	0.0	0.0		
103	51.44	0.1965		0.0	14.000	2.751		Vel = 11.03
103	19.70	1.61	T	8.0	4.210	14.937		K Factor @ node EQ02
to		120.0		0.0	8.000	0.0		
104	71.14	0.1690		0.0	12.210	2.063		Vel = 11.21
104	0.0	2.469		0.0	12.000	17.000		
to		120.0		0.0	0.0	0.0		
105	71.14	0.0211		0.0	12.000	0.253		Vel = 4.77
105	71.67	2.469		0.0	4.140	17.253		
to		120.0		0.0	0.0	0.0		
106	142.81	0.0763		0.0	4.140	0.316		Vel = 9.57
106	0.0	2.469	2E	12.0	150.000	17.569		
to		120.0		0.0	12.000	0.0		
TOR	142.81	0.0765		0.0	162.000	12.385		Vel = 9.57
TOR	0.0	2.469	E	6.0	16.000	29.954		
to		120.0	A	7.7	13.700	12.930		* * Fixed Loss = 6
BOR	142.81	0.0764		0.0	29.700	2.270		Vel = 9.57
BOR	0.0	4.1		0.0	50.000	45.154		
to		140.0		0.0	0.0	-1.732		
TEST	142.81	0.0049		0.0	50.000	0.243		Vel = 3.47
	100.00							Qa = 100.00
	242.81					43.665		K Factor = 36.75
107	16.93	1.38		0.0	14.000	10.747		K Factor @ node EQ01
to		120.0		0.0	0.0	0.0		
108	16.93	0.0251		0.0	14.000	0.352		Vel = 3.63
108	16.98	1.38		0.0	14.000	11.099		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
109	33.91	0.0909		0.0	14.000	1.272		Vel = 7.27
109	17.92	1.38		0.0	14.000	12.371		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
110	51.83	0.1993		0.0	14.000	2.790		Vel = 11.12

Using this pressure per foot.
We do not account for the "T" fitting of 5' or the elevation gain as both of these would also apply to the regular sprinkler drop. Thus 24' equivalent flex - the 12' existing equivalent drop results in a new equivalent of 12' x 0.0942 = 1.13 psi more than a center of tile drop.

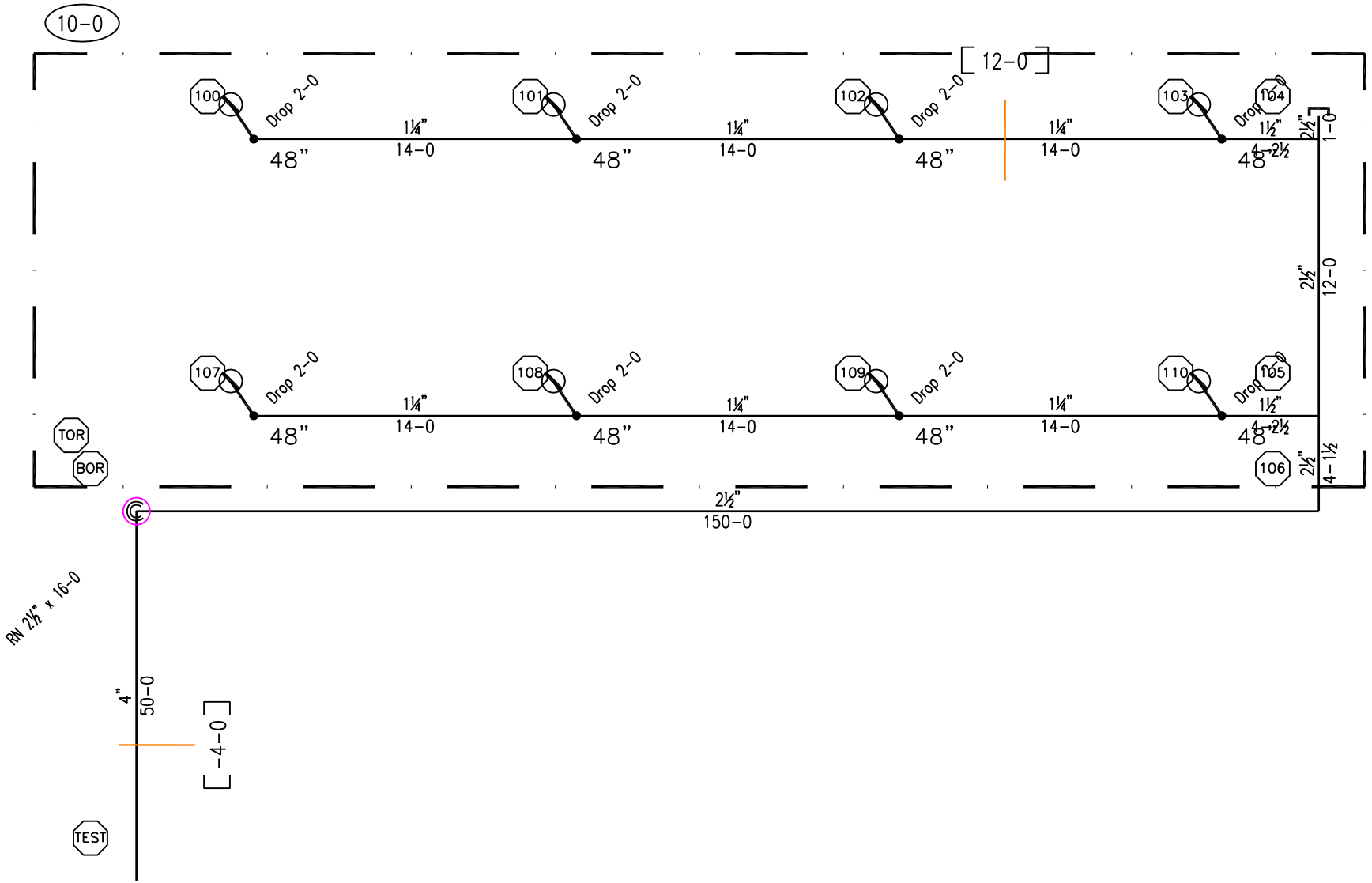
Final Calculations - Hazen-Williams

Lacey Fire Protection Eng. LLC
48 Inch Long FlexHead Equal to 24' Schedule 40 1"

Date 10/11/2017

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
110	19.84	1.61	T	8.0	4.210	15.161		K Factor @ node EQ02
to		120.0		0.0	8.000	0.0		
105	71.67	0.1713		0.0	12.210	2.092		Vel = 11.29
	0.0							
	71.67					17.253		K Factor = 17.25

48 INCH FLEXHEAD



VIKING SPRINKFLEX EXAMPLE

FLEXIBLE SPRINKLER RETROFIT ANALYZER

Used to evaluate the impact of adding flexible drops to an existing system.

Enter information into Green and Yellow fields.

Project Name: Sample Renovation to Office Space Date: 10/11/2017

Project #: 17-01234 If applicable Permit #:

Project Address (street, city, st, zip): 1234 Happy Valley Dr. Your City and State

Installing Contractor: Want to Do it Right, LLC

Contact Person: Will Design, Jr Phone: 501-712-1272

Brand & Length of Flexible hose used: Viking SprinkFlex 48" 1/2" Out Model: SFN48H

Equivalent UL length of 1" Schedule 40 pipe: (Attach mfg. data sheet.) 56.0 ft Allowed bends: 3 Based on longest length used accounting for length, bends,& fittings, per mfg.

Common equivalent lengths for existing drops: Existing arm-over center of tile 12' Credit taken in ft (will be subtracted from flex): 12.0 ft

Maximum coverage area per sprinkler: length 12.0 ft x width 14.0 ft = 168 ft²

Density: 0.10 gpm/ft Flow per sprinkler: 16.8 psi loss per ft: 0.094

Total additional psi required for hose selected: 4.15 psi

In the field below, click on pull-down arrow and select the source used to establish the existing systems safety margin:

Known safety margin from hydraulic calculations

Note: When using existing hydraulic calculations, they must be relevant for the same zone/riser and the same floors remote area.

Enter safety margin below:

Safety: 10.9 psi

Some jurisdictions may allow a default value for hydraulic systems.

If calculations were used for establishing safety factor, provide information below and attach copy of calculations.

Date of the calculations: 10/11/2017 Name of project calculated: Example by Lacey FPE

Based on the information provided for the flexible hose indicated: **SAFETY MARGIN IS ACCEPTABLE** ←Results

Warnings (if applicable):

I hereby attest that the information represented in this form is accurate and represents the worst case conditions for the flexible drops to be used in the project indicated.

Contractor Signature: _____ Date: _____

Accepted by: _____ Date: _____

Notes:

Actual calculations indicated that center of tile arm-over pipe with 2' of movement had pressure loss of 1.31 psi, while 48" flexible drop (same movement) had pressure loss of 4.88 psi. A difference of 3.57 psi.

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Job Name	:	48 Inch Long SprinkFlex Equal to 56' Schedule 40 1"
Building	:	
Location	:	
System	:	
Contract	:	
Data File	:	48SprinkFlex Area 1.WXF

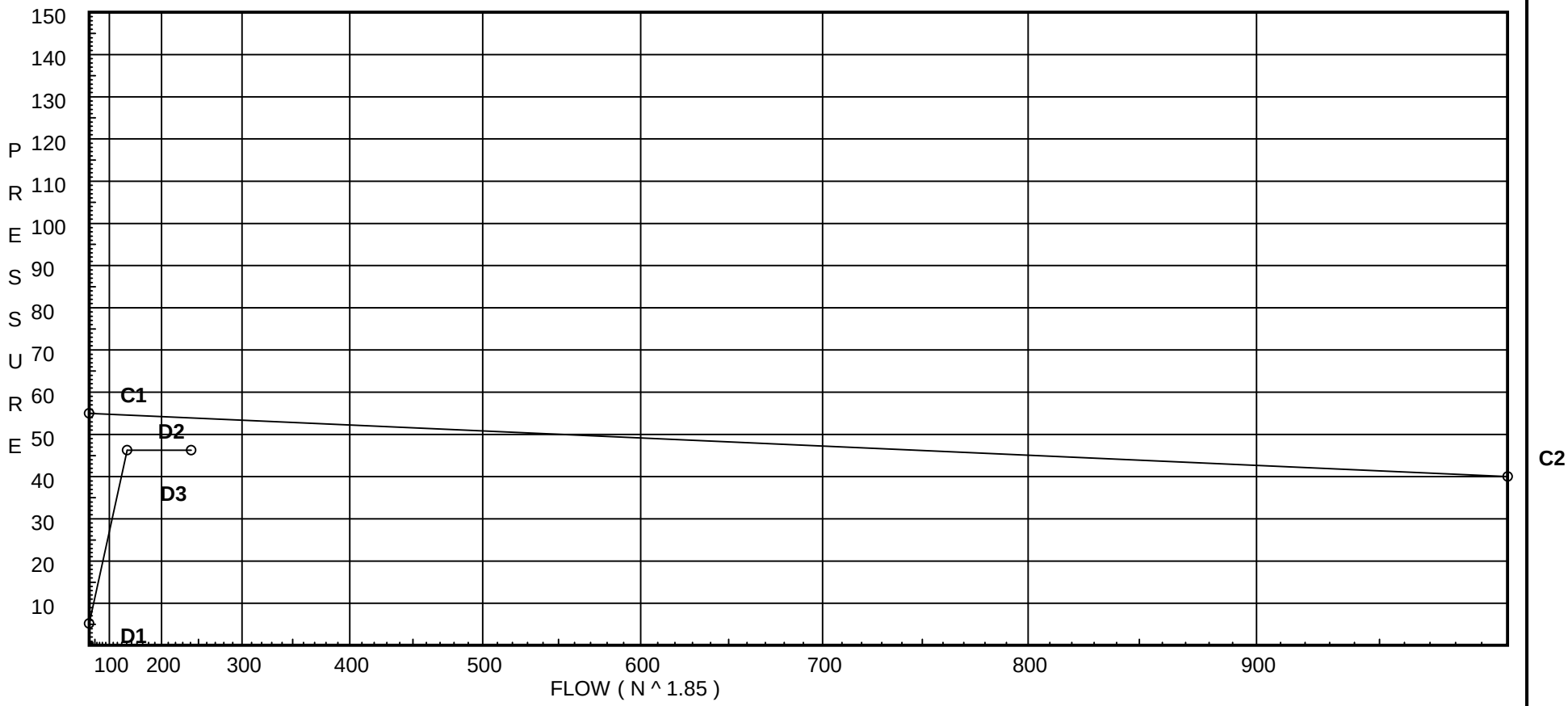
Water Supply Curve C

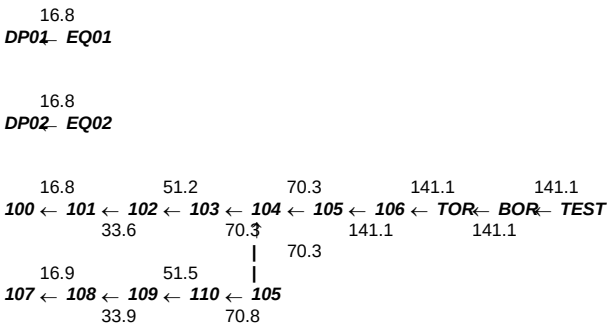
Lacey Fire Protection Eng. LLC
48 Inch Long SprinkFlex Equal to 56' Schedule 40 1"

Date 10/11/2017

City Water Supply:
- C1 - Static Pressure : 55
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

Demand:
- D1 - Elevation : 5.197
- D2 - System Flow : 141.063
- D2 - System Pressure : 46.266
- Hose (Demand) : 100
- D3 - System Demand : 241.063
- Safety Margin : 7.655




16.8
DP01
EQ01
16.8
DP02
EQ02
16.8
51.2
70.3
141.1
141.1
100
101
102
103
104
105
106
TOR
BOR
TEST
33.6
70.3
141.1
141.1
70.3
16.9
51.5
107
108
109
110
105
33.9
70.8

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
A	Alarm Rel E1 & E3							7.7	21.5		17		27	29							
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Units Summary

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

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ01	12.0		13.6	na				
DP02	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ02	12.0		13.88	na				
100	12.0	K = K @ EQ01	13.6	na	16.8			
101	12.0	K = K @ EQ02	13.95	na	16.84			
102	12.0	K = K @ EQ02	15.2	na	17.58			
103	12.0	K = K @ EQ02	17.93	na	19.09			
104	12.0		19.95	na				
105	12.0		20.2	na				
106	12.0		20.51	na				
TOR	12.0		32.61	na				
BOR	-4.0		47.76	na				
TEST	0.0		46.27	na	100.0			
107	12.0	K = K @ EQ01	13.77	na	16.91			
108	12.0	K = K @ EQ02	14.12	na	16.95			
109	12.0	K = K @ EQ02	15.39	na	17.69			
110	12.0	K = K @ EQ02	18.15	na	19.21			

The maximum velocity is 11.15 and it occurs in the pipe between nodes 110 and 105

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
DP01	16.80	1.049	E	2.0	56.000	9.000		K Factor = 5.60
to		120.0		0.0	2.000	-0.866		
EQ01	16.8	0.0942		0.0	58.000	5.466		Vel = 6.24
	0.0							
	16.80					13.600		K Factor = 4.56
DP02	16.80	1.049	T	5.0	56.000	9.000		K Factor = 5.60
to		120.0		0.0	5.000	-0.866		
EQ02	16.8	0.0942		0.0	61.000	5.749		Vel = 6.24
	0.0							
	16.80					13.883		K Factor = 4.51
100	16.80	1.38		0.0	14.000	13.600		K Factor @ node EQ01
to		120.0		0.0	0.0	0.0		
101	16.8	0.0249		0.0	14.000	0.348		Vel = 3.60
101	16.84	1.38		0.0	14.000	13.948		
to		120.0		0.0	0.0	0.0		
102	33.64	0.0895		0.0	14.000	1.253		
102	17.58	1.38		0.0	14.000	15.201		
to		120.0		0.0	0.0	0.0		
103	51.22	0.1949		0.0	14.000	2.729		
103	19.09	1.61	T	8.0	4.210	17.930		
to		120.0		0.0	8.000	0.0		
104	70.31	0.1654		0.0	12.210	2.019		
104	0.0	2.469		0.0	12.000	19.949		
to		120.0		0.0	0.0	0.0		
105	70.31	0.0207		0.0	12.000	0.248		Vel = 4.71
105	70.75	2.469		0.0	4.140	20.197		
to		120.0		0.0	0.0	0.0		
106	141.06	0.0746		0.0	4.140	0.309		Vel = 9.45
106	0.0	2.469	2E	12.0	150.000	20.506		
to		120.0		0.0	12.000	0.0		
TOR	141.06	0.0747		0.0	162.000	12.106		Vel = 9.45
TOR	0.0	2.469	E	6.0	16.000	32.612		
to		120.0	A	7.7	13.700	12.930		* * Fixed Loss = 6
BOR	141.06	0.0747		0.0	29.700	2.219		Vel = 9.45
BOR	0.0	4.1		0.0	50.000	47.761		
to		140.0		0.0	0.0	-1.732		
TEST	141.06	0.0047		0.0	50.000	0.237		Vel = 3.43
	100.00							Qa = 100.00
	241.06					46.266		K Factor = 35.44
107	16.91	1.38		0.0	14.000	13.774		K Factor @ node EQ01
to		120.0		0.0	0.0	0.0		
108	16.91	0.0251		0.0	14.000	0.351		Vel = 3.63
108	16.94	1.38		0.0	14.000	14.125		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
109	33.85	0.0906		0.0	14.000	1.268		Vel = 7.26
109	17.69	1.38		0.0	14.000	15.393		K Factor @ node EQ02
to		120.0		0.0	0.0	0.0		
110	51.54	0.1972		0.0	14.000	2.761		Vel = 11.06

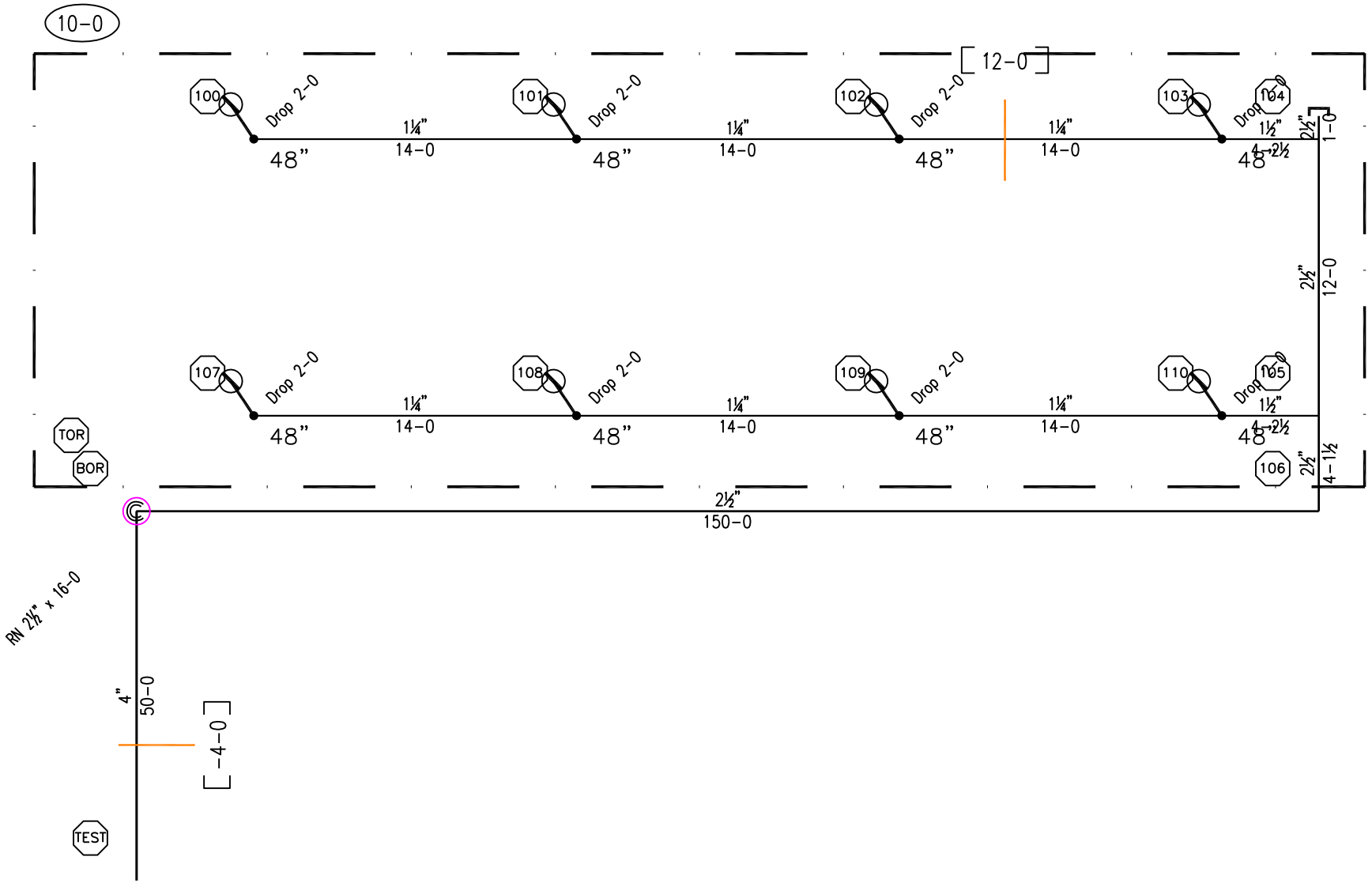
Using this pressure per foot.
We do not account for the "T" fitting of 5' or the elevation gain as both of these would also apply to the regular sprinkler drop. Thus 56' equivalent flex - the 12' existing equivalent drop results in a new equivalent of 44' x 0.0942 = 4.15 psi more than a center of tile drop.

Final Calculations - Hazen-Williams

Lacey Fire Protection Eng. LLC
48 Inch Long SprinkFlex Equal to 56' Schedule 40 1"

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
110	19.21	1.61	T	8.0	4.210	18.154		K Factor @ node EQ02
to		120.0		0.0	8.000	0.0		
105	70.75	0.1673		0.0	12.210	2.043		Vel = 11.15
	0.0							
	70.75					20.197		K Factor = 15.74

48 INCH SPRINKFLEX



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Job Name	:	Schedule 40 Center of Tile Arm-over
Building	:	
Location	:	
System	:	
Contract	:	
Data File	:	arm-over Area 1.WXF

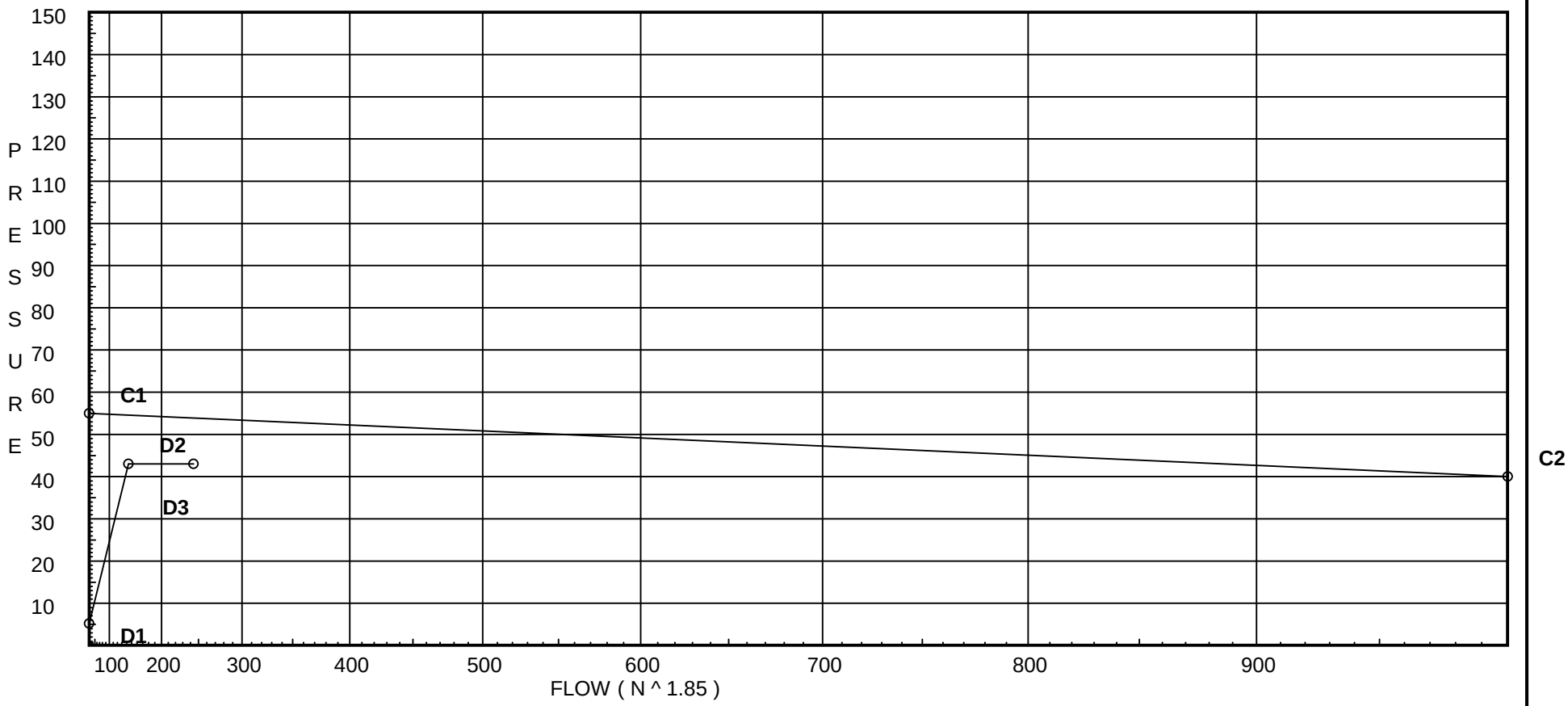
Water Supply Curve C

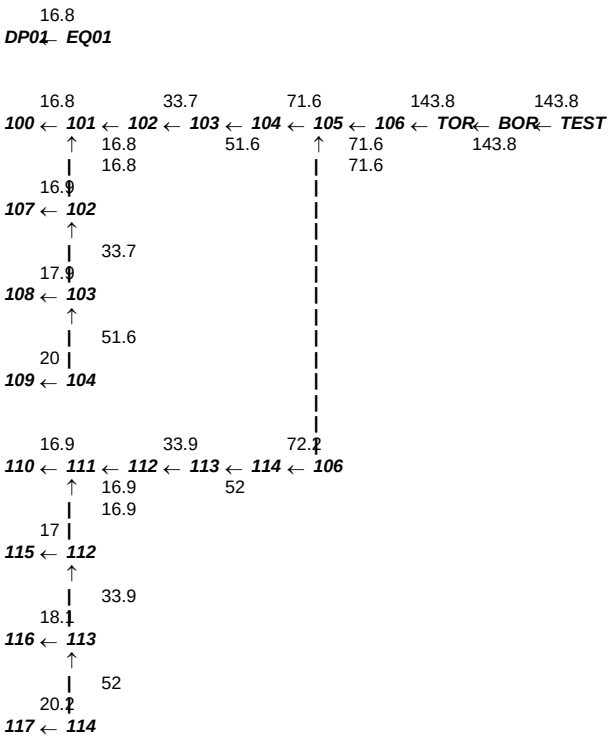
Lacey Fire Protection Eng. LLC
Schedule 40 Center of Tile Arm-over

Date 10/11/2017

City Water Supply:
- C1 - Static Pressure : 55
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

Demand:
- D1 - Elevation : 5.197
- D2 - System Flow : 143.759
- D2 - System Pressure : 42.996
- Hose (Demand) : 100
- D3 - System Demand : 243.759
- Safety Margin : 10.902




16.8
DP01 ← EQ01
16.8 33.7 71.6 143.8 143.8
100 ← 101 ← 102 ← 103 ← 104 ← 105 ← 106 ← TOR ← BOR ← TEST
16.8 51.6 71.6 143.8
16.8 71.6
16.9
107 ← 102
33.7
17.1
108 ← 103
51.6
20
109 ← 104
16.9 33.9 72.2
110 ← 111 ← 112 ← 113 ← 114 ← 106
16.9 52
16.9
17
115 ← 112
33.9
18.1
116 ← 113
52
20.2
117 ← 114

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
A	Alarm Rel E1 & E3							7.7	21.5		17		27	29							
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
G	NFPA 13 Gate Valve	0	0	0	0	0	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Units Summary

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

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ01	12.0		8.51	na				
100	12.0	K = K @ EQ01	8.51	na	16.8			
101	12.0		9.53	na				
102	12.0		9.88	na				
103	12.0		11.13	na				
104	12.0		13.9	na				
105	12.0		15.98	na				
106	12.0		16.24	na				
TOR	12.0		29.1	na				
BOR	-4.0		44.33	na				
TEST	0.0		43.0	na	100.0			
107	12.0	K = K @ EQ01	8.57	na	16.86			
108	12.0	K = K @ EQ01	9.67	na	17.9			
109	12.0	K = K @ EQ01	12.09	na	20.03			
110	12.0	K = K @ EQ01	8.65	na	16.94			
111	12.0		9.69	na				
112	12.0		10.04	na				
113	12.0		11.32	na				
114	12.0		14.12	na				
115	12.0	K = K @ EQ01	8.71	na	16.99			
116	12.0	K = K @ EQ01	9.83	na	18.05			
117	12.0	K = K @ EQ01	12.29	na	20.19			

The maximum velocity is 11.37 and it occurs in the pipe between nodes 114 and 106

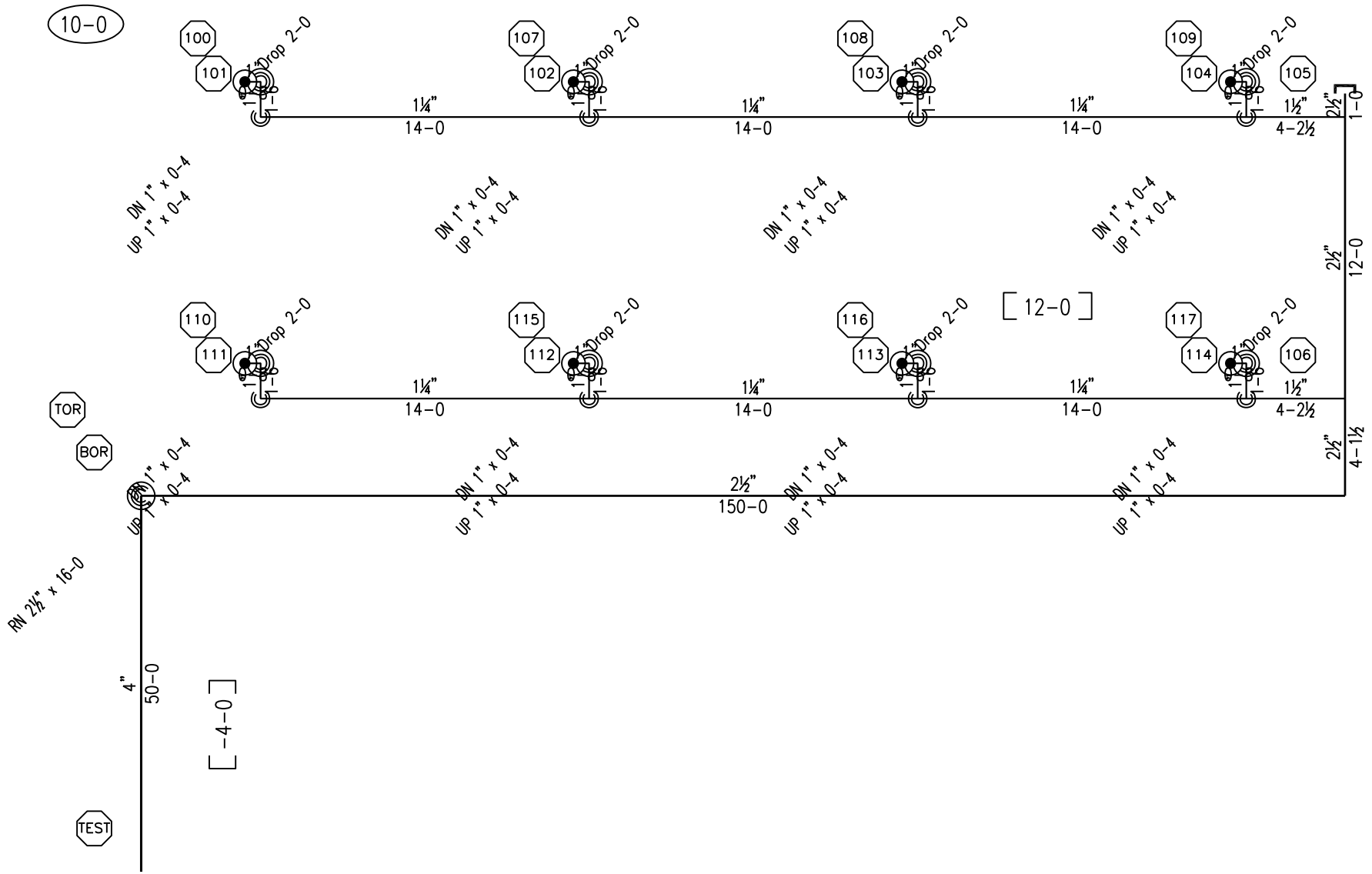
Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
DP01	16.80	1.049	E	2.0	2.000	9.000		K Factor = 5.60
to		120.0		0.0	2.000	-0.866		
EQ01	16.8	0.0942		0.0	4.000	0.377		Vel = 6.24
	0.0							
	16.80					8.511		K Factor = 5.76
100	16.80	1.049	4E	8.0	2.830	8.511		K Factor @ node EQ01
to		120.0		0.0	8.000	0.0		
101	16.8	0.0943		0.0	10.830	1.021		Vel = 6.24
101	0.0	1.38		0.0	14.000	9.532		
to		120.0		0.0	0.0	0.0		
102	16.8	0.0248		0.0	14.000	0.347		Vel = 3.60
102	16.86	1.38		0.0	14.000	9.879		
to		120.0		0.0	0.0	0.0		
103	33.66	0.0896		0.0	14.000	1.255		Vel = 7.22
103	17.90	1.38		0.0	14.000	11.134		
to		120.0		0.0	0.0	0.0		
104	51.56	0.1973		0.0	14.000	2.762		
104	20.03	1.61	T	8.0	4.210	13.896		
to		120.0		0.0	8.000	0.0		
105	71.59	0.1710		0.0	12.210	2.088		
105	0.0	2.469		0.0	12.000	15.984		
to		120.0		0.0	0.0	0.0		
106	71.59	0.0213		0.0	12.000	0.255		
106	72.17	2.469	2E	12.0	154.140	16.239		
to		120.0		0.0	12.000	0.0		
TOR	143.76	0.0774		0.0	166.140	12.858		
TOR	0.0	2.469	E	6.0	16.000	29.097		
to		120.0	A	7.7	13.700	12.930		
BOR	143.76	0.0774		0.0	29.700	2.298		Vel = 5.83
BOR	0.0	4.1	T	29.067	50.000	44.325		
to		140.0	G	2.907	31.974	-1.732		
TEST	143.76	0.0049		0.0	81.974	0.403		Vel = 3.49
	100.00							Qa = 100.00
	243.76					42.996		K Factor = 37.17
107	16.86	1.049	3E	6.0	2.830	8.567		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
102	16.86	0.0949		0.0	13.830	1.312		Vel = 6.26
	0.0							
	16.86					9.879		K Factor = 5.36
108	17.90	1.049	3E	6.0	2.830	9.667		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
103	17.9	0.1061		0.0	13.830	1.467		Vel = 6.64
	0.0							
	17.90					11.134		K Factor = 5.36
109	20.03	1.049	3E	6.0	2.830	12.092		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
104	20.03	0.1304		0.0	13.830	1.804		Vel = 7.44
	0.0							

This elbow and 2' drop are added to the arm-over below.

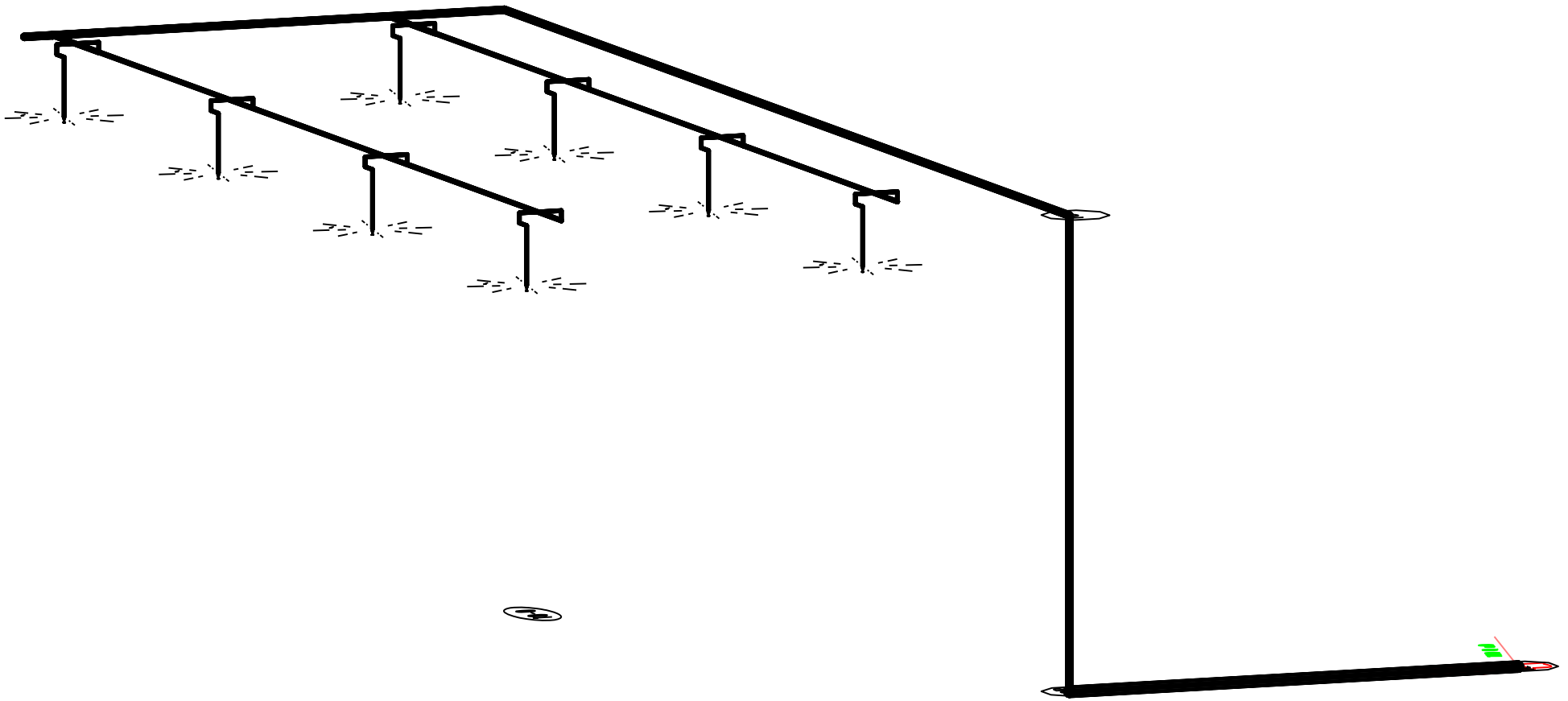
Arm-over values. Using this pressure per foot.
We do not account for the "T" fitting of 5' or the elevation gain as both of these would also apply to the regular sprinkler drop. Thus 4' drop + 8.83' armover = 12.83' existing equivalent x 0.0949 = 1.22 psi for existing center of tile drop.

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
	20.03					13.896		K Factor = 5.37
110	16.94	1.049	4E	8.0	2.830	8.652		K Factor @ node EQ01
to		120.0		0.0	8.000	0.0		
111	16.94	0.0958		0.0	10.830	1.037		Vel = 6.29
111	0.0	1.38		0.0	14.000	9.689		
to		120.0		0.0	0.0	0.0		
112	16.94	0.0251		0.0	14.000	0.352		Vel = 3.63
112	16.99	1.38		0.0	14.000	10.041		
to		120.0		0.0	0.0	0.0		
113	33.93	0.0910		0.0	14.000	1.274		Vel = 7.28
113	18.06	1.38		0.0	14.000	11.315		
to		120.0		0.0	0.0	0.0		
114	51.99	0.2004		0.0	14.000	2.805		Vel = 11.15
114	20.18	1.61	T	8.0	4.210	14.120		
to		120.0		0.0	8.000	0.0		
106	72.17	0.1735		0.0	12.210	2.119		Vel = 11.37
	0.0							
	72.17					16.239		K Factor = 17.91
115	16.99	1.049	3E	6.0	2.830	8.709		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
112	16.99	0.0963		0.0	13.830	1.332		Vel = 6.31
	0.0							
	16.99					10.041		K Factor = 5.36
116	18.05	1.049	3E	6.0	2.830	9.826		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
113	18.05	0.1077		0.0	13.830	1.489		Vel = 6.70
	0.0							
	18.05					11.315		K Factor = 5.37
117	20.19	1.049	3E	6.0	2.830	12.289		K Factor @ node EQ01
to		120.0	T	5.0	11.000	0.0		
114	20.19	0.1324		0.0	13.830	1.831		Vel = 7.50
	0.0							
	20.19					14.120		K Factor = 5.37

SCHEDULE 40 CENTER OF TILE ARM-OVER



SCHEDULE 40 CENTER OF TILE ARM-OVER 3D VIEW



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(501) 679-1753

Job Name	:	Schedule 40 Simple Arm-over
Building	:	
Location	:	
System	:	
Contract	:	
Data File	:	arm-over not center of tile Area 1.WXF

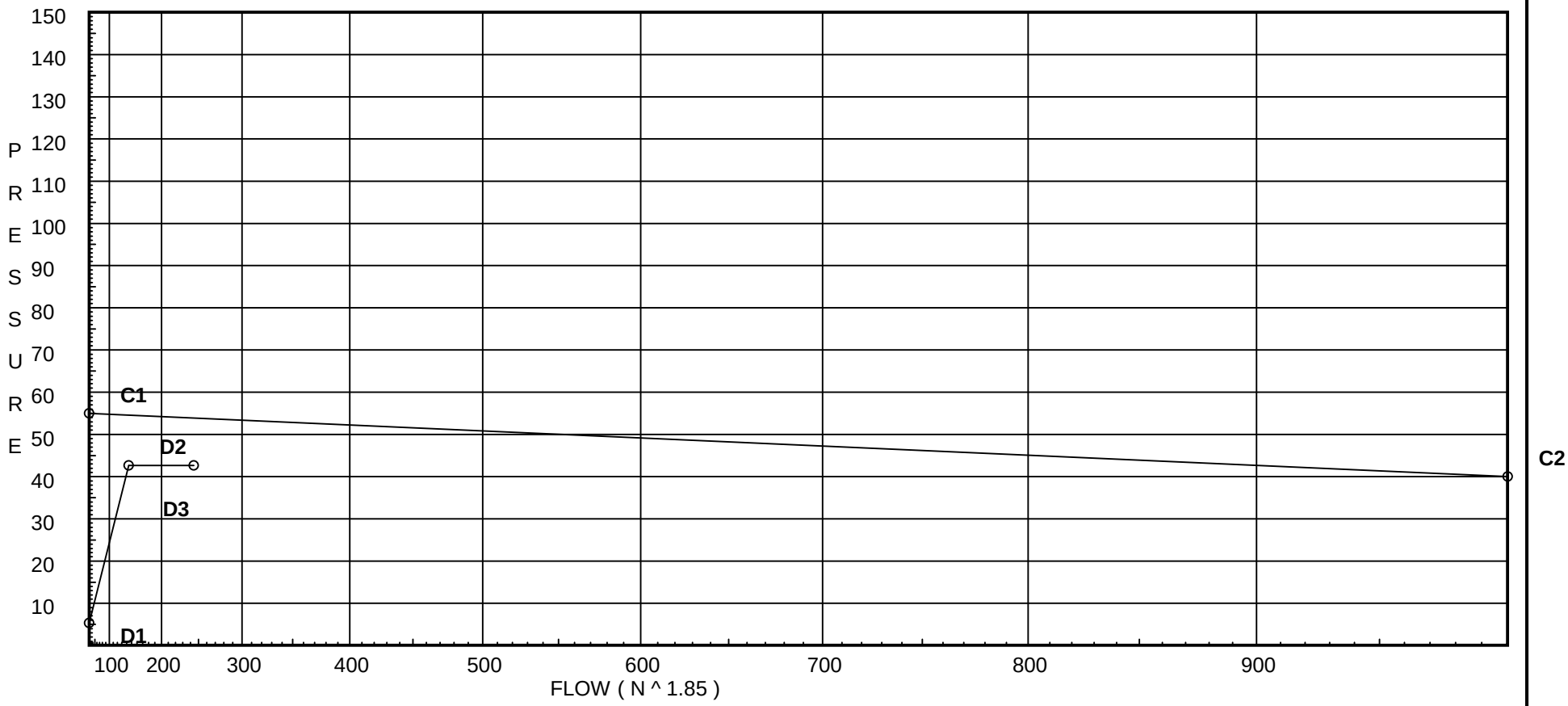
Water Supply Curve C

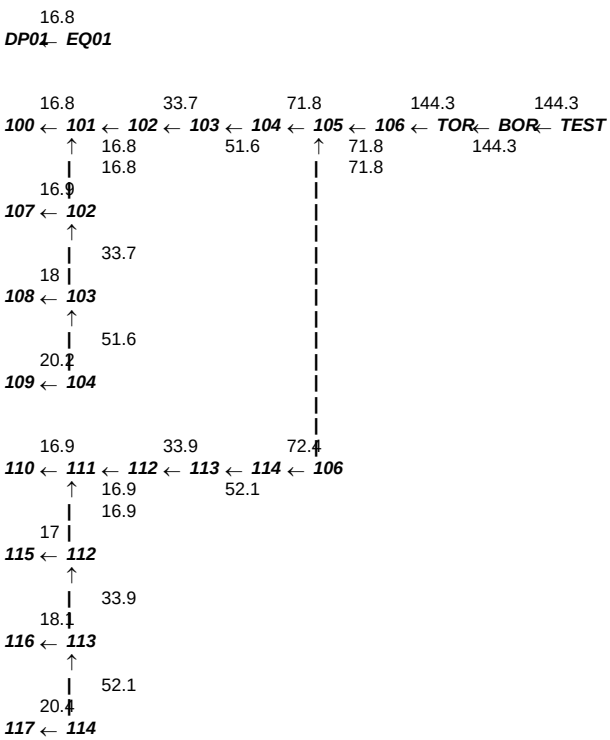
Lacey Fire Protection Eng. LLC
Schedule 40 Simple Arm-over

Date 10/11/2017

City Water Supply:
- C1 - Static Pressure : 55
- C2 - Residual Pressure: 40
- C2 - Residual Flow : 1000

Demand:
- D1 - Elevation : 5.340
- D2 - System Flow : 144.28
- D2 - System Pressure : 42.683
- Hose (Demand) : 100
- D3 - System Demand : 244.28
- Safety Margin : 11.212

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16.8 33.7 71.8 144.3 144.3
100 ← 101 ← 102 ← 103 ← 104 ← 105 ← 106 ← TOR ← BOR ← TEST
16.8 51.6 71.8 144.3
16.8 71.8
16.9
107 ← 102
33.7
18
108 ← 103
51.6
20.2
109 ← 104
16.9 33.9 72.4
110 ← 111 ← 112 ← 113 ← 114 ← 106
16.9 52.1
16.9
17
115 ← 112
33.9
18.1
116 ← 113
52.1
20.4
117 ← 114

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
A	Alarm Rel E1 & E3							7.7	21.5		17		27	29							
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
G	NFPA 13 Gate Valve	0	0	0	0	0	1	1	1	1	2	2	3	4	5	6	7	8	10	11	13
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Units Summary

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

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	10.0	5.6	9.0	na	16.8	0.1	168	7.0
EQ01	12.33		8.4	na				
100	12.33	K = K @ EQ01	8.4	na	16.8			
101	12.0		9.09	na				
102	12.0		9.44	na				
103	12.0		10.69	na				
104	12.0		13.46	na				
105	12.0		15.56	na				
106	12.0		15.82	na				
TOR	12.0		28.77	na				
BOR	-4.0		44.01	na				
TEST	0.0		42.68	na	100.0			
107	12.33	K = K @ EQ01	8.46	na	16.86			
108	12.33	K = K @ EQ01	9.61	na	17.97			
109	12.33	K = K @ EQ01	12.15	na	20.21			
110	12.33	K = K @ EQ01	8.54	na	16.94			
111	12.0		9.25	na				
112	12.0		9.6	na				
113	12.0		10.87	na				
114	12.0		13.69	na				
115	12.33	K = K @ EQ01	8.6	na	17.0			
116	12.33	K = K @ EQ01	9.77	na	18.12			
117	12.33	K = K @ EQ01	12.35	na	20.38			

The maximum velocity is 11.42 and it occurs in the pipe between nodes 114 and 106

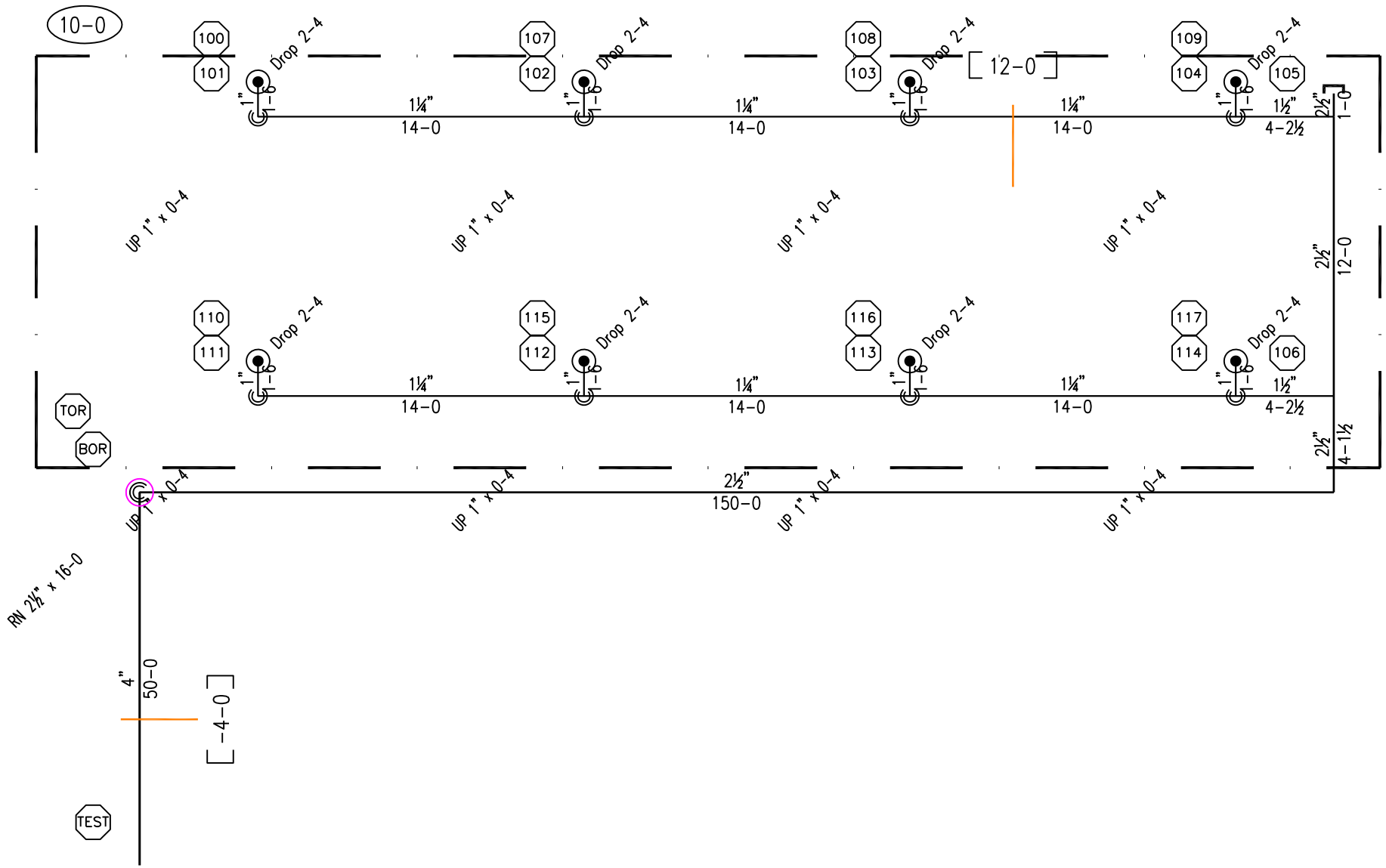
Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
DP01	16.80	1.049	E	2.0	2.330	9.000		K Factor = 5.60
to		120.0		0.0	2.000	-1.009		
EQ01	16.8	0.0942		0.0	4.330	0.408		Vel = 6.24
	0.0							
	16.80					8.399		K Factor = 5.80
100	16.80	1.049	2E	4.0	1.830	8.399		K Factor @ node EQ01
to		120.0		0.0	4.000	0.143		
101	16.8	0.0942		0.0	5.830	0.549		Vel = 6.24
101	0.0	1.38		0.0	14.000	9.091		
to		120.0		0.0	0.0	0.0		
102	16.8	0.0248		0.0	14.000	0.347		Vel = 3.60
102	16.86	1.38		0.0	14.000	9.438		
to		120.0		0.0	0.0	0.0		
103	33.66	0.0897		0.0	14.000	1.256		Vel = 7.22
103	17.97	1.38		0.0	14.000	10.694		
to		120.0		0.0	0.0	0.0		
104	51.63	0.1978		0.0	14.000	2.769		
104	20.20	1.61	T	8.0	4.210	13.463		
to		120.0		0.0	8.000	0.0		
105	71.83	0.1721		0.0	12.210	2.101		Vel = 11.32
105	0.0	2.469		0.0	12.000	15.564		
to		120.0		0.0	0.0	0.0		
106	71.83	0.0214		0.0	12.000	0.257		Vel = 4.81
106	72.45	2.469	2E	12.0	154.140	15.821		
to		120.0		0.0	12.000	0.0		
TOR	144.28	0.0779		0.0	166.140	12.944		
TOR	0.0	2.469	E	6.0	16.000	28.765		
to		120.0	A	7.7	13.700	12.930		
BOR	144.28	0.0779		0.0	29.700	2.314		
BOR	0.0	4.1	T	29.067	50.000	44.009		
to		140.0	G	2.907	31.974	-1.732		
TEST	144.28	0.0050		0.0	81.974	0.406		
	100.00							Qa = 100.00
	244.28					42.683		K Factor = 37.39
107	16.86	1.049	E	2.0	1.830	8.458		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
102	16.86	0.0948		0.0	8.830	0.837		Vel = 6.26
	0.0							
	16.86					9.438		K Factor = 5.49
108	17.97	1.049	E	2.0	1.830	9.608		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
103	17.97	0.1068		0.0	8.830	0.943		Vel = 6.67
	0.0							
	17.97					10.694		K Factor = 5.50
109	20.21	1.049	E	2.0	1.830	12.149		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
104	20.21	0.1326		0.0	8.830	1.171		Vel = 7.50
	0.0							

This elbow and 2.3' drop are added to the arm-over below.

Arm-over values. Using this pressure per foot.
We do not account for the "T" fitting of 5' or the elevation gain as both of these would also apply to the regular sprinkler drop. Thus 4.3' drop + 3.83' armover = 8.13' existing equivalent x 0.0948 = 0.77 psi for existing center of tile drop.

Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
	20.21					13.463		K Factor = 5.51
110	16.94	1.049	2E	4.0	1.830	8.544		K Factor @ node EQ01
to		120.0		0.0	4.000	0.143		
111	16.94	0.0959		0.0	5.830	0.559		Vel = 6.29
111	0.0	1.38		0.0	14.000	9.246		
to		120.0		0.0	0.0	0.0		
112	16.94	0.0251		0.0	14.000	0.352		Vel = 3.63
112	17.01	1.38		0.0	14.000	9.598		
to		120.0		0.0	0.0	0.0		
113	33.95	0.0911		0.0	14.000	1.275		Vel = 7.28
113	18.12	1.38		0.0	14.000	10.873		
to		120.0		0.0	0.0	0.0		
114	52.07	0.2010		0.0	14.000	2.814		Vel = 11.17
114	20.38	1.61	T	8.0	4.210	13.687		
to		120.0		0.0	8.000	0.0		
106	72.45	0.1748		0.0	12.210	2.134		Vel = 11.42
	0.0							
	72.45					15.821		K Factor = 18.21
115	17.00	1.049	E	2.0	1.830	8.604		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
112	17.0	0.0964		0.0	8.830	0.851		Vel = 6.31
	0.0							
	17.00					9.598		K Factor = 5.49
116	18.12	1.049	E	2.0	1.830	9.773		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
113	18.12	0.1084		0.0	8.830	0.957		Vel = 6.73
	0.0							
	18.12					10.873		K Factor = 5.50
117	20.38	1.049	E	2.0	1.830	12.355		K Factor @ node EQ01
to		120.0	T	5.0	7.000	0.143		
114	20.38	0.1347		0.0	8.830	1.189		Vel = 7.57
	0.0							
	20.38					13.687		K Factor = 5.51

SCHEDULE 40 SIMPLE ARM-OVER



SCHEDULE 40 SIMPLE ARM-OVER