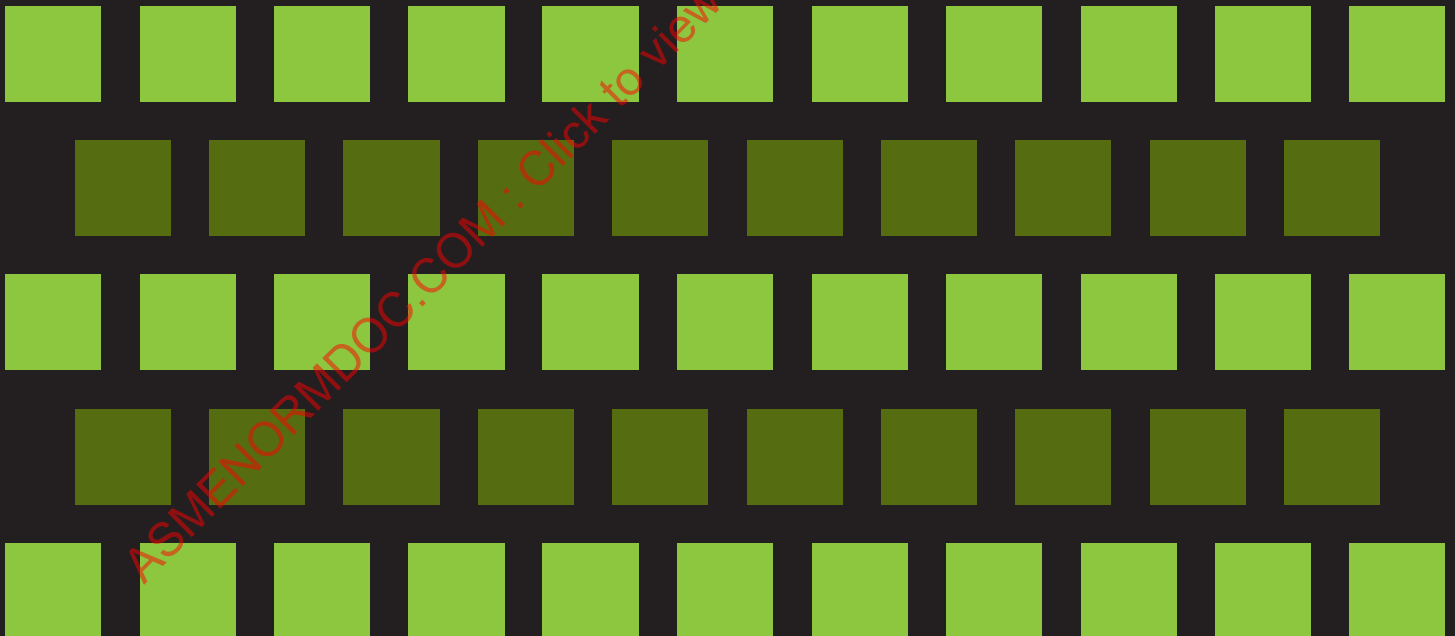


BRANCH LEG STUDY FOR BIOPROCESSING EQUIPMENT



STP-PT-065

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FOREWORD

Industry standards for dead legs in biopharmaceutical processing equipment have been in place for over a decade. A dead leg is defined as an area of entrapment in a vessel or piping run that could lead to contamination of the product (ASME BPE 2012 GR-8). While an L/D (ratio of length leg over diameter of leg) of six may have been the historical maximum acceptable ratio, multiple studies promote designing to an L/D less than two. The drivers for reducing the L/D ratio are cleanability and the fact that today's technology renders the L/D target of two or less achievable.

The prevailing opinion was that optimum cleaning of process piping was achieved with a tangential turbulent flow rate of 5 feet/sec, and that solution passing through a pipe at this velocity would be sufficient to clean-un-place the piping with branches having an L/D less than two.

The purpose of this document is to provide information on the flow conditions required to displace air from piping branches in a timely manner. When air is displaced from the branched fitting, the cleaning solution comes in contact with the branched piping components being cleaned-in-place (CIP'ed) and effective cleaning can occur. Without contact of CIP solutions, there is no cleaning. This document is a study on the flow conditions required to ensure contact of the cleaning solution with the branched fittings – a key requirement for cleaning.

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- Mallory Corbin, Stevens Institute, Applied Chemistry Graduate – *Data Analysis*
- Randy Cotter, Sr., Cotter Brothers Corporation - *Contributor*
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- Deborah Botham, Cotter Brothers Corporation – *Contributing Editor*
- Jay Ankers, M+W U.S., Inc. – *ASME BPE Committee Chair*

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- Polypropylene Test Pieces - Arkema (through George Fisher)
- Hoses - AdvantaPure
- Valves - ITT, Gemu, Crane/Saunders, PBM
- Instruments - Anderson
- Fittings - VNE
- Seals - Parker
- Hangers - Behringer
- Pump - Fristam
- Spool Pieces - Cotter Brothers

1 PURPOSE AND USE

Industry standards for dead legs in biopharmaceutical processing equipment have been in place for over a decade. A dead leg is defined as an area of entrapment in a vessel or piping run that could lead to contamination of the product (ASME BPE 2012 GR-8). While an L/D (ratio of length leg over diameter of leg) of six may have been the historical maximum acceptable ratio, multiple studies promote designing to an L/D of less than two. The drivers for reducing the L/D ratio to less than two, are cleanability and the fact that today's technology renders the L/D target of two or less achievable.

The prevailing opinion was that optimum cleaning of process piping was achieved with a tangential turbulent flow rate of 5 feet/sec, and that solution passing through a pipe at this velocity would be sufficient to clean-in-place the piping with branches having an L/D of less than two.

The purpose of this document is to provide information on the flow conditions required to displace air from piping branches in a timely manner. When air is displaced from the branched fitting, the cleaning solution comes in contact with the branched piping components being cleaned-in-place (CIP'ed) and effective cleaning can occur. Without contact of CIP solutions, there is no cleaning. Note: The actual cleaning of process piping is more complicated than simply supplying an adequate flow rate (it involves many other factors such as the reagent concentration, temperature, contact time, etc.) and cleaning processes are outside of the scope of this document. The focus of this document is on the flow conditions required to ensure contact of the cleaning solution with the branched fittings – a key requirement for cleaning.

The desire to minimize the L/D of branches in piping systems to facilitate cleaning is intuitive. The original $L/D \leq 6$ specification was driven mostly by technology limitations in the pre-1997 (1st edition of the ASME BPE) era. As fabrication methods improved making smaller L/D ratios achievable, the $L/D \leq 2$ became the standard. This requirement for L/D of < 2 created new challenges in equipment, components, and process piping design; however Mr. Randy Cotter Sr. questioned whether the L/D of ≤ 2 target was valid. Until now, there was no scientific basis for the new standard.

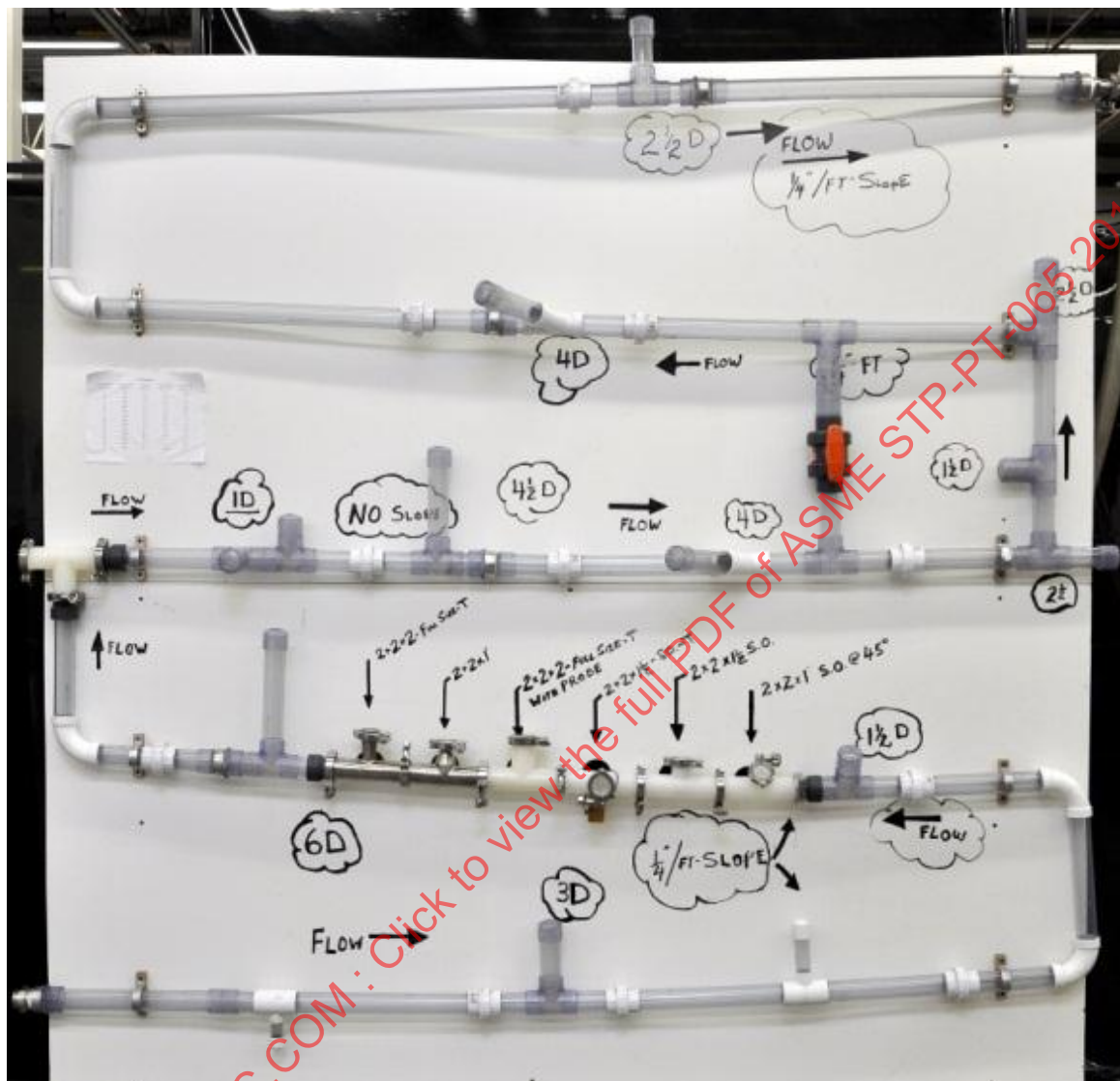
In 2010, Cotter fabricated a serpentine test fixture from 1½ inch Sch. 40 clear PVC tubing with a 1.610 inch ID (see next page for Figure 4-1) to model a typical biopharmaceutical piping system and typical CIP conditions. The test fixture incorporated various branch connections with different L/D ratios ($L/D = 1, 2, 3, 4$, and 6), oriented 90° vertical upward, 45° upward, and 90° vertical downward. Testing was performed with water at ambient temperature with flow rates ranging from 10 to 80 gpm, and back pressure ranging from 5 to 80 psig.

Initial test results indicated that for both the 45° and 90° vertical upward tee installations, regardless of flow or pressure, entrapped air could not be fully expelled from the branches. Further testing performed using red dye indicated that the turbulence created by the tangential flow of water across a downward oriented branch (L/D ratio of > 4) was insufficient to evacuate the red solution in a timely manner. The tests were performed at a variety of flow rates.

Cotter also had a series of discussions with collaborators who had developed CFD models. The CRD models had not included the presence of air in their evaluation.

Cotter Brothers Corporation presented their data complete with videos of the tests to the ASME BPE Committee. The Committee decided that further research was required. The ASME BPE commissioned a study that was executed in 2011-2012. This report provides the data from the study and includes conclusions and recommendations.

Figure 1-1: Cotter's Test Fixture Used in the Pre-Study



2 INTRODUCTION

BioProcess equipment is primarily used for the manufacture of products which are either generated by a biological process or contain biochemicals, e.g. biopharmaceuticals. Bioprocess equipment and systems typically house aqueous-based processes that are prone to bioburden. These systems are designed to be cleaned, sanitized and or sterilized to mitigate the risk of contamination from the environment and/or from carryover/crossover contamination as a result of inadequate removal of soils post-processing. The ASME BPE Standard provides requirements for systems and components that are subjected to cleaning and sanitization and/or sterilization. This includes systems that are cleaned in place (CIP) and/or steamed in place (SIP) and/or other suitable processes.

Effective removal of air during CIP and SIP operations is critical for effective cleaning and sanitization. Removal of air is difficult requiring:

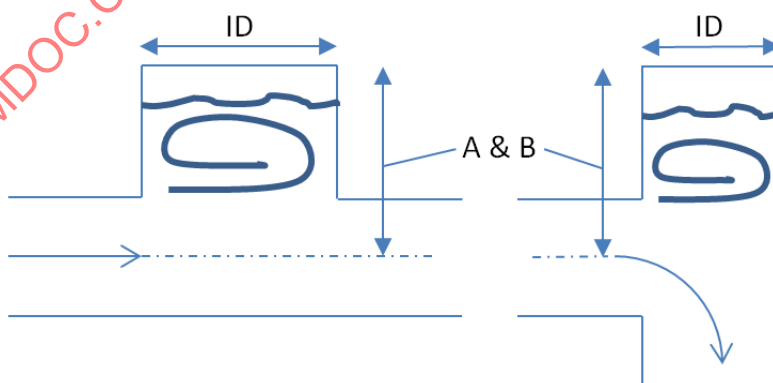
- Detailed piping design to many of the ASME BPE Standards requirements
- Effective process conditions (i.e. flow rates, pressures, temperatures)
- Proper sequence of operations (e.g. valve sequencing, venting, draining)

2.1 Dead Leg

Branch tee connections that are capped and/or closed off are routinely referred to as dead legs. The ASME BPE Standard defines a dead leg as “an area of entrapment in a vessel or piping run that could lead to contamination of product.”

Dead legs are no-flow or limited-flow process fluid regions usually formed at process tubing branch connections (typically at 90° to tangential flow). Typical examples include instruments or components that are attached using tee style fittings such as to provide an insertion location into the process flow path. Examples are analytical probes, rupture disks, diaphragm pressure gauges, thermowells, etc. The geometry of some of these branches may be slightly different than a flat-capped end due to the shape of the component or configuration. Tee fitting sizes most widely used in biotechnology processes and clean-in-place piping systems are ½, ¾, 1, 1½, and 2 inch. Both straight-through and right-angle tee configurations are used in piping systems. Both are examined in this study.

Figure 2-1: Principle Sketch of Branches



Left side: An upward pointing branch on a horizontal line.
Right side: An upward pointing branch in an elbow.

A branch is defined in the 2012 ASME BPE Standard (Tables SD-1, SD-2) as the process length, L, measured from the inside diameter of the main run line to the closure device on the branch (a flat cap or a valve weir). The ratio of this L dimension to the inside diameter, ID, of the branch is referred to as the L/D. The ASME BPE Standard recommends a target L/D ratio not exceed 2:1. It should be noted that early industry practice was to measure the L dimension from the centerline of the main flow line, not the inside diameter. Some countries still use this centerline dimension when discussing dead legs; it is therefore important to define term when presenting and comparing testing information.

The “L” dimension is not readily obtainable from vendor literature as they have long provided fitting dimensions from the centerline to the edge. (Vendors and the BPE Standard refer to this centerline dimension with the letter designation A or B.) Both piping designers and detailers need these centerline dimensions to accurately develop design drawings and models.

The ASME BPE Standard has established a “benchmark” set of these centerline-based dimensions (see Part DT) for stainless steel tube and fittings to permit designers and detailers to have uniform dimensions available regardless of individual manufacturers. The “L” is a process dimension, calculated as:

$$L = (A \& B) - \frac{1}{2} ID$$

2.2 Standard and Short Outlet Tee

The introduction of short outlet (SO) tee fittings where the A and B dimensions are significantly reduced (thus reducing the process dimension L), has greatly enhanced the ability of piping designers and detailers to achieve the target L/D of < 2:1. Not all short outlet branched fittings yield an L/D ratio less than the recommended two value when used as is. The addition of a standard valve versus a cap would increase the L and resultant L/D ratio. This study will examine both the L/D ratio obtained from using a standard short outlet tee fitting and a fixed L/D ratio equal to two. (See Figure 5-3 in Section 5).

3 LITERATURE REVIEW

Most of the prior articles covered the mixing within dead legs, with a focus on achieving effective cleaning in the branch leg. No reference was found which focused on the removal of air, and only a few references even mentioned it.

Gaerke's study [3] on the flow rate required to displace the air/flood sections of straight piping (without branched fittings) of different diameters of transparent schedule 40/80 PVC piping fabricated with socket joints in a variety of installation configurations (horizontal, sloped, and vertical) with different outlet configurations (open on the end and liquid sealed) indicated the following:

- The piping configuration that required the highest flow rate to displace the air was a vertical pipe with the flow directed downward that was open on the end.
- The addition of backpressure had no impact on the flow rate required to displace the air from the piping systems evaluated.

Although it was not the primary focus of the study, Gaerke looked briefly at transparent PVC branched tees fabricated with socket joints and determined that liquid velocities as high as 7 feet/sec were insufficient to displace air from a 2 inch branched tee directed upward to an L/D ratio of 2.

Young's study [4] discusses air removal in the effective SIP of a system. Air is heavier than steam at routine SIP conditions. The primary issue is to displace the air with the steam. They concluded:

- L/D values do not provide a general guideline which can be used to predict sterilization. Tubes with similar L/Ds, but different diameters, showed sterilization times varying up to 250%
- SIP of dead legs with saturated steam is dependent on tube diameter, length and orientation with respect to the gravitational vector
- Saturated steam sterilization did not occur at any location above the initial steam-air interface

Young stresses that the proper sizing of the tube diameter had the greatest effect on sterilization as it increased the ratio of buoyant forces to viscous dissipation forces. They effectively showed how a small tube of 40mm ID and 88mm long, L/D of 22, exhibited little buoyant driven convective flows, and the minimal air displacement observed was due primarily to diffusion.

These buoyant forces are in reverse in CIP where the process liquid is heavier than the air. Even with proper tube diameter the air requires more than gravity to remove it from a branch sloped above the horizontal centerline.

Grasshoff [5][6] verified that flows into the dead leg, rather than away from the dead leg, provided better mixing in the dead leg, but their work did not mention the removal of air.

They showed that if the L/D is large enough, a secondary recirculation zone is formed at the end of the dead leg reducing exchange of mass (liquid or air) from the dead leg to the main pipe. They also showed that the net velocities in the primary recirculation zone were as low as one-eighth of the bulk velocity. These results were confirmed in Jensen's Computational Fluid Dynamic (CFD) and experimentation. Seven Helium (He) experimented with a flow diverter to improve cleaning.

Sassanami [8] noted that the soil removal rate would be much lower in the dead space area than the pipe because the fluid mechanics involved in this area are significantly different, reducing the ability to clean this area. This study showed that for a dead space with an L/D value of 1, there was a significant advantage to operating at Reynolds numbers above 70,000 since this caused a significant increase in cleaning. For dead zones with an L/D of 4, the cleaning rate becomes independent of the Reynolds number.

4 EXPERIMENT

Experiments for estimating the removal of air were conducted using a translucent test spool system by recirculating liquid in the system. Removal of air was recorded on video to estimate the time for removal with various configurations. A series of experiments were conducted over a wide range of flow rates, different geometrical configurations, two different temperatures, and different back pressures. A grade system was developed for quantification of air removal. The following sections provide detail on the experimental set-up and data analysis, ending with the configurations investigated.

4.1 System Description

The system (Figure 4-1) consisted of a manually operated liquid reservoir tank, pump, recirculation piping, instrumentation, and hand valves. The system was reconfigured as needed to allow for different arrangements. Most of the system piping was comprised of two inch stainless steel and silicone hose. Experiments for estimating the removal of air were done in translucent natural polypropylene (PP-R) test spool pieces while recirculating liquid in the system. The major system components are:

- Centrifugal Pump, maximum 155 gpm, (flow energy)
- Turbine Flow Meters, two, ranges 1.75-150 gpm, (flow rate)
- Digital Temperature Gauge, 0-100 °C, (fluid temperature)
- Analog Pressure Gauges, two, 0-100 psig, (inlet/outlet pressure)
- Digital Pressure Gauge, 0-100 psig, (outlet pressure)
- 2 inch Diaphragm Valves, three, (feed control, bypass control, backpressure control)
- 2 inch Ball Valves, three, (feed on/off, bypass on/off, feed outlet on/off)
- ½ inch Ball Valves, two (air bleed valve, pump drain valve)
- 1 inch Ball Valve (spool drain valve)
- 250 gallon Tank, natural polypropylene (system sump)
- 500 liter Tank, stainless steel (system sump)
- Heat Exchanger (heat energy)
- Pipe Fittings, stainless steel and polypropylene
- Piping, stainless steel, mostly 2 inch
- Hoses, 2 inch, stainless steel end crimped silicone

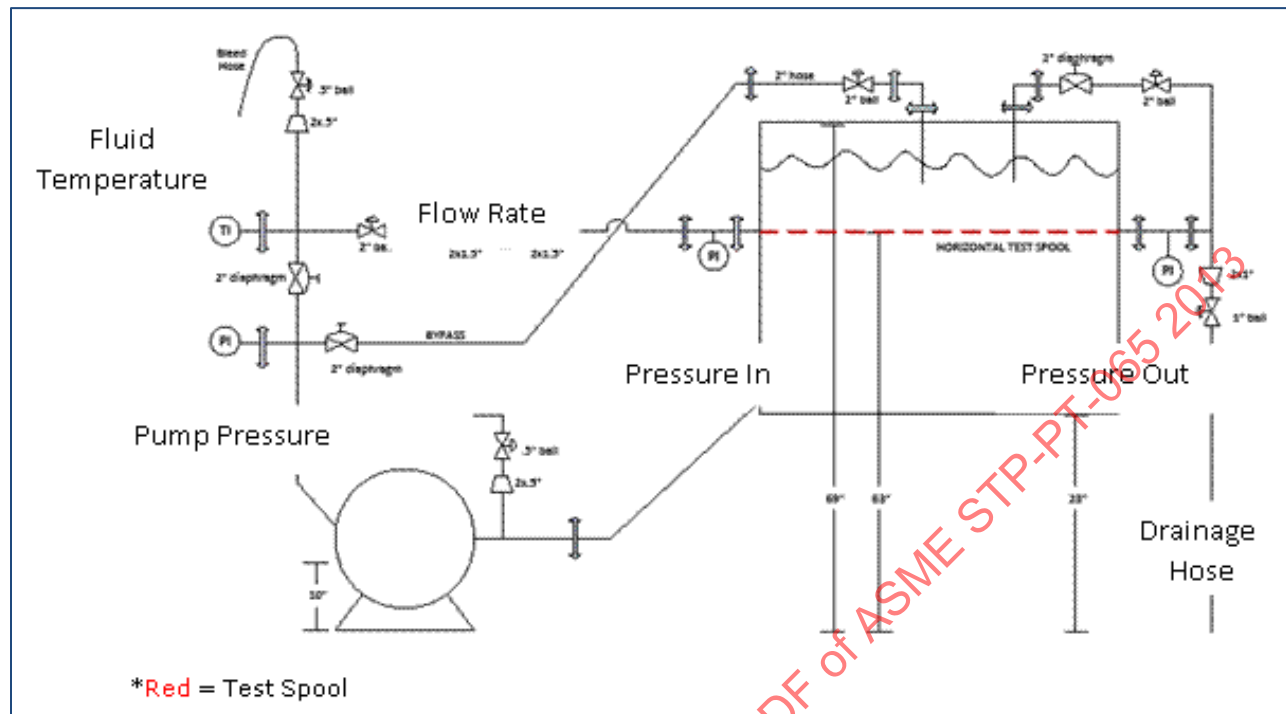
The central system consists of a 250 gallon feed tank that serves as the liquid reservoir, in which gravity feeds the centrifugal pump. The pump drives the water at the desired flow rate and is adjusted by varying the opening of the diaphragm valve at the beginning of the feed line. Opening this valve allows a higher flow rate through the line, while closing it decreases the flow rate through the line. The bypass diaphragm valve allows the operator to divert some amount of flow from the main line so as to more easily find the correct flow rate through the main line.

The water next moves in ascending order through:

- the pump pressure gauge
- the fluid temperature gauge
- the flow meter
- the inlet pressure gauge
- the test spool
- outgoing pressure gauge

It is then directed back into the tank, using flexible hosing, to be recirculated.

Figure 4-1: Test Schematic for Horizontal Runs



Note: The rest spool is the milk white section in the top part of the picture. Schematic for the other configurations can be seen in Appendix A.



The remaining valves are used to prepare the system for tests, e.g. drain the system. An air bleed ball valve, which can be opened to allow air into the system and out of the test spool, is located above the feed control diaphragm valve. A back pressure diaphragm valve is located on the return line just before the

water re-enters the feed tank. Closing this valve will increase the pressure on the line to test effects of increasing back pressure on the test spools. A heat exchanger is added to the return line and the tank is changed to the smaller stainless steel tank during runs which require heating.

4.2 Testing Procedure

1. Start up the pump in order to run water through the pipeline.
2. Adjust the flow rate using the diaphragm valve until the desired BPI Visual Air Grade is reached. A low flow rate is suggested to begin, so that immediate flooding of the branch leg does not occur.
3. Once the desired visual air grade is reached
 - (a) Photograph the result.
 - (b) Record the flow rate, pump pressure, water temperature, incoming pressure, outgoing pressure, and visual air grade.
 - (c) Close the test spool using the two ball valves on either side.
 - (d) Photograph the still spool.
 - (e) Remove the cap from the branch leg, and pour water into it from a graduated cylinder.
 - (f) Record the volume of water needed to fill the branch leg, as that is the volume of air that was left in the branch leg.
4. Drain and repeat two subsequent times for this amount of air, and then repeat the procedure for each individual visual air grade (from 0-5 – see Section 5.6).

This experiment will also be repeated for a test spool with its branch leg rotated from the vertical position to an angle of 45°, (from 1-4). This, however, does require one to rotate the test spool back into the vertical position once the photos have been taken. This allows the experimenter to safely measure the amount of air using the above method with a graduated cylinder without losing water and contaminating the results.

4.3 Experimental Technique

For each configuration, four different tests were performed to collect data. Each test was repeated three times to ensure redundancy of results. These four tests are as follows:

4.3.1 Flow Rate Increase (FRI) Test

Increase flow incrementally (minimal back pressure). This test is a quick screening to assess the high level performance characteristics of the configuration.

- Record temperature, flow rate, air quality, and pressures at each flow increment
- Take photos of branch leg at each flow increment
- Determine what flow rates to run Flow Rate Maintain tests

4.3.2 Flow Rate Maintain (FRM) Test

Maintain a certain flow rate over time (minimal back pressure). This test simulates most process conditions, including CIP.

- Record temperature, flow rate, air quality, and pressures at regular time increments
- Record video (whether real time or 2 second snapshots) of branch leg at regular time increments
- Determine flow rate needed to clear branch leg at 1 min and 5 minutes

Anything over 5 minutes is considered unacceptable.

4.3.3 Pressure Increase (PI) Test

Increase pressure incrementally while maintaining a certain flow rate. This test is a quick screening test to assess if increasing the pressure will assist in air elimination.

- Record temperature, flow rate, air quality, and pressures at each pressure increment, and with pump shut off

- Take photos of the branch leg at each pressure increment, and when pump is shut off
- Determine what pressures and flow rates to run Pressure Maintain tests

4.3.4 Pressure Maintain (PM) Test

Maintain a certain pressure and flow rate over time. This test simulates some process conditions where pressure is maintained.

- Record temperature, flow rate, air quality, and pressures at regular time increments
- Record video (whether real time or 2 second snapshots) of branch leg at regular time increments
- Determine flow rate needed to clear branch leg at 1 min and 5 minutes.

Anything over 5 minutes is considered unacceptable.

4.4 Explanation of Rotation/Slope

A digital level that measured in tenths of degrees was used for the different slopes and rotations. For the slopes, it was calculated that 1/8 by 12 inches is about 0.6 degrees; that set point was employed to find the correct slopes. For the rotations, the level was placed on the dead leg until the correct rotation in degrees for that orientation was achieved.

4.5 Data Collected

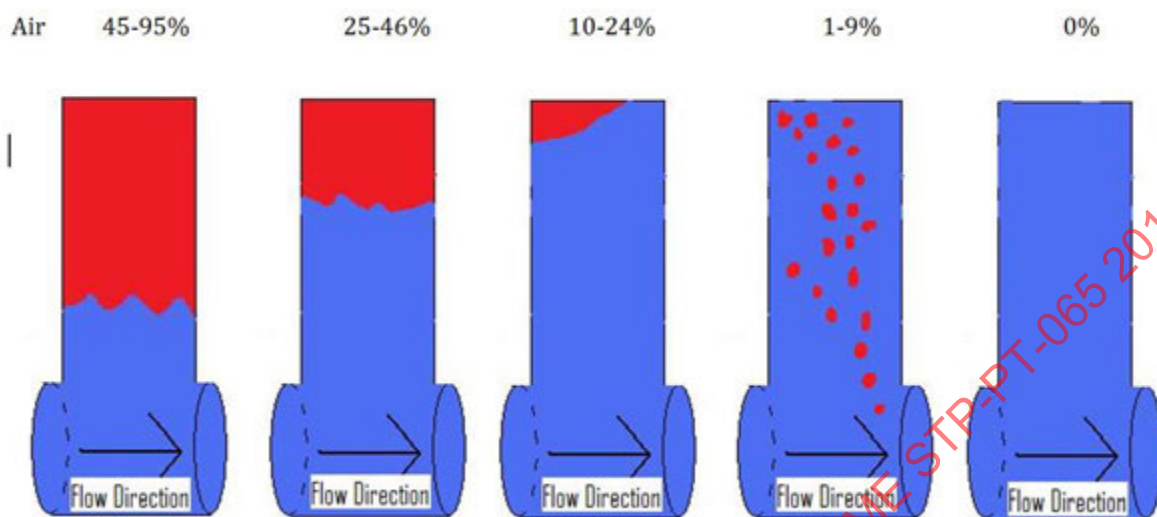
Visual observations, such as the amount of air left in the branch leg, were recorded with the test spools. Flow rate, temperature, time, and pressure data were all recorded where applicable.

4.6 Evaluation Method

A qualitative scale to judge the amount of air still trapped in the branch leg was used to assess the level of air elimination in the system. This scale ranged from 0 to 5, making it possible to record how much air was still left in the dead leg for different configurations (see Figure 4-2).

0. No water in the branch
1. Less than $\frac{1}{2}$ full of water (more than $\frac{1}{2}$ full of air)
2. $\frac{1}{2}$ to $\frac{3}{4}$ full of water ($\frac{1}{4}$ to $\frac{1}{2}$ full of air)
3. $\frac{3}{4}$ to completely full of water (clear to $\frac{1}{4}$ full of air), there is always a standing bubble of air
4. Completely full of water; many bubbles remain throughout the branch leg (nearly clear of air)
5. Completely full of water (clear of air)

Figure 4-2: Example Images of a Visual Air Grade



From left to right, the Air Grade is 1,2,3,4 and 5 respectively

Figure 4-3: Example Image of Air Grade 1



Left: No rotation with the pump off and the spool closed. Right: No rotation with the pump running and the spool open.

By performing this experiment, a quantitative standard has been introduced in which the amount of air can be measured in a branch leg. This is important to the BioProcess Equipment (BPE) community, as a standard will help when determining how quickly a leg reaches a 4 or 5 when cleaning the equipment.

Figure 4-4: Evaluation Scheme for Including Time for Clearing Air into the Evaluation of Data-Developed During the Project

Time to Clear	All Air Removed (5)	All Surfaces Wetted Some Bubbles Present (4)
<1 minute	Preferred	Acceptable
5 minutes	Acceptable	Borderline
> 5 minutes	Unacceptable	Unacceptable

Removal of air is not only flow rate dependent, but time dependent as well. Therefore, an additional scale for simultaneous evaluation of time and flow rate was proposed (see Figure 4-4).

5 THE FITTING TEST SPECIMEN

In order to conduct an experiment and analysis of a fluid's performance in a dead leg, it was necessary to view the internals of the tubing system. In the industry, the majority of the tubing is made of stainless steel with dimensions per the ASME BPE standard (see Table DT-4-1 on page 87 of the BPE 2012) with a smooth surface roughness of Ra 25µin or smoother.

As the evaluation basis for this study was visual, a transparent/translucent material with a surface roughness similar to that of stainless steel pipes was required to simulate standard conditions. Natural Polypropylene (PP-R) was selected as the material to replicate the BPE Standard's stainless steel fittings because of its optical characteristics, heat tolerance, smooth interior surface and existing industry use (see Appendix B for PP-R material data). Suitable material was available from the Georg Fischer Company (PROGEF Natural) in piping sizes 20 mm < OD < 90 mm (16.2 mm < ID < 79.8 mm). The roughness of this material is Ra 63 µin.

Since there is not a direct correlation between pipe and tube dimensions, the PP-R pipe's inside diameters were reviewed and a pipe size was selected to match up with the equivalent ASME BPE tube size (see Figure 5-1). The inside dimensions matched within 15%.

Figure 5-1: Justification of the Designation Given to the Polypropylene (PP-R) and PVC Piping

	Nominal size – original. Outside Diameter [mm]	Inner Diameter Average measured [inch]	Inner Diameter nearest ASME BPE pipe [inch]	Nominal Size - ASME BPE pipe [inch]	Designation in Report [inch]
Polypropylene pipe	20	0.61	0.62	0.75	pp - 0.75
	25	0.78	0.87	1	pp - 1
	40	1.25	1.37	1.5	pp - 1.5
	50	1.56	1.87	2	pp - 2
PVC	Sch. 40 SW	1.57	1.87	2	pvc - 2
Stainless steel	2"	1.86	1.87	2	ss - 2

Note: Actual measured data in inch and mm can be found in Appendix C.

There was no match for the ASME BPE ½ inch tube in the available piping sizes, so it was not fabricated in PP-R for testing.

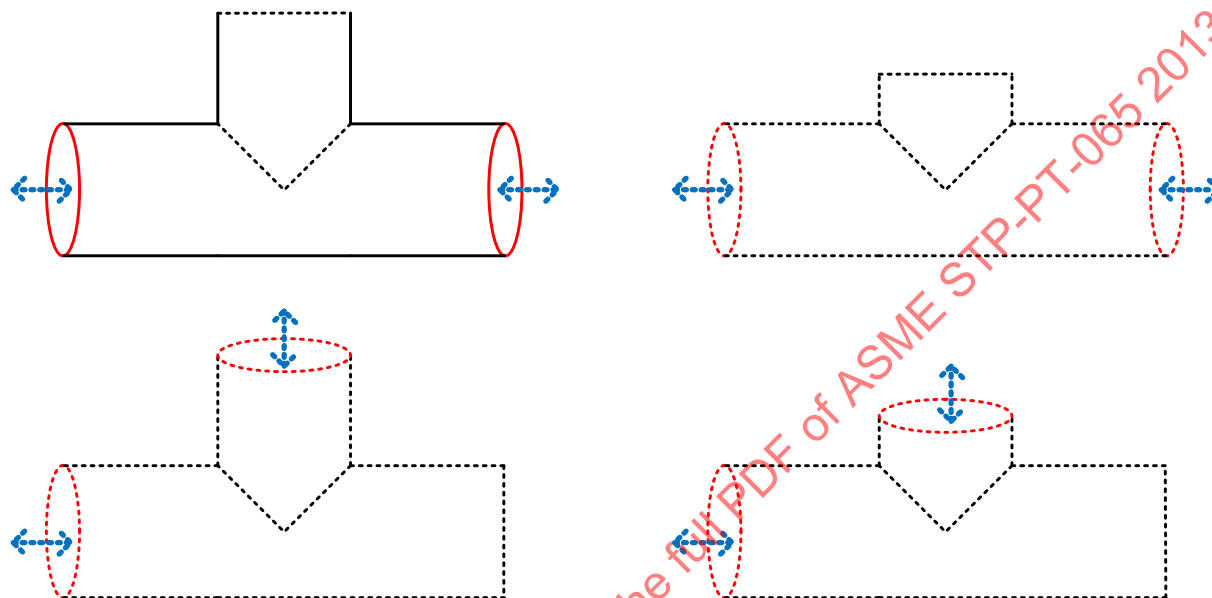
The PVC system was used in the pre-experiment done by Cotter and was a correlation/comparison to the current 2 inch stainless steel test skid. The PVC was transparent, which provided a clearer view of the internals, but it contained socket welds, which were not representative of typical flush welded stainless steel systems. In the new test skid, stainless steel fittings with clear end caps were used to provide visibility of the branch interior.

Five feet per second (5 fps) represents the typical average velocity used in CIP operations. This velocity is well into the turbulent regime (see Appendix D for Reynolds number at different flow rates and velocity at different GPM for the four sizes of pipes used in these experiments). All sizes but the smallest (pp-0.75") are in the fully developed range, meaning that flow patterns are unaffected by flow rate. For

pp-0.75" the flow is just below the $Re = 40,000$ normally considered as the limit where flow patterns become independent of flow rate.

For each nominal pipe size, four different test configurations were assembled (a total of 16 test pieces): one set with a long branch and one set with a short branch, both sets with either straight through flow path (straight) or 90° flow path (elbow) (see Figure 5-2).

Figure 5-2: Principle Sketches of Manufactured Test Pieces



Top row: Straight flow path (Straight). Bottom row: 90° flow path (Elbow)

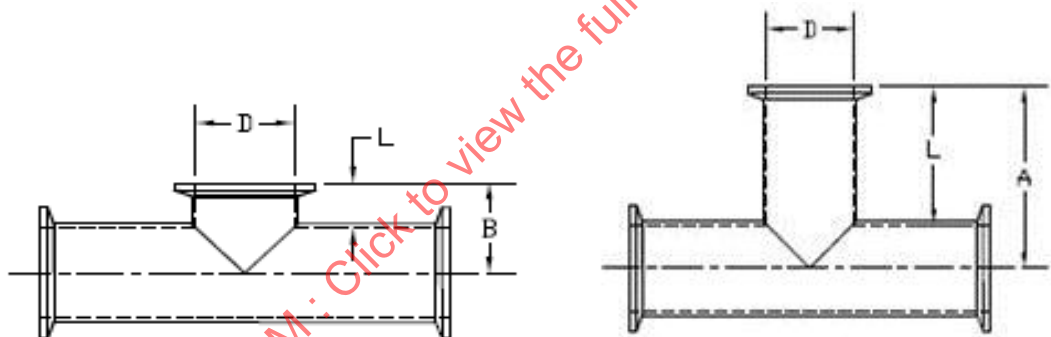
Fabrication of a hygienic-clamped end on the branches was not possible by the piping manufacturer due to tooling tolerances, so fixed end caps were used.

Figure 5-2 shows only the geometry around the branch. A minimum length of 3 straight feet of piping was provided to the supply side of a branch to mitigate the possible effect of flow path perturbations. A minimum of 1 foot was also provided after the study branch. Straight fittings had one foot after the branch (Figure 5-5), and 90° degree fittings had 3 feet after the branch (Figure 5-6) to allow for reverse flow mounting.

The PP-R piping test specimen's inside dimensions (see Figure 5-1) were used to back calculate the required L dimension of the branch to yield the same branch leg L/D ratios as the equivalent tubing size for both a 2:1 (L/D) branch leg and the short outlet (SO) branch leg from BPE Table DT-4.1.2.4 and DT-4.1.2.2. Figure 5-3 shows the L/D's based on the measured dimensions of the final pieces.

Figure 5-3: T- designation, the True L/D and for Reference the L/D Achieved by the Dimension of ASME BPE Tees

	T-designation	Inner Diameter (D) [inch]	Distance from center line to top of dead-end (A) [inch]	Depth of dead-end (L = A-D/2) [inch]	L/D of Test samples	ASME BPE L/D for nominal sizes
pp - 0.75"	L/D = 2	0.61	1.598	1.293	2.12	3.33
pp - 1"	L/D = 2	0.78	2.011	1.621	2.08	2.23
pp - 1.5"	L/D = 2	1.25	3.213	2.588	2.07	1.23
pp - 2"	L/D = 2	1.56	4.012	3.232	2.07	0.77
pp - 0.75"	SO - L/D = 1.8	0.61	1.157	0.852	1.40	1.31
pp - 1"	SO - L/D = 1.5	0.78	1.043	0.653	0.84	0.79
pp - 1.5"	SO - L/D = 0.7	1.25	1.291	0.666	0.53	0.50
pp - 2"	SO - L/D = 0.4	1.56	1.394	0.614	0.39	0.37

Figure 5-4: BPE Hygienic Clamp Joint: Short Outlet Tee (BPE 2012 Table DT-4.1.2-5) and Straight Tee (Table DT-4.1.2-4 BPE 2012)

5.1 Variables Evaluated

During the experimentation phase, the influence of different parameters on the removal of air from the branch was investigated. The choice of variables was based on literature review and prior experience with the test setup (pre-experiments by Cotter and pre-experiments by the group). The following variables were evaluated:

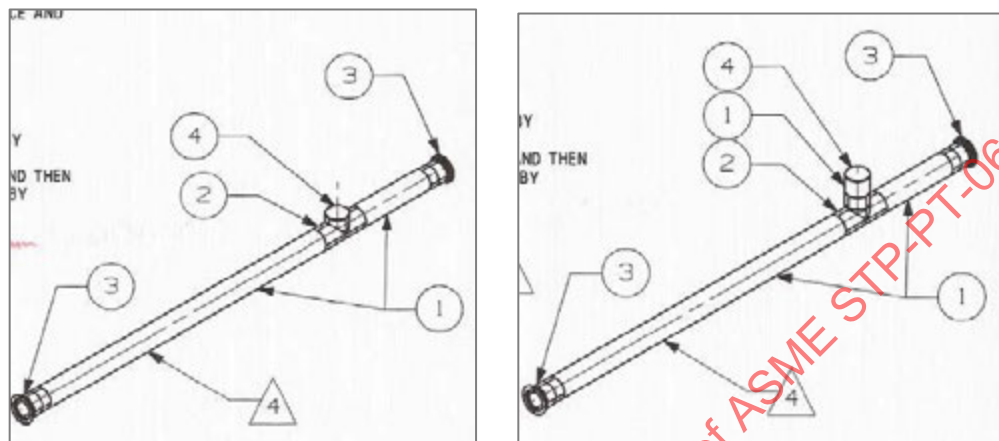
- Pipe style
- Flow direction
- Branch orientation
- Pipe slope
- Back pressure
- Temperature

5.1.1 Pipe Style

Six different types of pipe were tested as follows (see Figure 4-1 for sketches of branch section).

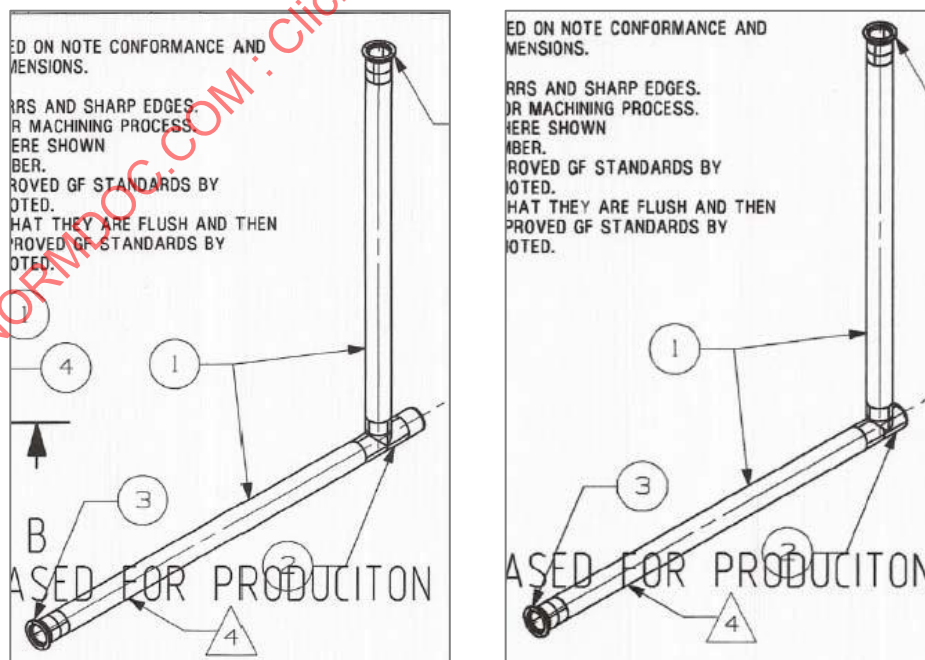
1. Polypropylene (PP-R) Straight Tee (L/D of 2) – *PP-straight-2:1*
 - Defined as a 4 foot long straight tube with a branch whose length is twice the diameter of the tube. The branch's centerline is 1 foot from one end of the tube.
2. Polypropylene (PP-R) Straight Tee (SO) – *PP-straight-SO*
 - Defined the same as above, with a short outlet branch as opposed to an L/D of 2.

Figure 5-5: PP-2 Inch Straight Geometry L/D = Short (left) and L/D = 2 (right)



3. Polypropylene (PP-R) Elbow Tube (L/D of 2) - *PP-Elbow-2:1*
 - Defined as two 3-foot long straight tubes attached at a 90 degree angle at their ends, with a branch whose length is twice the diameter of the tube. The branch is off the connection, with it being parallel to one tube and perpendicular to the other.
4. Polypropylene (PP-R) Elbow Tube (SO) - *PP-Elbow-SO*
 - Defined the same as above, with a short outlet branch as opposed to an L/D of 2.

Figure 5-6: PP-2 Inch Elbow Geometry L/D = 2 (left) and L/D = Short (right)



5. PVC Straight Tee

- Defined as a 9 inch pipe and a 34 inch pipe attached at opposite ends to a tee, with a branch capped at a length that is twice its pipe diameter.

6. Stainless Steel Straight Tee

- Defined as a 24 inch pipe and 16 inch pipe attached to a standard tee at opposite ends, with its other branch capped with a clear end cap.

The majority of the experiments were performed in the PP-R pipes. The PVC and stainless pieces were used mainly for verification purposes.

5.1.2 Flow Direction

Eleven different flow directions were tested: Three for the tees on the straight lengths, and eight for the elbow (see Appendix E for sketches of geometry and flow direction- *underlined words in the appendix are the terms used in the Excel data sheet for raw data and those used to reference the combination in the results section of the report*):

Straight through flow:

- Main pipe horizontal
- Main pipe vertical
 - Bottom-to-top
 - Top-to-bottom

Elbow flow:

- Pipes are horizontal (on the floor)
 - Parallel
 - Perpendicular
- Pipes are vertical (on the wall)
 - Flow up to horizontal – branch up
 - Flow up to horizontal – branch horizontal
 - Flow horizontal to up – branch horizontal
 - Flow horizontal to down – branch up
 - Flow horizontal to down – branch horizontal
 - Flow down to horizontal – branch horizontal

5.1.3 Pipe Slope

The straight tee was evaluated in the horizontal direction with slopes of 0° , $+0.6^\circ$ ($+1/8$ inch per foot), and -0.6° ($-1/8$ inch per foot). The horizontal runs of the elbow tubes also were configured with slope of tangential pipe.

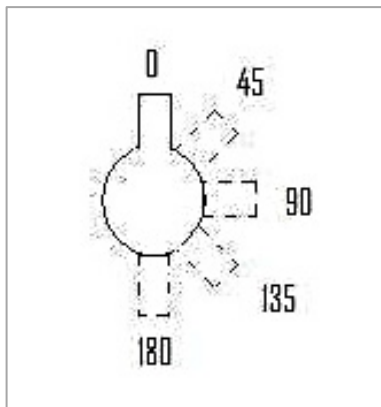
Slope description: For every 12 inches that the pipe is long, one end of the pipe will be $1/8$ inch higher than the other. For example, the four feet long pipe will rise $1/2$ inch from one end to the other.

(See Appendix E for sketches of geometry and flow direction - *Underlined words in the appendix are those terms used in the Excel data sheet for raw data and that are used to reference the combination in the results section of the report.*)

5.1.4 Branch Rotation

The straight tee was evaluated in the horizontal direction with branch rotations of 0, 45, 90, 135, and 180 degrees from the vertical.

Figure 5-7: Branch Rotation Designation



5.1.5 Back Pressure

The impact of back pressure on the filling of the branch leg was evaluated. Testing was performed with negligible back pressure up to 60 psig back pressure, and only on 2 inch and $\frac{3}{4}$ inch horizontal lines.

5.1.6 Temperature

First tests were performed at ambient temperatures. Subsequent tests were performed at 65°C to mimic typical CIP conditions. The 65°C tests were performed only on 2 inch and $\frac{3}{4}$ inch lines.

Test Plan

- (a) 2 inch piping, all configurations, ambient temperature
- (b) Horizontal comparison with standard stainless steel tee, ambient temperature
- (c) Horizontal comparison with Cotter Brothers tee, ambient temperature
- (d) $\frac{3}{4}$ inch piping, most configurations, ambient temperature
- (e) 1 and 1 1/2 inch piping, some configurations (chosen from experience with 2 and $\frac{3}{4}$ inch lines), ambient temperature
- (f) 2 inch and $\frac{3}{4}$ inch piping, some configurations, 65 °C
- (g) Standard stainless steel tees with clear end caps, 65 °C

6 RESULTS AND DISCUSSION

This section contains a case by case discussion of the results presented earlier. An overall discussion of all the results is provided in the next chapter on recommendations for the industry.

6.1 Variables Evaluated

During this testing the following variables were evaluated (See Section 5 for further details):

- Pipe diameter (3/4" – 2" nominal)
- Tee rotation angle – reference 0° = vertical (0°, 45°, 90°, 135°, 180°)
- L/D ratio (L/D = 2 and L/D = equivalent to that of ASME-BPE short outlet tee for that size)
- Temperature (only evaluated for 2" and 3/4" size)
- Back pressure (only evaluated under 2" and 3/4" horizontal conditions)

During each study, the flow rate required to achieve the desired air removal state (e.g., air removal ranking of 2, 3, 4 and 5) within the allotted time duration was recorded. The corresponding velocities and Reynolds numbers were calculated for the flow rates. All were plotted versus pipe diameter for the following:

- Preferred – Complete air removal from the branch within one minute. 2D only.
- Acceptable – Complete air removal from the branch within 5 minutes. 2D and SO.
- Borderline – Completely wetted within 5 minutes. Some moving air bubbles remained in the branch. 2D only.

6.2 Impact of L/D Ratio on Flow Rate Required to Achieve Air Removal State

With the larger diameters, as the L/D ratio is decreased, the flow rate required to achieve a given air removal state for a given pipe configuration also decreased. The smaller diameters' similar flow rates were required to remove the air from the branch.

6.2.1 Impact of Rotation Angle on Flow Rate Required to Achieve Air Removal State

As one would expect, it is easiest to displace the air from a tee installed in a horizontal line when it is rotated so that the branched portion is directed straight downward (180° rotation angle) and it becomes more and more difficult to displace the air as the branched portion is directed straight upward (0° rotation angle).

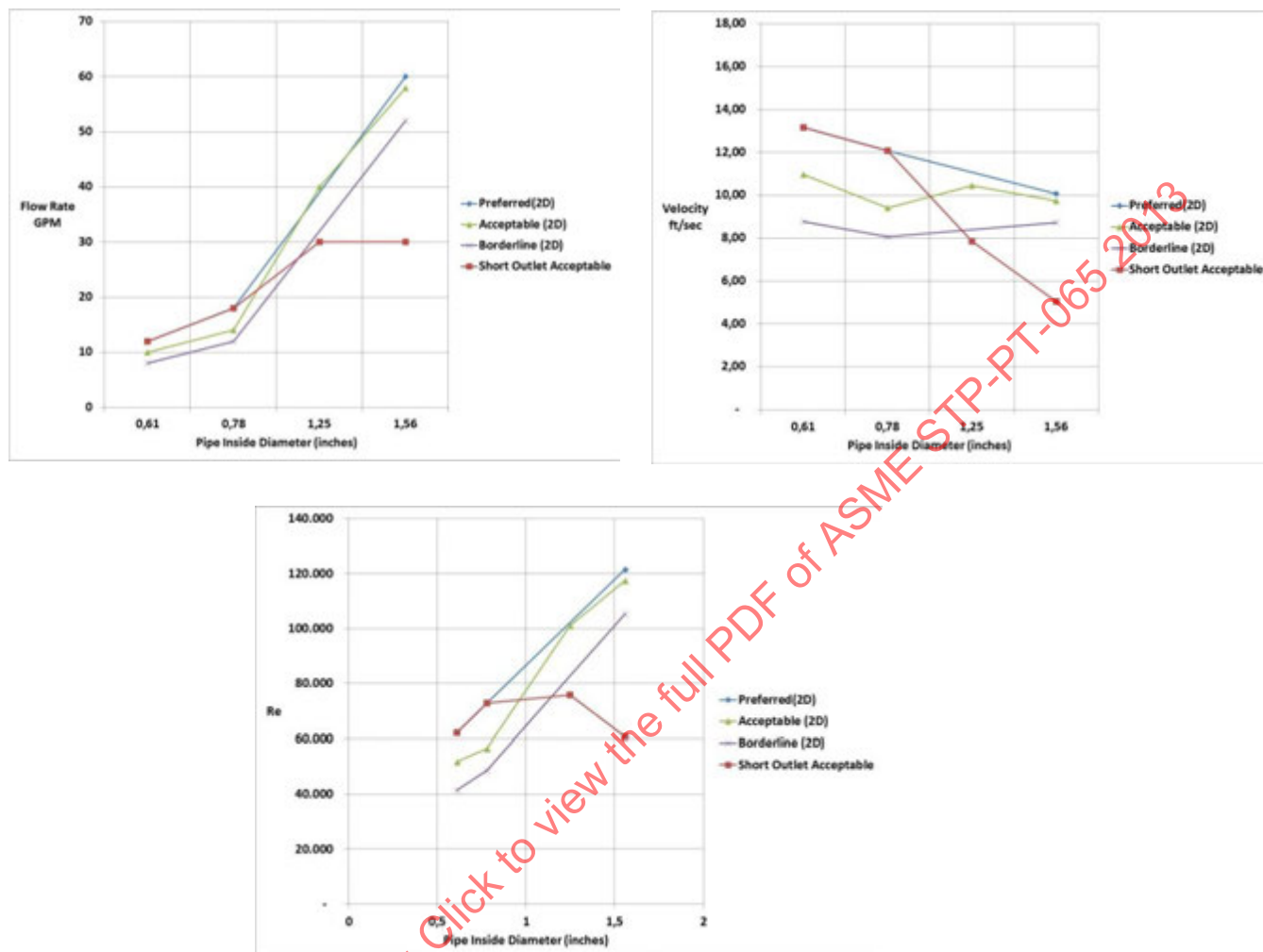
6.2.2 Parameters for Predicting Air Removal States

With the data obtained for different flow rates and different pipe dimensions, it is possible to evaluate if reaching a certain air removal state (preferred or acceptable) is best related to Reynolds number, velocity or flow rate for the different conditions evaluated. The test results indicate that the best parameter to predict an air removal state for different pipe diameter branches with a constant L/D ratio of two is the velocity in the main pipe, as this gives an almost constant velocity to reach an air removal state independent of pipe diameter. With Reynolds number and flow rate, a parabolic to linear relationship is seen between the required Reynolds number and flow rate to reach a certain state.

For the short outlet tee, the Reynolds number would be the best parameter as it appears to be independent of pipe dimension, while it has an almost linear relationship with flow rate and velocity (see more in the discussion on short outlet tees).

The velocities appeared to be linear across the diameters and ranged between 8 and 13 feet/sec to clear air out of the 2D branches. The velocities were similar for the short outlet of 3/4 and 1 inch and were as low as 6 feet/sec for the 2 inch size.

Figure 6-1: Data for Upward Pointing Branch (0°) on a Horizontal Line at Ambient Temperature Plotted with Reynolds Number, Velocity and Flow Rate

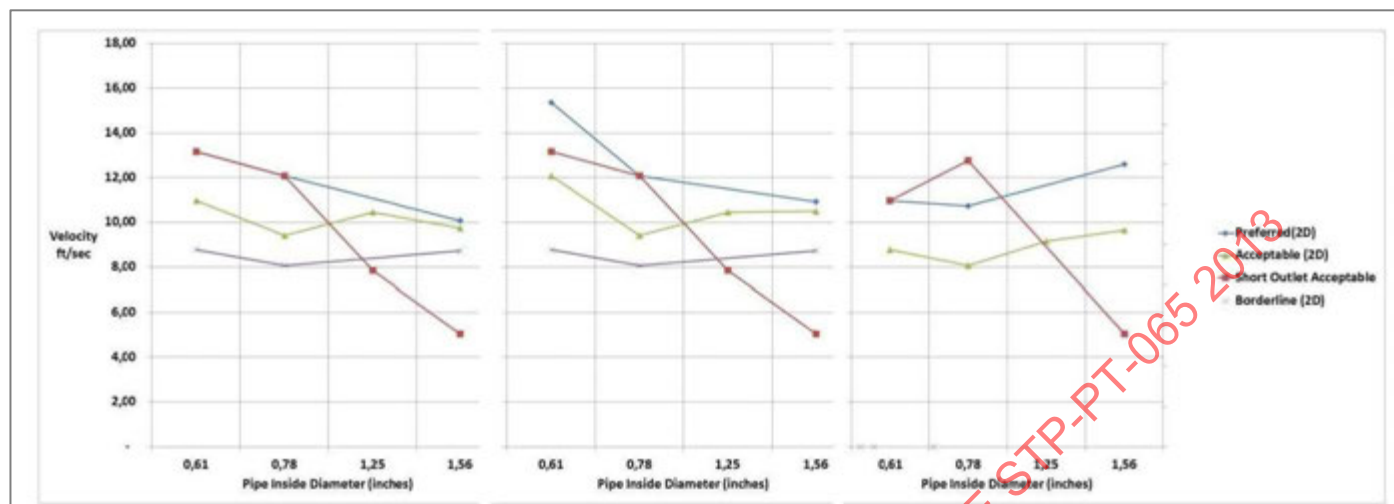


6.2.3 Influence Flow Startup

Experiments were performed increasing the flow rate to obtain a certain grade (4 or 5), and experiments were performed with a constant flow rate starting immediately from $t = 0s$, recording the time to reach a certain grade. A certain grade was reached in a similar time frame when flow was increased compared to when flow was maintained at a predefined flow rate.

6.2.4 Horizontal T-pieces Straight Through ($L/D = 2$)

For the five configurations tested, air was most easily removed from the two with the downward pointing branch, as gravity and density differences assisted in air removal. In all the situations tested with a downward pointing branch, less than 5 feet/sec was needed to immediately remove air to a grade 5.

Figure 6-2: Velocity Required to Reach Certain State

From Left To Right: 0° Branch (Upward Pointing), 45° and 90° T-Pieces Straight Through Ambient Temperature

For the configuration with a horizontal branch (90°) the velocity required to reach the acceptable state (grade 4 in 1 min) was approximately 9 feet/sec and the preferred state (grade 5 in 1 min) was approx. 12.5 feet/sec.

For the configuration with a branch angled 0° and 45°, the velocity required to reach the acceptable state was approximately 12 feet/sec and the preferred state was approximately 13 feet/sec. For all cases, there were no significant differences when sloping the pipe line from $\pm 0.6^\circ$.

6.2.5 Vertical T-pieces Straight Through (L/D = 2)

A considerable difference was seen for an upward going flow compared to a downward going flow. For the upward flow, a velocity of 12.9 feet/sec was needed to reach preferred state; for a downward flow, the velocity was approximately 9.6 feet/sec.

6.2.6 Horizontal T-pieces Straight Through (Short Outlet Tee)

For the short outlet tee there was a decrease in the velocity required for reaching the acceptable state with increasing diameter, starting from approximately 13 feet/sec at the smallest diameter to roughly 5 feet/sec for the largest inner diameter.

The decrease in velocity for increasing diameter is likely for two reasons: the influence of surface tension on retaining the bubbles in the branch is greater in the smaller ID as the surface to liquid ratio is larger and/or the L/D for the short outlet tee actually decreases with increasing pipe size (See Figure 5-3). Studies by Jensen have shown that very short outlet tees change the flow pattern in the dead-end dramatically, as the recirculation zone seen in larger branches ($L/D \sim 2$) no longer exists if the branch has significantly reduced L/D. This could explain why an L/D of 1.4 and 0.8 need velocity above 12 feet/sec, while L/D 0.5 and 0.4 require velocity below 8 feet/sec.

6.2.7 Elbow on the Wall

Flows *into* the branch result in significantly lower velocities required to clear the air than passing the branch at an elbow. This is a way to overcome the high velocity rates.

Figure 6-3: Results from the Elbows Configurations Test for L/D =2
Velocity to reach grade 4 in less than 1 minute

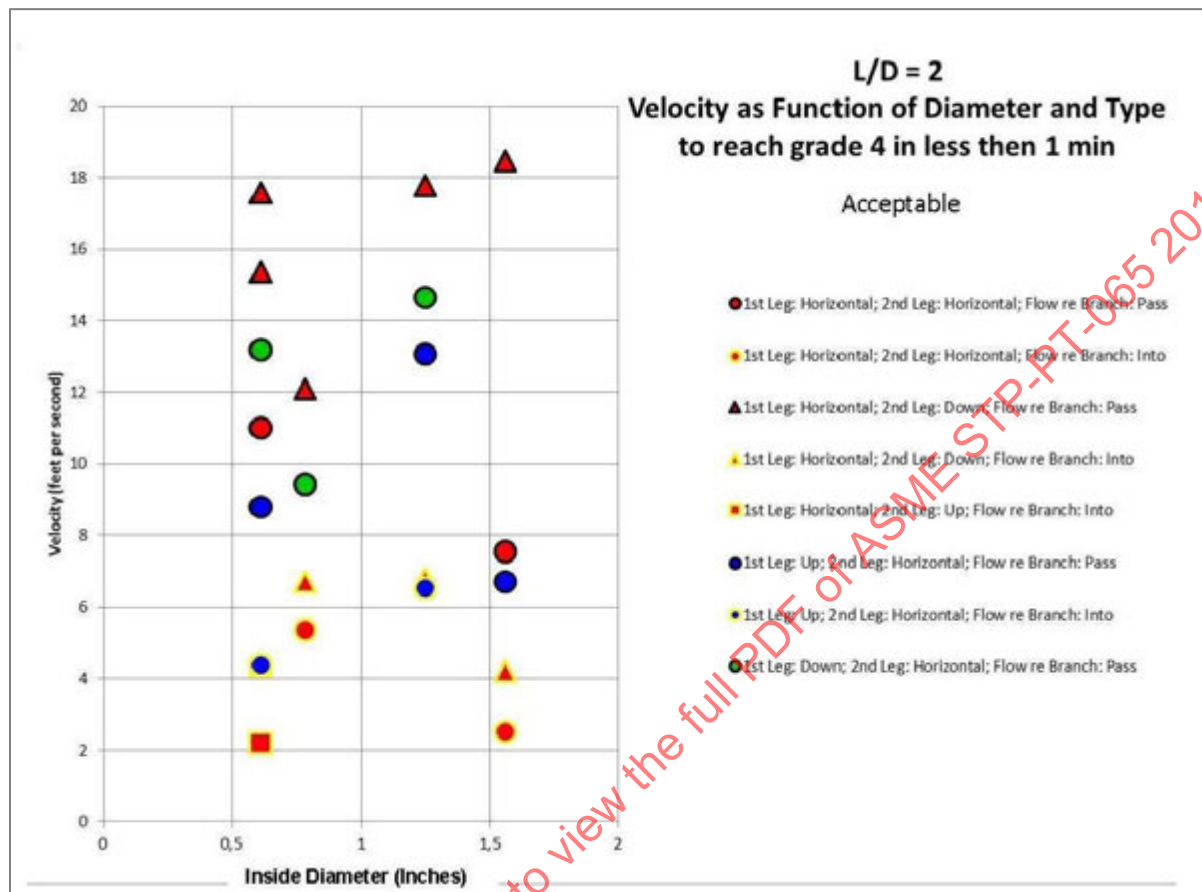
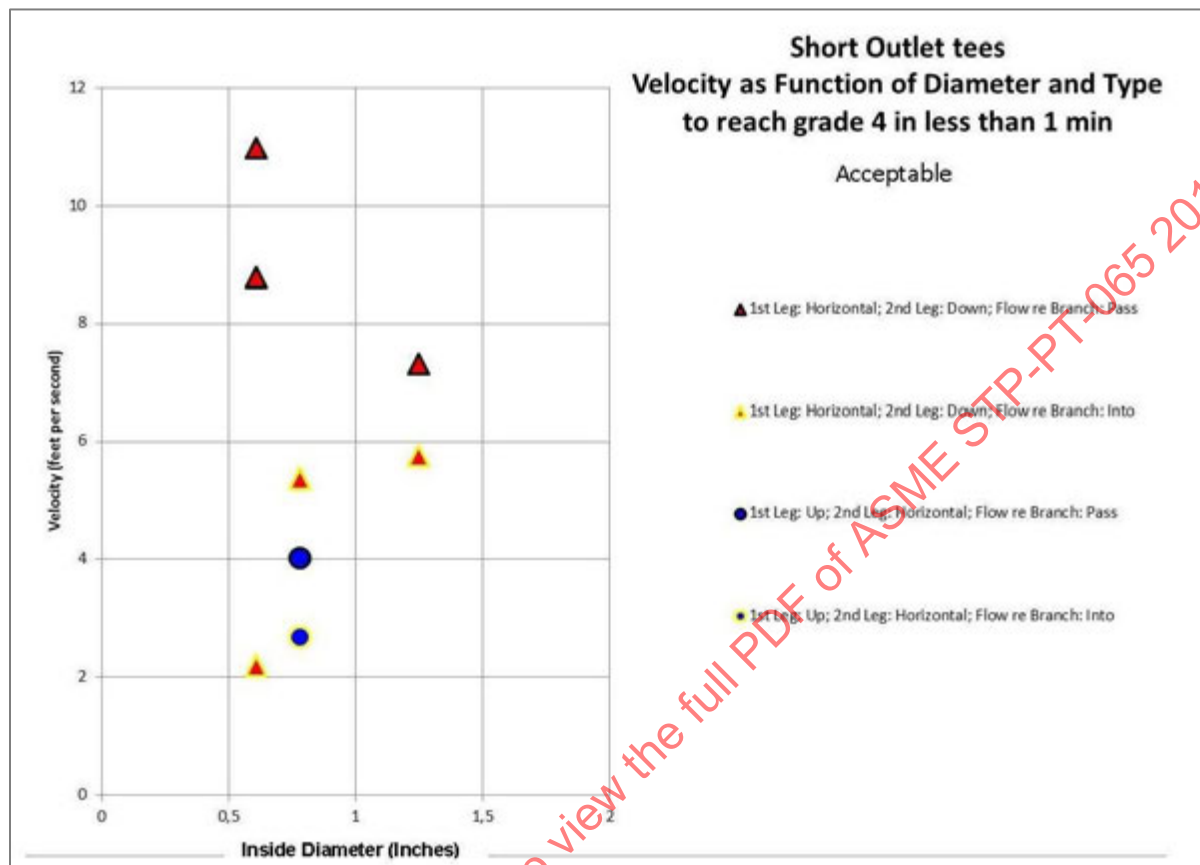


Figure 6-4: Results from the Elbow Configurations Test for SO tee
Velocity to reach grade 4 in less than 1 minute



6.2.8 Influence of Temperature

Increasing the temperature decreases the rate at which the air is removed from the branch. Hence, a higher velocity is required to remove air from a hotter solution within the same amount of time. (Note: This can be significant for those who typically perform CIP at 65° or hotter)

For the horizontal T-pieces with straight through flow, the velocity increase is approximately 2 feet/sec. For the vertical T-pieces, data support these findings, but is not sufficient to conclude on the velocity increase needed.

6.2.9 Influence of Back Pressure

Back pressure had little to no effect on the clearance of the air. The air bubble volume decreased due to increased pressure, and returned to its original size when the pressure was relieved.

7 CONCLUSIONS & RECOMMENDATIONS

This study confirmed that a high flow rate is the driving factor for optimized removal of air in BioProcess piping systems, specifically it confirmed that flow rates much greater than the traditional 5 feet/second would be required. Direction of flow and orientation also have some influence. The following trends were noticed:

- Pressure increases provide little improvement to the removal of air.
- Vertical runs require lower flow rates to remove air.
- Short Outlet Tees require lower flow rates to remove air.
- Rotation of the branch leg influences its ability to clear.
- Minor effects were seen with elevated temperatures, mainly due to the physical property changes in the fluid.
- Configuration of the fittings has an effect

The buoyant forces between the two phases are very much in play. The fluid transfer momentum from the higher flow rates provides turbulence. When high enough, they can displace the air which is lighter at the top of the fittings. The stagnant zone was witnessed where bubbles would remain in the branch for extended periods of time.

As such, this study proposes the following recommendations for optimizing air removal from the system (not taking into account other aspects of cleaning and sterilization):

- (1) Design piping systems with only downward pointing branches (Note: This is not good for sterilization or an acceptable practice in the BPE)
- (2) If branches are needed, put them on vertical lines
- (3) Branches (regardless of orientation and position) should be SOT as short as 0.4 (this requires only 5 feet/sec to remove air) – only proven for 2 inch pipe
- (4) If branches of any kind are unavoidable, refer to Figure 6-1 for design velocities
- (5) Removal of air should be done with liquid at ambient temperature rather than hotter temperatures
- (6) Removal of air should be done by steadily increasing the flow to the desired flow rate or by instantly increasing the flow to the desired flow rate
- (7) Elbows should be oriented for the flow to enter the branch rather than passing by them

7.1 Considerations When Evaluating Existing Designs

The goal of this report is to share the results of the test data obtained to better understand the flow conditions required to displace air from tees in a variety of different pipe sizes, L/D ratios, installation orientations, and flow directions. Although this testing was conducted in a thorough and robust manner, the results of this testing should not be used to definitively determine if the air is being removed from a specific process application.

As an example, assume that an existing process application involves CIP cleaning of a horizontal section of 2 inch stainless steel tubing with a tee with an L/D ratio of two directed vertically upward that contains a conductivity sensor which protrudes into the process line. This line is CIP cleaned at a flow rate which corresponds to a linear velocity of 5 feet/sec. In reviewing the results of the testing, one would expect to need a much higher flow rate to displace the air from the system in a timely manner and ensure adequate contact between the cleaning reagents and the process residue. Even though the flow rate is significantly less than the value listed in this report, the air may be easily displaced from the tee (e.g. due to interaction with the conductivity sensor, pulsing that occurs during the CIP operation, rinsing lasting more than one minute).

The guidance set forth in this document should be used as a starting point for additional study and dialogue, but it should not be implied that air is not being displaced from applications that do not meet this criteria. Successful displacement of air from each application will be determined by the specific installation and process conditions.

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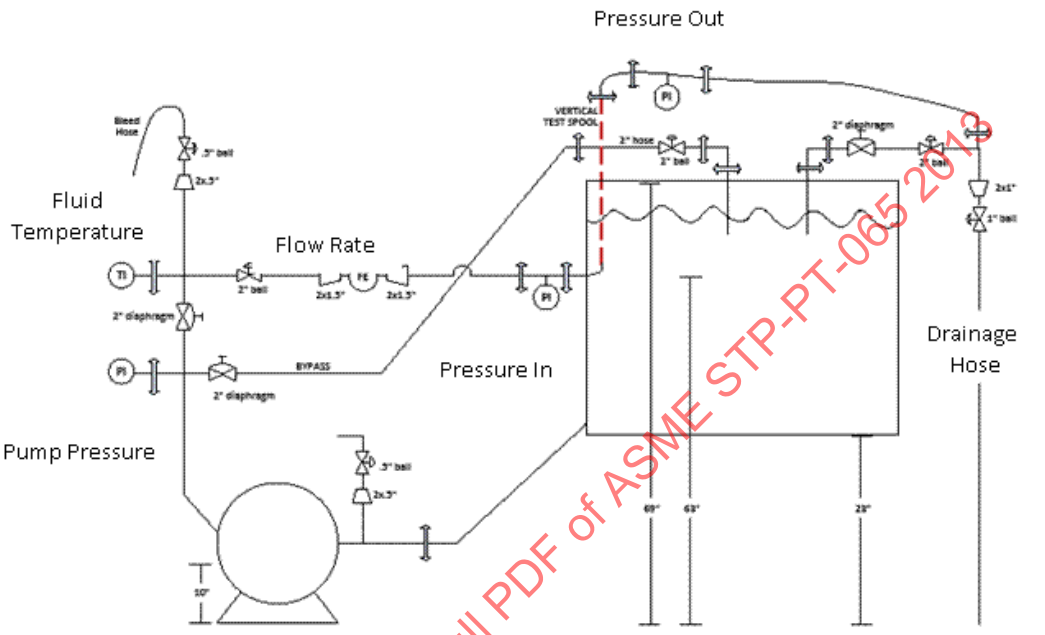
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APPENDICES

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APPENDIX A: TEST SCHEMATIC

Horizontal w. Branch	See Figure 4-1 in report
Vertical w. branch	 The schematic diagram illustrates a vertical test loop. A pump at the bottom circulates fluid upwards. Key components include: Pump Pressure: Measured at the pump outlet. Flow Rate: Measured using a flow meter (FE) and two 2x5.5" pipes. Pressure In: Measured at the inlet to the vertical test spool. Pressure Out: Measured at the outlet of the vertical test spool. Vertical Test Spool: A central vertical component where the test is conducted, with a red dashed line indicating the test section. Drainage Hose: Located at the bottom right for fluid collection. Fluid Temperature: Measured using a temperature indicator (TI) and a 2" diaphragm. Bypass: A line that allows fluid to bypass the main loop. Valves: Various valves (2" ball, 2" diaphragm) are used to control flow. Dimensions: Vertical dimensions of 69", 63", and 29" are indicated for the test spool section. *Red = Test Spool
Elbow Vertical	 A photograph of the physical test setup, showing the pump, piping, and test spool. The setup is mounted on a metal frame. A large blue container is visible on the left, and a white container is on the right. The test spool is a vertical pipe with various fittings and valves.

APPENDIX B: PROPERTIES FOR PP-R PIPE

The PROGEF material used in these experiments is the PROGEF Natural.

General Properties (Polypropylene)

Material Data

The following table lists typical physical properties of Polypropylene thermoplastic materials. Variations may exist depending on specific compounds and product.

Mechanical

Properties	Unit	PROGEF Standard PP-H	PROGEF Natural PP-R	PPro-Seal Natural PP-R	ASTM Test
Density	lb/in ³	0.0325	0.0325	0.0327	ASTM D792
Tensile Strength @ 73°F (Yield)	PSI	4,500	3,625	4,350	ASTM D638
Tensile Strength @ 73°F (Break)	PSI	5,600	4,500	5,000	ASTM D638
Modules of Elasticity Tensile @ 73°F	PSI	188,500	130,500	150,000	ASTM D638
Compressive Strength @ 73°F	PSI	6,500	5,500	5,500	ASTM D695
Flexural Modulus @ 73°F	PSI	181,250	130,500	130,000	ASTM D790
Izod Impact @ 73°F	Ft-Lbs/In of Notch	11.3	8.0	8.0	ASTM D256
Relative Hardness @ 73°F	Shore	70	70	70	ASTM D2240

Thermodynamics

Properties	Unit	PROGEF Standard	PROGEF Natural	PPro-Seal Natural	ASTM Test
Melt Index	gm/10min	0.25	0.30-0.40	0.40-0.80	ASTM D1238
Melting Point	°F	320	316	316	ASTM D789
Coefficient of Thermal Linear Expansion per °F	in/in/°F	0.5 x 10 ⁻⁴	0.5 x 10 ⁻⁴	0.61 x 10 ⁻⁴	ASTM D696
Thermal Conductivity	BTU-in/ft ² /hr/°F	1.6	1.6	1.2	ASTM D177
Maximum Operating Temperature	°F	176	176	176	
Heat Distortion Temperature @ 264 PSI	°F	125	125	130	ASTM D648

Other

Properties	Unit	PROGEF Standard	PROGEF Natural	PPro-Seal Natural	ASTM Test
Water Absorption	%	<0.1%	<0.1%	<0.03%	ASTM D570
Poisson's Ratio @ 73°F		0.38	0.38	0.38	
Industry Standard Color		7032	Neutral	Neutral	RAL 9005
Food and Drug Association (FDA)		YES	YES	YES	CFR 21.177.1520
United States Pharmacopeia (USP)		YES	YES	YES	USP 25 Class VI

Note: This data is based on information compiled from multiple sources.

APPENDIX C: MEASURE DATA FOR PP-R PIPES USED IN EXPERIMENTS

Spool Component	Size designation in report	Outside Diameter		Inside Diameter		Corresponding ASME BPE pipe inner diameter
		(inch)	(mm)	(inch)	(mm)	(Inch)
Polypropylene parts (20 mm)	pp - 0.75"	0.79	20.19	0.61	15.61	0.62
Polypropylene parts (25 mm)	pp - 1"	0.99	25.15	0.78	19.89	0.87
Polypropylene parts (40 mm)	pp - 1.5"	1.57	39.90	1.25	31.69	1.37
Polypropylene parts (50 mm)	pp - 2"	1.98	50.23	1.56	39.64	1.87
PVC straight tube	pvc - 2"	1.90	48.27	1.57	39.95	1.87
PVC Tee	pvc – 2"	2.24	56.78	1.83	46.51	
Stainless Steel Pipe	ss - 2"	2.00	50.89	1.86	47.32	1.87

Nominal dimensions of polypropylene parts are not comparable to Nominal dimensions of stainless steel parts as per ASME BPE – Table A3.1 shows the real Nominal size depending of pipe material (Polypropylene, PVC or Stainless steel).

APPENDIX D: FLOW RATE, VELOCITY AND REYNOLDS NUMBERS**Table A4.1: fps and Reynolds number for four Polypropylene pipe sizes used in this study as a function of the GPM used**

GPM	pp-0.75"		pp-1"		pp-1.5"		pp-2"	
	fps	Re @ 20C	fps	Re @ 20C	fps	Re @ 20C	fps	Re @ 20C
2	2.20	10579	1.34	6470	0.52	2519	0.34	1618
4	4.39	21158	2.69	12940	1.05	5039	0.67	3235
6	6.59	31737	4.03	19411	1.57	7558	1.01	4853
8	8.78	42316	5.37	25881	2.09	10077	1.34	6470
10	10.98	52895	6.71	32351	2.61	12597	1.68	8088
12	13.17	63474	8.06	38821	3.14	15116	2.01	9705
14	15.37	74053	9.40	45291	3.66	17635	2.35	11323
15	16.47	79343	10.07	48527	3.92	18895	2.52	12132
16	17.56	84633	10.74	51762	4.18	20155	2.69	12940
18	19.76	95212	12.08	58232	4.71	22674	3.02	14558
19	20.86	100501	12.76	61467	4.97	23934	3.19	15367
20	21.95	105791	13.43	64702	5.23	25193	3.36	16176
22	24.15	116370	14.77	71172	5.75	27713	3.69	17793
24	26.34	126949	16.11	77642	6.27	30232	4.03	19411
25	27.44	132238	16.78	80878	6.54	31492	4.20	20219
26	28.54	137528	17.46	84113	6.80	32751	4.36	21028
28	30.74	148107	18.80	90583	7.32	35271	4.70	22646
30	32.93	158686	20.14	97053	7.84	37790	5.04	24263
35	38.42	185134	23.50	113229	9.15	44088	5.87	28307
40	43.91	211581	26.85	129404	10.46	50387	6.71	32351
42	46.10	222160	28.20	135874	10.98	52906	7.05	33969
45	49.40	238029	30.21	145580	11.76	56685	7.55	36395
50	54.89	264477	33.57	161755	13.07	62984	8.39	40439
52	57.08	275056	34.91	168225	13.59	65503	8.73	42056
54	59.28	285635	36.25	174695	14.12	68022	9.06	43674
55	60.37	290924	36.92	177931	14.38	69282	9.23	44483
56	61.47	296214	37.60	181166	14.64	70542	9.40	45291
58	63.67	306793	38.94	187636	15.16	73061	9.73	46909
60	65.86	317372	40.28	194106	15.68	75580	10.07	48527
62	68.06	327951	41.62	200576	16.21	78100	10.41	50144
66	72.45	349109	44.31	213517	17.25	83138	11.08	53379
68	74.64	359688	45.65	219987	17.78	85658	11.41	54997
75	82.33	396715	50.35	242633	19.61	94475	12.59	60658
90	98.79	476058	60.42	291159	23.53	113370	15.11	72790
95	104.28	502506	63.78	307335	24.83	119669	15.94	76834
100	109.77	528953	67.14	323510	26.14	125967	16.78	80878
110	120.75	581849	73.85	355861	28.76	138564	18.46	88965

Appendix continues on next page.

Table A4.2: Reynolds number and flow rates based on average velocity for evaluating flow characteristics of experimental set-up

	at Laminar Flow Re 2000				at 2.5 fps				at 5 fps				at 7.5 fps			
	20 C		66 C		20 C		66 C		20 C		66 C		20 C		66 C	
SS Tube Size	GPM	Vel fps	GPM	Vel fps	GPM	Re	GPM	Re	GPM	Re	GPM	Re	GPM	Re	GPM	Re
OD. in																
1/2"																
3/4"																
1"																
1 1/2"																
2"	0.39	0.42	0.17	0.18	2.35	11952	2.35	27271	4.71	23903	4.71	54543	7.06	35855	7.06	81814
	0.55	0.30	0.24	0.13	4.63	16771	4.63	38268	9.26	33542	9.26	76536	13.90	50312	13.90	114804
	0.87	0.19	0.38	0.08	11.49	26409	11.49	60261	22.97	52818	22.97	120522	34.46	79227	34.46	180783
	1.19	0.14	0.52	0.06	21.40	36048	21.40	82254	42.80	72095	42.80	164508	64.21	108143	64.21	246762
PPn Pipe Size																
Nom. in																
20 mm	0.39	0.42	0.17	0.18	2.31	11846	2.31	27029	4.62	23691	4.62	54059	6.93	35537	6.93	81088
25 mm	0.50	0.33	0.22	0.15	3.75	15099	3.75	34452	7.51	30197	7.51	68904	11.26	45296	11.26	103356
40 mm	0.79	0.21	0.35	0.09	9.52	24048	9.52	54873	19.05	48095	19.05	109745	28.57	72143	28.57	164618
50 mm	0.99	0.17	0.43	0.07	14.90	30081	14.90	68640	29.81	60163	29.81	137280	44.71	90244	44.71	205921

Note 1: All flows 2.5 fps and above are in the turbulent regime ($4000 < Re < 40,000$)

Note 2: Fully developed flow, where flow rate no longer affects the flow pattern is approx. $Re = 40,000$

APPENDIX E: OVERVIEW OF COMBINATIONS OF CONFIGURATIONS, SLOPES AND ROTATIONS TESTED FOR STRAIGHT THROUGH FLOW AND ELBOW FLOW

Table A5.1: Orientation of T-pieces (straight) with flow going past the Tee. Underlined words are those that can be found in the results section

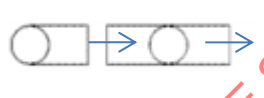
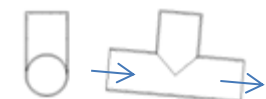
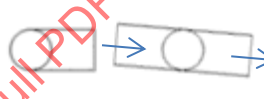
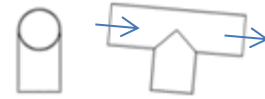
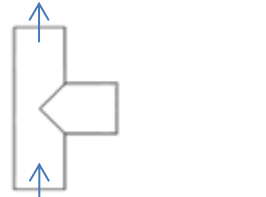
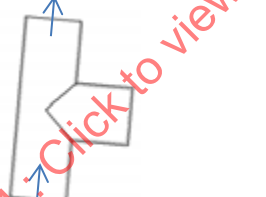
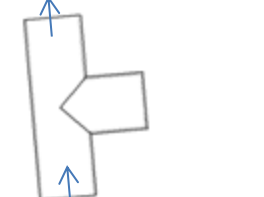
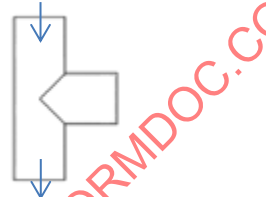
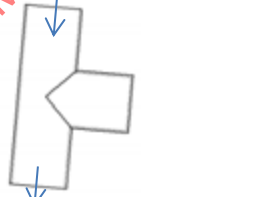
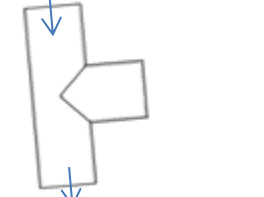
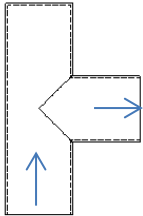
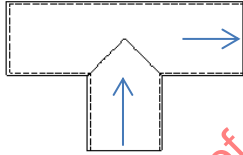
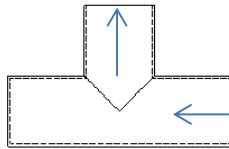
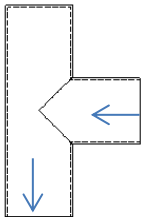
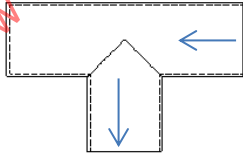
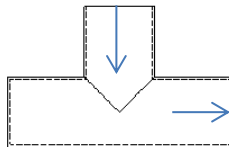
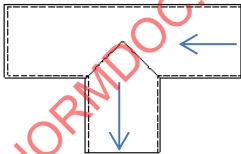
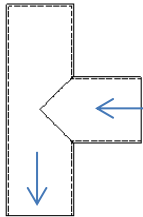
<u>Orientation</u>	<u>Slope</u>	<u>Rotation</u> 0°	<u>Rotation</u> 45°	<u>Rotation</u> 90°	<u>Rotation</u> 135°	<u>Rotation</u> 180°
Horizontal	0°					
	0.6° Up					
	0.6° Down					
	<u>Flow direction</u>	<u>Slope</u> Straight up/down	<u>Slope</u> 0.6° Down	<u>Slope</u> 0.6° Up		
Vertical	Bottom-to-top					
	Top-to-bottom					

Table D2: Orientation and flow direction of elbows
 Underlined words are those that can be found in the results section.

<u>Orientation</u>	<u>Flow direction</u> : Up to horizontal <u>Branch</u> : up	<u>Flow direction</u> : Up to horizontal <u>Branch</u> : horizontal	<u>Flow direction</u> : Horizontal to up <u>Branch</u> : horizontal
Vertical (on the wall)			
	<u>Flow direction</u> : Horizontal to down <u>Branch</u> : up	<u>Flow direction</u> : Horizontal to down <u>Branch</u> : Horizontal	<u>Flow direction</u> : Down to horizontal <u>Branch</u> : Horizontal
Vertical (on the wall)			
	<u>Branch</u> : Parallel	<u>Branch</u> : Perpendicular	
Horizontal (on the floor) Also with slope up and down as seen in table A5.1 for			

APPENDIX F: TEST RESULTS

The material in this and the subsequent appendices, documents experiments conducted by The BioProcess Institute as well as papers referenced within the body of this report.

The following tables are the committee's test results:

- Sorted Data reference visual grade
- Ambient Tests
- Hot Tests
- Tee Plus Spool Test
- Air Scale Test
- Sorted Data per various configurations
- Spool Pieces

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Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
1	110718	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.5	55	60	NA	NA	NA	NA	NA	NA	
2	110718	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.7	55	60	NA	NA	NA	NA	NA	NA	
3	110718	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.8	55	60	NA	NA	NA	NA	NA	NA	
4	110718	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	52	58	NA	NA	NA	NA	NA	NA	
5	110718	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.9	52	58	NA	NA	NA	NA	NA	NA	
6	110719	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.6	52	58	NA	NA	NA	NA	NA	NA	
7	110719	1	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.1	NA	NA	DNR	DNR	NA	NA	NA	NA	
8	110719	2	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
9	110719	3	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
10	110719	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.4	NA	NA	DNR	DNR	NA	NA	NA	NA	
11	110719	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
12	110719	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
13	110719	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.8	NA	NA	DNR	DNR	NA	NA	NA	NA	
14	110719	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
15	110720	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
16	110720	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36	NA	NA	5	DNR	NA	NA	NA	NA	
17	110720	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	NA	NA	5	DNR	NA	NA	NA	NA	
18	110720	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.1	NA	NA	5	DNR	NA	NA	NA	NA	
19	110720	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	NA	NA	1.5	2.5	NA	NA	NA	NA	Re-Verified Later
20	110720	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.5	NA	NA	1.5	2.5	NA	NA	NA	NA	Re-Verified Later
21	110720	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.7	NA	NA	1.5	2.5	NA	NA	NA	NA	Re-Verified Later
22	110720	1	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.8	NA	NA	0.25	0.5	NA	NA	NA	NA	
23	110720	2	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.9	NA	NA	0.25	0.5	NA	NA	NA	NA	
24	110720	3	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37	NA	NA	0.25	0.5	NA	NA	NA	NA	
25	110720	1	Flow Start-Up (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
26	110720	2	Flow Start-Up (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
27	110720	3	Flow Start-Up (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
28	110720	1	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.5	NA	NA	NA	NA	DNR	DNR	NA	NA	
29	110720	2	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.8	NA	NA	NA	NA	DNR	DNR	NA	NA	
30	110720	3	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.2	NA	NA	NA	NA	DNR	DNR	NA	NA	
31	110720	1	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.4	NA	NA	NA	NA	45	DNR	NA	NA	
32	110720	2	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.7	NA	NA	NA	NA	45	DNR	NA	NA	
33	110720	3	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.2	NA	NA	NA	NA	45	DNR	NA	NA	
34	110720	1	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.5	NA	NA	NA	NA	30	DNR	NA	NA	
35	110720	2	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.9	NA	NA	NA	NA	30	DNR	NA	NA	
36	110720	3	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.2	NA	NA	NA	NA	30	DNR	NA	NA	
37	110720	1	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	NA	NA	NA	NA	2	30	NA	NA	
38	110720	2	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.9	NA	NA	NA	NA	2	30	NA	NA	
39	110720	3	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.3	NA	NA	NA	NA	2	30	NA	NA	
40	110720	1	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.8	NA	NA	NA	NA	NA	NA	2	3	
41	110720	2	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	38	NA	NA	NA	NA	NA	NA	2	3	
42	110720	3	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	38.1	NA	NA	NA	NA	NA	NA	2	3	
43	110720	1	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.1	NA	NA	NA	NA	NA	NA	1.5	3	
44	110720	2	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.3	NA	NA	NA	NA	NA	NA	1.5	4	
45	110720	3	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.4	NA	NA	NA	NA	NA	NA	1.5	5	
46	110721	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.4	55	65	NA	NA	NA	NA	NA	NA	
47	110721	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.9	55	65	NA	NA	NA	NA	NA	NA	
48	110721	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.3	55	65	NA	NA	NA	NA	NA	NA	
49	110721	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.8	60	65	NA	NA	NA	NA	NA	NA	
50	110721	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.3	60	65	NA	NA	NA	NA	NA	NA	
51	110721	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.8	60	65	NA	NA	NA	NA	NA	NA	
52	110721	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
53	110721	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
54	110721	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
55	110721	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38	NA	NA	DNR	DNR	NA	NA	NA	NA	
56	110721	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
57	110721	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
58	110721	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	39.2	NA	NA	5	DNR	NA	NA	NA	NA	
59	110721	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	39.6	NA	NA	5	DNR	NA	NA	NA	NA	
60	110721	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	39.9	NA	NA	5	DNR	NA	NA	NA	NA	
61	110721	1	Flow Start-Up (65)	4	Straight	2	Horizontal	NA	NA	0	45	PP	40.3	NA	NA	1	5	NA	NA	NA	NA	
62	110721	2	Flow Start-Up (65)	4	Straight	2	Horizontal	NA	NA	0	45	PP	40.5	NA	NA	1	5	NA	NA	NA	NA	
63	110721	3	Flow Start-Up (65)	4	Straight	2	Horizontal	NA	NA	0	45	PP	40.7	NA	NA	1	5	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
64	110721	1	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	45	PP	40.9	NA	NA	0.25	1.5	NA	NA	NA	NA	
65	110721	2	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	45	PP	41	NA	NA	0.25	1.5	NA	NA	NA	NA	
66	110721	3	Flow Start-Up (75)	4	Straight	2	Horizontal	NA	NA	0	45	PP	41.1	NA	NA	0.25	1.5	NA	NA	NA	NA	
67	110725	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	28.7	55	75	NA	NA	NA	NA	NA	NA	
68	110725	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	29.2	55	75	NA	NA	NA	NA	NA	NA	
69	110725	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	29.7	55	75	NA	NA	NA	NA	NA	NA	
70	110725	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30	NA	NA	DNR	DNR	NA	NA	NA	NA	
71	110725	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
72	110725	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
73	110725	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.8	NA	NA	DNR	DNR	NA	NA	NA	NA	
74	110725	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31	NA	NA	DNR	DNR	NA	NA	NA	NA	
75	110725	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
76	110725	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31.6	NA	NA	3	DNR	NA	NA	NA	NA	
77	110725	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32	NA	NA	3	DNR	NA	NA	NA	NA	
78	110725	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.3	NA	NA	3	DNR	NA	NA	NA	NA	
79	110725	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.6	NA	NA	1	4	NA	NA	NA	NA	
80	110725	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.9	NA	NA	1	4	NA	NA	NA	NA	
81	110725	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	33.1	NA	NA	1	4	NA	NA	NA	NA	
82	110725	1	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
83	110725	2	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
84	110725	3	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
85	110725	1	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
86	110725	2	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
87	110725	3	Flow Start-Up (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
88	110726	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	28.8	60	75	NA	NA	NA	NA	NA	NA	
89	110726	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.3	60	75	NA	NA	NA	NA	NA	NA	
90	110726	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.7	60	75	NA	NA	NA	NA	NA	NA	
91	110726	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.1	58	DNR	NA	NA	NA	NA	NA	NA	
92	110726	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.5	58	DNR	NA	NA	NA	NA	NA	NA	
93	110726	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.8	58	DNR	NA	NA	NA	NA	NA	NA	
94	110726	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.1	NA	NA	DNR	DNR	NA	NA	NA	NA	
95	110726	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.4	NA	NA	DNR	DNR	NA	NA	NA	NA	
96	110726	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
97	110726	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32	NA	NA	DNR	DNR	NA	NA	NA	NA	
98	110726	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.4	NA	NA	DNR	DNR	NA	NA	NA	NA	
99	110726	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
100	110726	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.2	NA	NA	6	DNR	NA	NA	NA	NA	
101	110726	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.6	NA	NA	6	DNR	NA	NA	NA	NA	
102	110726	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34	NA	NA	6	DNR	NA	NA	NA	NA	
103	110726	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.4	NA	NA	3	5	NA	NA	NA	NA	
104	110726	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.7	NA	NA	3	5	NA	NA	NA	NA	
105	110726	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.9	NA	NA	3	5	NA	NA	NA	NA	
106	110726	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.9	60	75	NA	NA	NA	NA	NA	NA	
107	110726	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.4	60	75	NA	NA	NA	NA	NA	NA	
108	110726	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.4	60	75	NA	NA	NA	NA	NA	NA	
109	110726	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.8	58	DNR	NA	NA	NA	NA	NA	NA	
110	110726	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.1	58	DNR	NA	NA	NA	NA	NA	NA	
111	110726	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.5	58	DNR	NA	NA	NA	NA	NA	NA	
112	110726	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.1	NA	NA	DNR	DNR	NA	NA	NA	NA	
113	110726	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
114	110726	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
115	110726	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.8	NA	NA	DNR	DNR	NA	NA	NA	NA	
116	110726	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
117	110726	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
118	110727	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	32.4	NA	NA	6	DNR	NA	NA	NA	NA	
119	110727	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	32.8	NA	NA	6	DNR	NA	NA	NA	NA	
120	110727	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	45	PP	33.3	NA	NA	6	DNR	NA	NA	NA	NA	
121	110727	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	33.7	NA	NA	3	DNR	NA	NA	NA	NA	
122	110727	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.2	NA	NA	3	DNR	NA	NA	NA	NA	
123	110727	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.6	NA	NA	3	DNR	NA	NA	NA	NA	
124	110727	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	90	PP	35.3	60	75	NA	NA	NA	NA	NA	NA	
125	110727	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	90	PP	36.2	60	75	NA	NA	NA	NA	NA	NA	
126	110727	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	90	PP	36.5	60	75	NA	NA	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
127	110727	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	90	PP	36.9	56	DNR	NA	NA	NA	NA	NA	NA	
128	110727	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	90	PP	37.1	56	DNR	NA	NA	NA	NA	NA	NA	
129	110727	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	90	PP	37.5	56	DNR	NA	NA	NA	NA	NA	NA	
130	110727	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	37.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
131	110727	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	38	NA	NA	DNR	DNR	NA	NA	NA	NA	
132	110727	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	38.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
133	110727	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	38	NA	NA	DNR	DNR	NA	NA	NA	NA	
134	110727	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	38.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
135	110727	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	38.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
136	110727	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	39	NA	NA	2	DNR	NA	NA	NA	NA	
137	110727	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	39.3	NA	NA	2	DNR	NA	NA	NA	NA	
138	110727	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	39.5	NA	NA	2	DNR	NA	NA	NA	NA	
139	110727	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	39.8	NA	NA	1	3	NA	NA	NA	NA	
140	110727	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	40	NA	NA	1	3	NA	NA	NA	NA	
141	110727	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	40.1	NA	NA	1	3	NA	NA	NA	NA	
142	110728	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	34	60	75	NA	NA	NA	NA	NA	NA	
143	110728	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	34.3	60	75	NA	NA	NA	NA	NA	NA	
144	110728	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	34.6	60	75	NA	NA	NA	NA	NA	NA	
145	110728	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	35	58	DNR	NA	NA	NA	NA	NA	NA	
146	110728	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	35.3	58	DNR	NA	NA	NA	NA	NA	NA	
147	110728	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	35.5	58	DNR	NA	NA	NA	NA	NA	NA	
148	110728	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	35.9	NA	NA	DNR	DNR	NA	NA	NA	NA	
149	110728	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	36	NA	NA	DNR	DNR	NA	NA	NA	NA	
150	110728	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	36.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
151	110728	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	36.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
152	110728	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	36.9	NA	NA	DNR	DNR	NA	NA	NA	NA	
153	110728	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	37.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
154	110728	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	37.5	NA	NA	5	DNR	NA	NA	NA	NA	
155	110728	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	37.5	NA	NA	5	DNR	NA	NA	NA	NA	
156	110728	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	37.9	NA	NA	5	DNR	NA	NA	NA	NA	
157	110728	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	38.3	NA	NA	3	4	NA	NA	NA	NA	
158	110728	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	38.5	NA	NA	3	4	NA	NA	NA	NA	
159	110728	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	0	PP	38.3	NA	NA	3	4	NA	NA	NA	NA	
160	110728	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	38.4	60	75	NA	NA	NA	NA	NA	NA	
161	110728	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	38.9	60	75	NA	NA	NA	NA	NA	NA	
162	110729	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	39.2	60	75	NA	NA	NA	NA	NA	NA	
163	110729	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	32.9	58	DNR	NA	NA	NA	NA	NA	NA	
164	110729	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	33.3	58	DNR	NA	NA	NA	NA	NA	NA	
165	110729	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	33.7	58	DNR	NA	NA	NA	NA	NA	NA	
166	110729	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	34.1	NA	NA	DNR	DNR	NA	NA	NA	NA	
167	110729	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	34.3	NA	NA	DNR	DNR	NA	NA	NA	NA	
168	110729	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	34.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
169	110729	1	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	34.9	NA	NA	6	DNR	NA	NA	NA	NA	
170	110729	2	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	35.3	NA	NA	6	DNR	NA	NA	NA	NA	
171	110729	3	Flow Start-Up (55)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	35.8	NA	NA	6	DNR	NA	NA	NA	NA	
172	110729	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	36.2	NA	NA	2	DNR	NA	NA	NA	NA	
173	110729	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	36.3	NA	NA	2	DNR	NA	NA	NA	NA	
174	110729	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	45	PP	36.7	NA	NA	2	DNR	NA	NA	NA	NA	
175	110729	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0	90	PP	37.2	50	75	NA	NA	NA	NA	NA	NA	
176	110729	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0	90	PP	27.6	50	75	NA	NA	NA	NA	NA	NA	
177	110801	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0	90	PP	28.1	50	75	NA	NA	NA	NA	NA	NA	
178	110801	1	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	28.5	NA	NA	2	DNR	NA	NA	NA	NA	
179	110801	2	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	28.7	NA	NA	2	DNR	NA	NA	NA	NA	
180	110801	3	Flow Start-Up (50)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	29.1	NA	NA	2	DNR	NA	NA	NA	NA	
181	110801	1	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	28.5	NA	NA	1	3	NA	NA	NA	NA	
182	110801	2	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	28.7	NA	NA	1	3	NA	NA	NA	NA	
183	110801	3	Flow Start-Up (60)	4	Straight	2	Horizontal	NA	NA	-0	90	PP	29.1	NA	NA	1	3	NA	NA	NA	NA	
184	110801	1	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.3	NA	NA	3	6	NA	NA	NA	NA	
185	110801	2	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.5	NA	NA	3	6	NA	NA	NA	NA	
186	110801	3	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.7	NA	NA	3	6	NA	NA	NA	NA	
187	110801	1	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.1	NA	NA	3	6	NA	NA	NA	NA	
188	110801	2	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.5	NA	NA	3	6	NA	NA	NA	NA	
189	110801	3	Flow Start-Up (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	30.8	NA	NA	3	6	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
190	110802	1	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.1	NA	NA	0.25	2	NA	NA	NA	NA	
191	110802	2	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.2	NA	NA	0.25	2	NA	NA	NA	NA	
192	110802	3	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.3	NA	NA	0.25	2	NA	NA	NA	NA	
193	110802	1	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
194	110802	2	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
195	110802	3	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	0	PP	30.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
196	110802	1	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	30.8	NA	NA	2	5.5	NA	NA	NA	NA	
197	110802	2	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	31.2	NA	NA	2	5.5	NA	NA	NA	NA	
198	110802	3	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	31.5	NA	NA	2	5.5	NA	NA	NA	NA	
199	110802	1	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	31.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
200	110802	2	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	31.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
201	110802	3	Flow Start-Up (60)	1.625	Straight	2	Horizontal	NA	NA	0	45	PP	31.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
202	110802	1	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	90	PP	31.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
203	110802	2	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	90	PP	31.9	NA	NA	DNR	Imm	NA	NA	NA	NA	
204	110802	3	Flow Start-Up (30)	1.625	Straight	2	Horizontal	NA	NA	0	90	PP	31.8	NA	NA	DNR	Imm	NA	NA	NA	NA	
205	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	25.4	DNR	45	NA	NA	NA	NA	NA	NA	
206	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	25.9	DNR	45	NA	NA	NA	NA	NA	NA	
207	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	26.3	DNR	45	NA	NA	NA	NA	NA	NA	
208	110809	1	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	26.9	NA	NA	DNR	2	NA	NA	NA	NA	
209	110809	2	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27	NA	NA	DNR	2	NA	NA	NA	NA	
210	110809	3	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.2	NA	NA	DNR	2	NA	NA	NA	NA	
211	110809	1	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.4	NA	NA	DNR	1.5	NA	NA	NA	NA	
212	110809	2	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.5	NA	NA	DNR	1.5	NA	NA	NA	NA	
213	110809	3	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.6	NA	NA	DNR	1.5	NA	NA	NA	NA	
214	110809	1	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
215	110809	2	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.8	NA	NA	DNR	Imm	NA	NA	NA	NA	
216	110809	3	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.9	NA	NA	DNR	Imm	NA	NA	NA	NA	
217	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	28.1	DNR	45	NA	NA	NA	NA	NA	NA	
218	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	28.3	DNR	45	NA	NA	NA	NA	NA	NA	
219	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	28.6	DNR	45	NA	NA	NA	NA	NA	NA	
220	110809	1	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29	NA	NA	DNR	1	NA	NA	NA	NA	
221	110809	2	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29	NA	NA	DNR	1	NA	NA	NA	NA	
222	110809	3	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.1	NA	NA	DNR	1	NA	NA	NA	NA	
223	110809	1	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.2	NA	NA	DNR	0.5	NA	NA	NA	NA	
224	110809	2	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.2	NA	NA	DNR	0.5	NA	NA	NA	NA	
225	110809	3	Flow Start-Up (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.3	NA	NA	DNR	0.5	NA	NA	NA	NA	
226	110809	1	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.4	NA	NA	DNR	Imm	NA	NA	NA	NA	
227	110809	2	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.4	NA	NA	DNR	Imm	NA	NA	NA	NA	
228	110809	3	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0	0	PP	29.4	NA	NA	DNR	Imm	NA	NA	NA	NA	
229	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	29.6	DNR	45	NA	NA	NA	NA	NA	NA	
230	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	30	DNR	45	NA	NA	NA	NA	NA	NA	
231	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	30.2	DNR	45	NA	NA	NA	NA	NA	NA	
232	110812	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.3	150	DNR	NA	NA	NA	NA	NA	NA	
233	110812	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.4	150	DNR	NA	NA	NA	NA	NA	NA	
234	110812	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.5	150	DNR	NA	NA	NA	NA	NA	NA	
235	110812	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	28.2	150	DNR	NA	NA	NA	NA	NA	NA	
236	110812	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	28.6	150	DNR	NA	NA	NA	NA	NA	NA	
237	110812	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	29	150	DNR	NA	NA	NA	NA	NA	NA	
238	110812	1	Flow Start-Up (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	29.4	NA	NA	1	3	NA	NA	NA	NA	
239	110812	2	Flow Start-Up (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	30.5	NA	NA	1	3	NA	NA	NA	NA	
240	110812	3	Flow Start-Up (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	31	NA	NA	1	3	NA	NA	NA	NA	
241	110812	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	31.8	DNR	90	NA	NA	NA	NA	NA	NA	
242	110812	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	32.2	DNR	90	NA	NA	NA	NA	NA	NA	
243	110812	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	32.4	DNR	90	NA	NA	NA	NA	NA	NA	
244	110812	1	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
245	110812	2	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
246	110812	3	Flow Start-Up (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
247	110812	1	Flow Start-Up (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
248	110812	2	Flow Start-Up (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26.5	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
249	110812	3	Flow Start-Up (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26.8	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
250	110818	1	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
251	110818	2	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.4	NA	NA	DNR	Imm	NA	NA	NA	NA	
252	110818	3	Flow Start-Up (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.4	NA	NA	DNR	Imm	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
253	110818	1	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
254	110818	2	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
255	110818	3	Flow Start-Up (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	24.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
256	110819	1	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	25.2	45	60	NA	NA	NA	NA	NA	NA	
257	110819	2	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	25.7	45	60	NA	NA	NA	NA	NA	NA	
258	110819	3	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	26	45	60	NA	NA	NA	NA	NA	NA	
259	110819	1	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	26.3	NA	NA	2	DNR	NA	NA	NA	NA	
260	110819	2	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	26.9	NA	NA	2	DNR	NA	NA	NA	NA	
261	110819	3	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	27.3	NA	NA	2	DNR	NA	NA	NA	NA	
262	110819	1	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	27.7	NA	NA	1	1.5	NA	NA	NA	NA	
263	110819	2	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	27.8	NA	NA	1	1.5	NA	NA	NA	NA	
264	110819	3	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	28	NA	NA	1	1.5	NA	NA	NA	NA	
265	110819	1	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	28.3	45	60	NA	NA	NA	NA	NA	NA	
266	110819	2	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	28.7	45	60	NA	NA	NA	NA	NA	NA	
267	110819	3	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	28.9	45	60	NA	NA	NA	NA	NA	NA	
268	110819	1	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	29.3	NA	NA	1	DNR	NA	NA	NA	NA	
269	110819	2	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	30	NA	NA	1	DNR	NA	NA	NA	NA	
270	110819	3	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	30.5	NA	NA	1	DNR	NA	NA	NA	NA	
271	110822	1	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	25.7	NA	NA	1	1.5	NA	NA	NA	NA	
272	110822	2	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	26	NA	NA	1	1.5	NA	NA	NA	NA	
273	110822	3	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	26.1	NA	NA	1	1.5	NA	NA	NA	NA	
274	110822	1	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	26.3	45	60	NA	NA	NA	NA	NA	NA	
275	110822	2	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	26.6	45	60	NA	NA	NA	NA	NA	NA	
276	110822	3	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	26.8	45	60	NA	NA	NA	NA	NA	NA	
277	110822	1	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	27.3	NA	NA	2	6	NA	NA	NA	NA	
278	110822	2	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	27.7	NA	NA	2	6	NA	NA	NA	NA	
279	110822	3	Flow Start-Up (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	28.2	NA	NA	2	6	NA	NA	NA	NA	
280	110822	1	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	28.7	NA	NA	1	1.5	NA	NA	NA	NA	
281	110822	2	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	28.7	NA	NA	1	1.5	NA	NA	NA	NA	
282	110822	3	Flow Start-Up (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0	0	PP	28.9	NA	NA	1	1.5	NA	NA	NA	NA	
283	110823	1	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.4	35	40	NA	NA	NA	NA	NA	NA	
284	110823	2	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.6	35	40	NA	NA	NA	NA	NA	NA	
285	110823	3	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.7	35	40	NA	NA	NA	NA	NA	NA	
286	110823	1	Flow Start-Up (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28	NA	NA	5	DNR	NA	NA	NA	NA	
287	110823	2	Flow Start-Up (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.3	NA	NA	5	DNR	NA	NA	NA	NA	
288	110823	3	Flow Start-Up (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.5	NA	NA	5	DNR	NA	NA	NA	NA	
289	110823	1	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.7	NA	NA	Imm	0.75	NA	NA	NA	NA	
290	110823	2	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.8	NA	NA	Imm	0.75	NA	NA	NA	NA	
291	110823	3	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.9	NA	NA	Imm	0.75	NA	NA	NA	NA	
292	110823	1	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.1	35	50	NA	NA	NA	NA	NA	NA	
293	110823	2	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.2	35	50	NA	NA	NA	NA	NA	NA	
294	110823	3	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.5	35	50	NA	NA	NA	NA	NA	NA	
295	110823	1	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.9	NA	NA	Imm	DNR	NA	NA	NA	NA	
296	110823	2	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.1	NA	NA	Imm	DNR	NA	NA	NA	NA	
297	110823	3	Flow Start-Up (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.4	NA	NA	Imm	DNR	NA	NA	NA	NA	
298	110823	1	Flow Start-Up (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.8	NA	NA	Imm	4.5	NA	NA	NA	NA	
299	110823	2	Flow Start-Up (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	31.1	NA	NA	Imm	4.5	NA	NA	NA	NA	
300	110823	3	Flow Start-Up (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	31.3	NA	NA	Imm	4.5	NA	NA	NA	NA	
301	110824	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.1	15	30	NA	NA	NA	NA	NA	NA	
302	110824	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.3	15	30	NA	NA	NA	NA	NA	NA	
303	110824	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.5	15	30	NA	NA	NA	NA	NA	NA	
304	110824	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.5	30	45	NA	NA	NA	NA	NA	NA	
305	110824	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.6	30	45	NA	NA	NA	NA	NA	NA	
306	110824	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.8	30	45	NA	NA	NA	NA	NA	NA	
307	110824	1	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.9	NA	NA	1	2	NA	NA	NA	NA	
308	110824	2	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.1	NA	NA	1	2	NA	NA	NA	NA	
309	110824	3	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.1	NA	NA	1	2	NA	NA	NA	NA	
310	110824	1	Flow Start-Up (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
311	110824	2	Flow Start-Up (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
312	110824	3	Flow Start-Up (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
313	110825	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	27.7	100	120	NA	NA	NA	NA	NA	NA	
314	110825	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	28.3	100	120	NA	NA	NA	NA	NA	NA	
315	110825	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	28.7	100	120	NA	NA	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
316	110825	1	Flow Start-Up (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	29.2	NA	NA	4	DNR	NA	NA	NA	NA	
317	110825	2	Flow Start-Up (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	29.6	NA	NA	4	DNR	NA	NA	NA	NA	
318	110825	3	Flow Start-Up (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	30.1	NA	NA	4	DNR	NA	NA	NA	NA	
319	110825	1	Flow Start-Up (110)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	30.5	NA	NA	Imm	2	NA	NA	NA	NA	
320	110825	2	Flow Start-Up (110)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	30.7	NA	NA	Imm	2	NA	NA	NA	NA	
321	110825	3	Flow Start-Up (110)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	31	NA	NA	Imm	2	NA	NA	NA	NA	
322	110825	1	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	31.1	20	45	NA	NA	NA	NA	NA	NA	
323	110825	2	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	31.4	20	45	NA	NA	NA	NA	NA	NA	
324	110825	3	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	31.8	20	45	NA	NA	NA	NA	NA	NA	
325	110825	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	31.9	NA	NA	1	DNR	NA	NA	NA	NA	
326	110825	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	32.2	NA	NA	1	DNR	NA	NA	NA	NA	
327	110825	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	32.6	NA	NA	1	DNR	NA	NA	NA	NA	
328	110825	1	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	32.7	NA	NA	Imm	1	NA	NA	NA	NA	
329	110825	2	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	32.8	NA	NA	Imm	1	NA	NA	NA	NA	
330	110825	3	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	32.9	NA	NA	Imm	1	NA	NA	NA	NA	
331	110825	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.2	15	30	NA	NA	NA	NA	NA	NA	
332	110825	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	15	30	NA	NA	NA	NA	NA	NA	
333	110825	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	15	30	NA	NA	NA	NA	NA	NA	
334	110825	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.1	NA	NA	DNR	Imm	NA	NA	NA	NA	
335	110825	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
336	110825	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
337	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	23.6	15	30	NA	NA	NA	NA	NA	NA	
338	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	23.8	15	30	NA	NA	NA	NA	NA	NA	
339	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	24	15	30	NA	NA	NA	NA	NA	NA	
340	110830	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	24.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
341	110830	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	24.3	NA	NA	DNR	Imm	NA	NA	NA	NA	
342	110830	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	24.4	NA	NA	DNR	Imm	NA	NA	NA	NA	
343	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	24.5	15	30	NA	NA	NA	NA	NA	NA	
344	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	24.9	15	30	NA	NA	NA	NA	NA	NA	
345	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	24.9	15	30	NA	NA	NA	NA	NA	NA	
346	110830	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	25.1	NA	NA	DNR	Imm	NA	NA	NA	NA	
347	110830	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	25.1	NA	NA	DNR	Imm	NA	NA	NA	NA	
348	110830	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0	0	PP	25.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
349	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	25.5	45	50	NA	NA	NA	NA	NA	NA	
350	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	25.8	45	50	NA	NA	NA	NA	NA	NA	
351	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	26.2	45	50	NA	NA	NA	NA	NA	NA	
352	110830	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	26.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
353	110830	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	27.1	NA	NA	DNR	DNR	NA	NA	NA	NA	
354	110830	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	27.4	NA	NA	DNR	DNR	NA	NA	NA	NA	
355	110830	1	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	27.7	NA	NA	Imm	4	NA	NA	NA	NA	Hiccup, Dropped 10 gpm
356	110830	2	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	28.4	NA	NA	Imm	4	NA	NA	NA	NA	Hiccup, Dropped 10 gpm
357	110830	3	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0	0	PP	28.6	NA	NA	Imm	4	NA	NA	NA	NA	
358	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	29	45	50	NA	NA	NA	NA	NA	NA	
359	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	29.3	45	50	NA	NA	NA	NA	NA	NA	
360	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	29.6	45	50	NA	NA	NA	NA	NA	NA	
361	110831	1	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	27.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
362	110831	2	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	27.6	NA	NA	DNR	DNR	NA	NA	NA	NA	
363	110831	3	Flow Start-Up (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	27.9	NA	NA	DNR	DNR	NA	NA	NA	NA	
364	110831	1	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	28.1	NA	NA	1	4	NA	NA	NA	NA	
365	110831	2	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	28.3	NA	NA	1	4	NA	NA	NA	NA	
366	110831	3	Flow Start-Up (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	28.7	NA	NA	1	4	NA	NA	NA	NA	
367	110831	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	28.7	DNR	30	NA	NA	NA	NA	NA	NA	
368	110831	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29	DNR	30	NA	NA	NA	NA	NA	NA	
369	110831	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	DNR	30	NA	NA	NA	NA	NA	NA	
370	110831	1	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
371	110831	2	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
372	110831	3	Flow Start-Up (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
373	110831	1	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.3	DNR	45	NA	NA	NA	NA	NA	NA	
374	110831	2	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.5	DNR	45	NA	NA	NA	NA	NA	NA	
375	110831	3	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.7	DNR	45	NA	NA	NA	NA	NA	NA	
376	110831	1	Flow Start-Up (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30	NA	NA	DNR	DNR	NA	NA	NA	NA	
377	110831	2	Flow Start-Up (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.2	NA	NA	DNR	DNR	NA	NA	NA	NA	
378	110831	3	Flow Start-Up (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.5	NA	NA	DNR	DNR	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
379	110831	1	Flow Start-Up (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
380	110831	2	Flow Start-Up (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
381	110831	3	Flow Start-Up (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
382	110831	1	Flow Start-Up (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	NA	NA	DNR	Imm	NA	NA	NA	NA	
383	110831	2	Flow Start-Up (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	NA	NA	DNR	Imm	NA	NA	NA	NA	
384	110831	3	Flow Start-Up (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	NA	NA	DNR	Imm	NA	NA	NA	NA	
385	110913	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.7	10	12	NA	NA	NA	NA	NA	NA	
386	110913	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26	10	12	NA	NA	NA	NA	NA	NA	
387	110913	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.5	10	12	NA	NA	NA	NA	NA	NA	
388	110913	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
389	110913	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.7	NA	NA	Imm	DNR	NA	NA	NA	NA	
390	110913	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27	NA	NA	Imm	DNR	NA	NA	NA	NA	
391	110913	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.1	NA	NA	Imm	1	NA	NA	NA	NA	
392	110913	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.2	NA	NA	Imm	1	NA	NA	NA	NA	
393	110913	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.2	NA	NA	Imm	1	NA	NA	NA	NA	
394	110917	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	23.4	10	12	NA	NA	NA	NA	NA	NA	
395	110917	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	23.8	10	12	NA	NA	NA	NA	NA	NA	
396	110917	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	24.5	10	12	NA	NA	NA	NA	NA	NA	
397	110917	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	24.9	NA	NA	Imm	4.5	NA	NA	NA	NA	
398	110917	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.1	NA	NA	Imm	4.5	NA	NA	NA	NA	
399	110917	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.3	NA	NA	Imm	4.5	NA	NA	NA	NA	
400	110917	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.3	NA	NA	Imm	1	NA	NA	NA	NA	
401	110917	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.4	NA	NA	Imm	1	NA	NA	NA	NA	
402	110917	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.5	NA	NA	Imm	1	NA	NA	NA	NA	
403	110917	1	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.1	NA	NA	NA	NA	DNR	DNR	NA	NA	
404	110917	2	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.6	NA	NA	NA	NA	DNR	DNR	NA	NA	
405	110917	3	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27	NA	NA	NA	NA	DNR	DNR	NA	NA	
406	110922	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	22.6	10	12	NA	NA	NA	NA	NA	NA	Gasket Blocking Flow Meter
407	110922	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23	10	12	NA	NA	NA	NA	NA	NA	
408	110922	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.3	10	12	NA	NA	NA	NA	NA	NA	
409	110922	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.4	NA	NA	0.5	1	NA	NA	NA	NA	
410	110922	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.4	NA	NA	0.5	2	NA	NA	NA	NA	
411	110922	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.5	NA	NA	0.5	3	NA	NA	NA	NA	
412	110922	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
413	110922	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.6	NA	NA	DNR	Imm	NA	NA	NA	NA	
414	110922	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
415	110923	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	24.5	10	12	NA	NA	NA	NA	NA	NA	
416	110923	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.2	10	12	NA	NA	NA	NA	NA	NA	
417	110923	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.8	10	12	NA	NA	NA	NA	NA	NA	
418	110923	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.1	NA	NA	Imm	4	NA	NA	NA	NA	
419	110923	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.4	NA	NA	Imm	4	NA	NA	NA	NA	
420	110923	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.6	NA	NA	Imm	4	NA	NA	NA	NA	
421	110923	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.7	NA	NA	Imm	0.75	NA	NA	NA	NA	
422	110923	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.7	NA	NA	Imm	0.75	NA	NA	NA	NA	
423	110923	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.7	NA	NA	Imm	0.75	NA	NA	NA	NA	
424	110926	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	24.3	10	12	NA	NA	NA	NA	NA	NA	
425	110926	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25	10	12	NA	NA	NA	NA	NA	NA	
426	110926	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.7	10	12	NA	NA	NA	NA	NA	NA	
427	110926	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	26.4	NA	NA	Imm	4	NA	NA	NA	NA	
428	110926	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	26.6	NA	NA	Imm	4	NA	NA	NA	NA	
429	110926	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	26.8	NA	NA	Imm	4	NA	NA	NA	NA	
430	110926	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	27	NA	NA	Imm	0.75	NA	NA	NA	NA	
431	110926	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	27	NA	NA	Imm	0.75	NA	NA	NA	NA	
432	110926	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	27	NA	NA	Imm	0.75	NA	NA	NA	NA	
433	110927	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	26.5	DNR	10	NA	NA	NA	NA	NA	NA	
434	110927	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	26.9	DNR	10	NA	NA	NA	NA	NA	NA	
435	110927	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	27.1	DNR	10	NA	NA	NA	NA	NA	NA	
436	110928	1	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	25.4	NA	NA	4	5	NA	NA	NA	NA	Tiny stationary bubbles clinging to branch leg wall
437	110928	2	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	25.7	NA	NA	4	5	NA	NA	NA	NA	
438	110928	3	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	26	NA	NA	4	5	NA	NA	NA	NA	
439	110928	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	24.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
440	110928	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	25	NA	NA	DNR	Imm	NA	NA	NA	NA	
441	110928	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	25	NA	NA	DNR	Imm	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
442	110929	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	25	10	12	NA	NA	NA	NA	NA	NA	
443	110929	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	25.3	10	12	NA	NA	NA	NA	NA	NA	
444	110929	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	25.8	10	12	NA	NA	NA	NA	NA	NA	
445	110929	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	25.8	NA	NA	Imm	5	NA	NA	NA	NA	
446	110929	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	26	NA	NA	Imm	5	NA	NA	NA	NA	
447	110929	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	26.2	NA	NA	Imm	5	NA	NA	NA	NA	
448	110929	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	26.4	NA	NA	Imm	1	NA	NA	NA	NA	
449	110929	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	26.5	NA	NA	Imm	1	NA	NA	NA	NA	
450	110929	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	0	PP	26.5	NA	NA	Imm	1	NA	NA	NA	NA	
451	110929	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	27	10	12	NA	NA	NA	NA	NA	NA	
452	110929	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	27.4	10	12	NA	NA	NA	NA	NA	NA	
453	110929	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	27.7	10	12	NA	NA	NA	NA	NA	NA	
454	110930	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	24.5	NA	NA	Imm	4	NA	NA	NA	NA	
455	110930	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	24.7	NA	NA	Imm	4	NA	NA	NA	NA	
456	110930	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	24.9	NA	NA	Imm	4	NA	NA	NA	NA	
457	110930	1	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	25	NA	NA	Imm	1	NA	NA	NA	NA	
458	110930	2	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	25.1	NA	NA	Imm	1	NA	NA	NA	NA	
459	110930	3	Flow Start-Up (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0	45	PP	25.1	NA	NA	Imm	1	NA	NA	NA	NA	
460	110930	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	25.6	8	12	NA	NA	NA	NA	NA	NA	
461	110930	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	26.3	8	12	NA	NA	NA	NA	NA	NA	
462	110930	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	26.8	8	12	NA	NA	NA	NA	NA	NA	
463	110930	1	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	27.5	NA	NA	1	NA	NA	NA	NA	NA	Would Not Clear after 5
464	110930	2	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	27.7	NA	NA	Imm	1.5	NA	NA	NA	NA	Seems like the threshold is about 8.25 gpm
465	110930	3	Flow Start-Up (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	27.5	NA	NA	Imm	1.5	NA	NA	NA	NA	
466	110930	1	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	26.9	NA	NA	Imm	1	NA	NA	NA	NA	
467	110930	2	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	27	NA	NA	Imm	1	NA	NA	NA	NA	
468	110930	3	Flow Start-Up (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0	90	PP	27.1	NA	NA	Imm	1	NA	NA	NA	NA	
469	111001	1	Flow Start-Up (8)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.3	NA	NA	Imm	DNR	NA	NA	NA	NA	
470	111001	2	Flow Start-Up (8)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.8	NA	NA	Imm	DNR	NA	NA	NA	NA	
471	111001	1	Flow Start-Up (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26	NA	NA	Imm	DNR	NA	NA	NA	NA	
472	111001	2	Flow Start-Up (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.2	NA	NA	Imm	DNR	NA	NA	NA	NA	
473	111001	1	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
474	111001	2	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.8	NA	NA	Imm	DNR	NA	NA	NA	NA	
475	111001	1	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.3	NA	NA	Imm	2	NA	NA	NA	NA	
476	111001	2	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.4	NA	NA	Imm	2	NA	NA	NA	NA	
477	111001	3	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.5	NA	NA	Imm	2	NA	NA	NA	NA	
478	111001	1	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.6	NA	NA	Imm	1	NA	NA	NA	NA	
479	111001	2	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.6	NA	NA	Imm	1	NA	NA	NA	NA	
480	111001	3	Flow Start-Up (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.7	NA	NA	Imm	1	NA	NA	NA	NA	
481	111001	1	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	27.9	NA	NA	Imm	DNR	NA	NA	NA	NA	
482	111001	2	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.1	NA	NA	Imm	DNR	NA	NA	NA	NA	
483	111001	3	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.4	NA	NA	Imm	DNR	NA	NA	NA	NA	
484	111001	1	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29	NA	NA	Imm	2	NA	NA	NA	NA	
485	111001	2	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.1	NA	NA	Imm	2	NA	NA	NA	NA	
486	111001	3	Flow Start-Up (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.3	NA	NA	Imm	2	NA	NA	NA	NA	
487	111001	1	Flow Start-Up (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	290	NA	NA	Imm	DNR	NA	NA	NA	NA	
488	111001	2	Flow Start-Up (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.7	NA	NA	Imm	DNR	NA	NA	NA	NA	
489	111003	1	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	23.9	14	18	NA	NA	NA	NA	NA	NA	
490	111003	2	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	24.7	14	18	NA	NA	NA	NA	NA	NA	
491	111003	3	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.2	14	18	NA	NA	NA	NA	NA	NA	
492	111003	1	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.5	NA	NA	Imm	2	NA	NA	NA	NA	
493	111003	2	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.6	NA	NA	Imm	2	NA	NA	NA	NA	
494	111003	3	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.8	NA	NA	Imm	2	NA	NA	NA	NA	
495	111003	1	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	0	PP	26.3	NA	NA	Imm	DNR	NA	NA	NA	NA	
496	111003	2	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	0	PP	26.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
497	111003	1	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.6	NA	NA	Imm	3	NA	NA	NA	NA	
498	111003	2	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.7	NA	NA	Imm	3	NA	NA	NA	NA	
499	111003	3	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.9	NA	NA	Imm	3	NA	NA	NA	NA	
500	111003	1	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	45	PP	27.2	NA	NA	Imm	DNR	NA	NA	NA	NA	
501	111003	2	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	45	PP	27.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
502	111003	1	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	NA	NA	Imm	1	NA	NA	NA	NA	
503	111003	2	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	NA	NA	Imm	1	NA	NA	NA	NA	
504	111003	3	Flow Start-Up (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	NA	NA	Imm	1	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
505	111003	1	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.8	NA	NA	Imm	2	NA	NA	NA	NA	
506	111003	2	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.9	NA	NA	Imm	2	NA	NA	NA	NA	
507	111003	3	Flow Start-Up (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28	NA	NA	Imm	2	NA	NA	NA	NA	
508	111003	1	Flow Start-Up (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.2	NA	NA	Imm	3	NA	NA	NA	NA	
509	111003	2	Flow Start-Up (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.3	NA	NA	Imm	3	NA	NA	NA	NA	
510	111003	3	Flow Start-Up (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.4	NA	NA	Imm	3	NA	NA	NA	NA	
511	111004	1	Flow Start-Up (16)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25	NA	NA	Imm	DNR	NA	NA	NA	NA	
512	111004	1	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.3	NA	NA	Imm	5	NA	NA	NA	NA	
513	111004	2	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.6	NA	NA	Imm	5	NA	NA	NA	NA	
514	111004	3	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.8	NA	NA	Imm	5	NA	NA	NA	NA	
515	111004	1	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	45	PP	26	NA	NA	3	5	NA	NA	NA	NA	
516	111004	2	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	45	PP	26.2	NA	NA	3	5	NA	NA	NA	NA	
517	111004	1	Flow Start-Up (16)	1.125	Straight	1	Horizontal	NA	NA	0	90	PP	26.5	NA	NA	DNR	DNR	NA	NA	NA	NA	
518	111004	1	Flow Start-Up (18)	1.125	Straight	1	Horizontal	NA	NA	0	90	PP	26.7	NA	NA	2	DNR	NA	NA	NA	NA	
519	111004	1	Flow Start-Up (19)	1.125	Straight	1	Horizontal	NA	NA	0	90	PP	27	NA	NA	1	5	NA	NA	NA	NA	
520	111004	2	Flow Start-Up (19)	1.125	Straight	1	Horizontal	NA	NA	0	90	PP	27.3	NA	NA	1	5	NA	NA	NA	NA	
521	111006	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	22.6	8	12	NA	NA	NA	NA	NA	NA	
522	111006	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	22.8	8	12	NA	NA	NA	NA	NA	NA	
523	111006	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	23	8	12	NA	NA	NA	NA	NA	NA	
524	111007	1	Flow Start-Up (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	20.7	NA	NA	Imm	1	NA	NA	NA	NA	
525	111007	2	Flow Start-Up (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21	NA	NA	Imm	1	NA	NA	NA	NA	
526	111007	3	Flow Start-Up (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21.1	NA	NA	Imm	1	NA	NA	NA	NA	
527	111007	1	Flow Start-Up (10)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21.5	NA	NA	Imm	4	NA	NA	NA	NA	
528	111007	2	Flow Start-Up (10)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21.7	NA	NA	Imm	4	NA	NA	NA	NA	
529	111007	3	Flow Start-Up (10)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21.9	NA	NA	Imm	4	NA	NA	NA	NA	
530	111007	1	Flow Start-Up (10)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.2	NA	NA	Imm	DNR	NA	NA	NA	NA	
531	111007	2	Flow Start-Up (10)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.4	NA	NA	Imm	DNR	NA	NA	NA	NA	
532	111007	1	Flow Start-Up (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.6	NA	NA	Imm	4	NA	NA	NA	NA	
533	111007	2	Flow Start-Up (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.9	NA	NA	Imm	6	NA	NA	NA	NA	
534	111007	3	Flow Start-Up (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	23.1	NA	NA	Imm	5	NA	NA	NA	NA	
535	111011	1	Flow Start-Up (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.5	NA	NA	1	2	NA	NA	NA	NA	
536	111011	2	Flow Start-Up (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.7	NA	NA	1	2	NA	NA	NA	NA	
537	111011	3	Flow Start-Up (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.9	NA	NA	1	2	NA	NA	NA	NA	
538	111011	1	Flow Start-Up (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.1	NA	NA	1	4	NA	NA	NA	NA	
539	111011	2	Flow Start-Up (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.4	NA	NA	1	4	NA	NA	NA	NA	
540	111011	3	Flow Start-Up (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.6	NA	NA	1	4	NA	NA	NA	NA	
541	111011	1	Flow Start-Up (15)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	23	NA	NA	DNR	DNR	NA	NA	NA	NA	
542	111011	1	Flow Start-Up (19)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	23.7	NA	NA	4	NA	NA	NA	NA	NA	
543	111011	1	Flow Start-Up (20)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	24	NA	NA	3	4	NA	NA	NA	NA	
544	111011	2	Flow Start-Up (20)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	24.2	NA	NA	3	4	NA	NA	NA	NA	
545	111014	1	Flow Start-Up (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.5	NA	NA	Imm	1	NA	NA	NA	NA	
546	111014	2	Flow Start-Up (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.6	NA	NA	Imm	1	NA	NA	NA	NA	
547	111014	3	Flow Start-Up (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.8	NA	NA	Imm	1	NA	NA	NA	NA	
548	111017	1	Flow Start-Up (8)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.2	NA	NA	1	DNR	NA	NA	NA	NA	
549	111017	2	Flow Start-Up (8)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.6	NA	NA	1	DNR	NA	NA	NA	NA	
550	111017	1	Flow Start-Up (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.8	NA	NA	Imm	1	NA	NA	NA	NA	
551	111017	2	Flow Start-Up (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.7	NA	NA	Imm	1	NA	NA	NA	NA	
552	111017	3	Flow Start-Up (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.7	NA	NA	Imm	1	NA	NA	NA	NA	
553	111017	1	Flow Start-Up (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.3	NA	NA	1	DNR	NA	NA	NA	NA	
554	111017	2	Flow Start-Up (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.6	NA	NA	1	5	NA	NA	NA	NA	
555	111017	3	Flow Start-Up (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.7	NA	NA	1	5	NA	NA	NA	NA	
556	111019	1	Flow Start-Up (6)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
557	111019	2	Flow Start-Up (6)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.7	NA	NA	Imm	DNR	NA	NA	NA	NA	
558	111019	1	Flow Start-Up (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.6	NA	NA	Imm	1	NA	NA	NA	NA	
559	111019	2	Flow Start-Up (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.8	NA	NA	Imm	2	NA	NA	NA	NA	
560	111019	3	Flow Start-Up (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.8	NA	NA	Imm	1	NA	NA	NA	NA	
561	111020	1	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.6	4	10	NA	NA	NA	NA	NA	NA	
562	111020	2	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26	4	10	NA	NA	NA	NA	NA	NA	
563	111020	3	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.2	4	10	NA	NA	NA	NA	NA	NA	
564	111020	1	Flow Start-Up (6)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.4	NA	NA	1	NA	NA	NA	NA	NA	
565	111020	1	Flow Start-Up (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.3	NA	NA	Imm	1.5	NA	NA	NA	NA	
566	111020	2	Flow Start-Up (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.4	NA	NA	Imm	1.5	NA	NA	NA	NA	
567	111020	3	Flow Start-Up (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.6	NA	NA	Imm	1.5	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from center of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade (FI)		BPI Visual Grade (FSU)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
														4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
568	111021	1	Flow Start-Up (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.6	NA	NA	Imm	1	NA	NA	NA	NA	
569	111021	2	Flow Start-Up (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.6	NA	NA	Imm	1	NA	NA	NA	NA	
570	111021	3	Flow Start-Up (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.7	NA	NA	Imm	1	NA	NA	NA	NA	
571	111021	1	Flow Start-Up (2)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	26.2	NA	NA	1	2	NA	NA	NA	NA	
572	111021	2	Flow Start-Up (2)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	26	NA	NA	1	2	NA	NA	NA	NA	
573	111024	1	Flow Start-Up (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	22.8	NA	NA	Imm	DNR	NA	NA	NA	NA	
574	111024	2	Flow Start-Up (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23	NA	NA	Imm	DNR	NA	NA	NA	NA	
575	111024	3	Flow Start-Up (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.3	NA	NA	Imm	DNR	NA	NA	NA	NA	
576	111024	1	Flow Start-Up (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.8	NA	NA	Imm	2	NA	NA	NA	NA	
577	111024	2	Flow Start-Up (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.9	NA	NA	Imm	2	NA	NA	NA	NA	
578	111024	3	Flow Start-Up (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	24	NA	NA	Imm	2	NA	NA	NA	NA	
579	111026	1	Flow Start-Up (6)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.6	NA	NA	Imm	DNR	NA	NA	NA	NA	
580	111026	2	Flow Start-Up (6)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.9	NA	NA	Imm	DNR	NA	NA	NA	NA	
581	111026	1	Flow Start-Up (8)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	27	NA	NA	Imm	DNR	NA	NA	NA	NA	
582	111026	2	Flow Start-Up (8)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	27.2	NA	NA	Imm	DNR	NA	NA	NA	NA	
583	111027	1	Flow Start-Up (10)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.3	NA	NA	Imm	0.5	NA	NA	NA	NA	
584	111027	2	Flow Start-Up (10)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.3	NA	NA	Imm	0.5	NA	NA	NA	NA	
585	111027	1	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	28.3	NA	NA	DNR	1	NA	NA	NA	NA	
586	111027	2	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	28.4	NA	NA	DNR	1	NA	NA	NA	NA	
587	111028	1	Flow Start-Up (18)	2	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	23.8	NA	NA	Imm	DNR	NA	NA	NA	NA	
588	111028	2	Flow Start-Up (18)	2	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	24.1	NA	NA	Imm	DNR	NA	NA	NA	NA	
589	111028	1	Flow Start-Up (20)	2	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	24.4	NA	NA	Imm	3	NA	NA	NA	NA	
590	111028	2	Flow Start-Up (20)	2	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	24.6	NA	NA	Imm	3	NA	NA	NA	NA	
591	111028	3	Flow Start-Up (20)	2	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	24.8	NA	NA	Imm	3	NA	NA	NA	NA	
592	111031	1	Flow Start-Up (10)	2	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	18.1	NA	NA	Imm	2	NA	NA	NA	NA	
593	111031	2	Flow Start-Up (10)	2	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	18.2	NA	NA	Imm	2	NA	NA	NA	NA	
594	111031	3	Flow Start-Up (10)	2	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	18.4	NA	NA	Imm	2	NA	NA	NA	NA	
595	111103	1	Flow Start-Up (8)	1.125	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	19.6	NA	NA	Imm	0.5	NA	NA	NA	NA	
596	111103	2	Flow Start-Up (8)	1.125	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	19.9	NA	NA	Imm	0.5	NA	NA	NA	NA	
597	111103	1	Flow Start-Up (18)	1.125	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	20.1	NA	NA	DNR	Imm	NA	NA	NA	NA	
598	111103	2	Flow Start-Up (18)	1.125	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	20.2	NA	NA	DNR	Imm	NA	NA	NA	NA	
599	111103	1	Flow Increase	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21	DNR	4	NA	NA	NA	NA	NA	NA	
600	111103	2	Flow Increase	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.3	DNR	4	NA	NA	NA	NA	NA	NA	
601	111103	1	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.6	NA	NA	DNR	Imm	NA	NA	NA	NA	Air out of tube in 30 sec
602	111103	2	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.8	NA	NA	DNR	Imm	NA	NA	NA	NA	Air out of tube in 30 sec
603	111104	1	Flow Start-Up (4)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	22.7	NA	NA	DNR	DNR	NA	NA	NA	NA	
604	111104	2	Flow Start-Up (4)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	23	NA	NA	DNR	DNR	NA	NA	NA	NA	
605	111104	1	Flow Start-Up (6)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25	NA	NA	Imm	DNR	NA	NA	NA	NA	
606	111104	2	Flow Start-Up (6)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.3	NA	NA	Imm	DNR	NA	NA	NA	NA	
607	111104	1	Flow Start-Up (8)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.6	NA	NA	Imm	DNR	NA	NA	NA	NA	
608	111104	2	Flow Start-Up (8)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.9	NA	NA	Imm	DNR	NA	NA	NA	NA	
609	111107	1	Flow Start-Up (10)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	24.2	NA	NA	Imm	DNR	NA	NA	NA	NA	
610	111107	2	Flow Start-Up (10)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	24.5	NA	NA	Imm	DNR	NA	NA	NA	NA	
611	111107	1	Flow Start-Up (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25	NA	NA	Imm	3	NA	NA	NA	NA	
612	111107	2	Flow Start-Up (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.2	NA	NA	Imm	3	NA	NA	NA	NA	
613	111107	3	Flow Start-Up (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.3	NA	NA	Imm	3	NA	NA	NA	NA	
614	111108	1	Flow Start-Up (14)	2	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.4	NA	NA	Imm	0.75	NA	NA	NA	NA	
615	111108	2	Flow Start-Up (14)	2	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.4	NA	NA	Imm	0.75	NA	NA	NA	NA	
616	111108	1	Flow Start-Up (8)	1.125	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.5	NA	NA	DNR	Imm	NA	NA	NA	NA	
617	111108	2	Flow Start-Up (8)	1.125	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.7	NA	NA	DNR	Imm	NA	NA	NA	NA	
618	111109	1	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.7	DNR	4	NA	NA	NA	NA	NA	NA	
619	111109	2	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.2	4	8	NA	NA	NA	NA	NA	NA	
620	111109	3	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.6	2	8	NA	NA	NA	NA	NA	NA	
621	111109	1	Flow Start-Up (2)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.8	NA	NA	DNR	Imm	NA	NA	NA	NA	
622	111109	2	Flow Start-Up (2)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	26	NA	NA	DNR	Imm	NA	NA	NA	NA	
623	111109	3	Flow Start-Up (2)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	26	NA	NA	DNR	Imm	NA	NA	NA	NA	
624	111110	1	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.6	NA	NA	DNR	2	NA	NA	NA	NA	
625	111110	2	Flow Start-Up (2)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.9	NA	NA	1	2	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
1	110718	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.5	NA	NA	55	60	NA	NA	NA	NA	NA		
2	110718	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.7	NA	NA	55	60	NA	NA	NA	NA	NA		
3	110718	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.8	NA	NA	55	60	NA	NA	NA	NA	NA		
4	110718	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	NA	NA	52	58	NA	NA	NA	NA	NA		
5	110718	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.9	NA	NA	52	58	NA	NA	NA	NA	NA		
6	110719	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.6	NA	NA	52	58	NA	NA	NA	NA	NA		
7	110719	1	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.1	4.78	5.9261E+04	NA	NA	DNR	DNR	NA	NA	NA		
8	110719	2	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.2	4.78	5.9261E+04	NA	NA	DNR	DNR	NA	NA	NA		
9	110719	3	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.5	4.78	5.9261E+04	NA	NA	DNR	DNR	NA	NA	NA		
10	110719	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.4	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
11	110719	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
12	110719	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
13	110719	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.8	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
14	110719	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.3	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
15	110720	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.6	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
16	110720	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.0	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA		
17	110720	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA		
18	110720	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.1	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA		
19	110720	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.3	9.56	1.1852E+05	NA	NA	1.5	2.5	NA	NA	NA	Re-Verified Later	
20	110720	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.5	9.56	1.1852E+05	NA	NA	1.5	2.5	NA	NA	NA	Re-Verified Later	
21	110720	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.7	9.56	1.1852E+05	NA	NA	1.5	2.5	NA	NA	NA	Re-Verified Later	
22	110720	1	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.8	11.95	1.4815E+05	NA	NA	0.3	0.5	NA	NA	NA		
23	110720	2	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	36.9	11.95	1.4815E+05	NA	NA	0.3	0.5	NA	NA	NA		
24	110720	3	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.0	11.95	1.4815E+05	NA	NA	0.3	0.5	NA	NA	NA		
25	110720	1	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	14.34	1.7778E+05	NA	NA	DNR	Imm	NA	NA	NA		
26	110720	2	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	14.34	1.7778E+05	NA	NA	DNR	Imm	NA	NA	NA		
27	110720	3	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.2	14.34	1.7778E+05	NA	NA	DNR	Imm	NA	NA	NA		
28	110720	1	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.5	4.92	5.9261E+04	NA	NA	NA	NA	DNR	DNR	NA		
29	110720	2	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	31.8	4.92	5.9261E+04	NA	NA	NA	NA	DNR	DNR	NA		
30	110720	3	Increase Back Pressure with Maintained Flow (30)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.2	4.92	5.9261E+04	NA	NA	NA	NA	DNR	DNR	NA		
31	110720	1	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.4	7.39	8.8891E+04	NA	NA	NA	NA	45	DNR	NA		
32	110720	2	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	32.7	7.39	8.8891E+04	NA	NA	NA	NA	45	DNR	NA		
33	110720	3	Increase Back Pressure with Maintained Flow (45)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.2	7.39	8.8891E+04	NA	NA	NA	NA	45	DNR	NA		
34	110720	1	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.5	8.21	9.8768E+04	NA	NA	NA	NA	30	DNR	NA		
35	110720	2	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	33.9	8.21	9.8768E+04	NA	NA	NA	NA	30	DNR	NA		
36	110720	3	Increase Back Pressure with Maintained Flow (50)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.2	8.21	9.8768E+04	NA	NA	NA	NA	30	DNR	NA		
37	110720	1	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.6	9.86	1.8152E+05	NA	NA	NA	NA	2	30	NA		
38	110720	2	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	34.9	9.86	1.8152E+05	NA	NA	NA	NA	2	30	NA		
39	110720	3	Increase Back Pressure with Maintained Flow (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	35.3	9.86	1.8152E+05	NA	NA	NA	NA	2	30	NA		
40	110720	1	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.8	4.92	5.9261E+04	NA	NA	NA	NA	NA	2	3		
41	110720	2	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	38.0	4.92	5.9261E+04	NA	NA	NA	NA	NA	2	3		
42	110720	3	Maintain Back Pressure with Maintained Flow (30, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	38.1	4.92	5.9261E+04	NA	NA	NA	NA	NA	2	3		
43	110720	1	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.1	9.86	1.8152E+05	NA	NA	NA	NA	NA	1.5	3		
44	110720	2	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.3	9.86	1.8152E+05	NA	NA	NA	NA	NA	1.5	4		
45	110720	3	Maintain Back Pressure with Maintained Flow (60, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	37.4	9.86	1.8152E+05	NA	NA	NA	NA	NA	1.5	5		
46	110721	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.4	NA	NA	55	65	NA	NA	NA	NA	NA		
47	110721	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	34.9	NA	NA	55	65	NA	NA	NA	NA	NA		
48	110721	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.3	NA	NA	55	65	NA	NA	NA	NA	NA		
49	110721	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	35.8	NA	NA	60	65	NA	NA	NA	NA	NA		
50	110721	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.3	NA	NA	60	65	NA	NA	NA	NA	NA		
51	110721	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	45	PP	36.8	NA	NA	60	65	NA	NA	NA	NA	NA		
52	110721	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.3	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
53	110721	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.5	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
54	110721	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	45	PP	37.7	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
55	110721	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	45	PP	38.0	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
56	110721	2																						

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
67	110725	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	28.7	NA	NA	55	75	NA	NA	NA	NA	NA		
68	110725	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	29.2	NA	NA	55	75	NA	NA	NA	NA	NA		
69	110725	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	90	PP	29.7	NA	NA	55	75	NA	NA	NA	NA	NA		
70	110725	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.0	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
71	110725	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.3	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
72	110725	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.5	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
73	110725	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	30.8	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
74	110725	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31.0	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
75	110725	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31.3	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
76	110725	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	31.6	8.77	1.0864E+05	NA	NA	3	DNR	NA	NA	NA		
77	110725	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.0	8.77	1.0864E+05	NA	NA	3	DNR	NA	NA	NA		
78	110725	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.3	8.77	1.0864E+05	NA	NA	3	DNR	NA	NA	NA		
79	110725	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.6	9.56	1.1852E+05	NA	NA	1	4	NA	NA	NA		
80	110725	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	32.9	9.56	1.1852E+05	NA	NA	1	4	NA	NA	NA		
81	110725	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	90	PP	33.1	9.56	1.1852E+05	NA	NA	1	4	NA	NA	NA		
82	110725	1	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.6	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
83	110725	2	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.5	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
84	110725	3	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	135	PP	32.5	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
85	110725	1	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
86	110725	2	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
87	110725	3	Flow Maintain (30)	4	Straight	2	Horizontal	NA	NA	0	180	PP	32.2	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA		
88	110726	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	28.8	NA	NA	60	75	NA	NA	NA	NA	NA		
89	110726	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	29.3	NA	NA	60	75	NA	NA	NA	NA	NA		
90	110726	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	29.7	NA	NA	60	75	NA	NA	NA	NA	NA		
91	110726	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	30.1	NA	NA	58	DNR	NA	NA	NA	NA	NA		
92	110726	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	30.5	NA	NA	58	DNR	NA	NA	NA	NA	NA		
93	110726	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	30.8	NA	NA	58	DNR	NA	NA	NA	NA	NA		
94	110726	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	31.1	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
95	110726	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	31.4	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
96	110726	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	31.7	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
97	110726	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	32.0	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
98	110726	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	32.4	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
99	110726	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	32.7	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
100	110726	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	33.2	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
101	110726	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	33.6	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
102	110726	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	34.0	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
103	110726	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	34.4	9.56	1.1852E+05	NA	NA	3	5	NA	NA	NA		
104	110726	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	34.7	9.56	1.1852E+05	NA	NA	3	5	NA	NA	NA		
105	110726	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	0	PP	34.9	9.56	1.1852E+05	NA	NA	3	5	NA	NA	NA		
106	110726	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	34.9	NA	NA	60	75	NA	NA	NA	NA	NA		
107	110726	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	34.4	NA	NA	60	75	NA	NA	NA	NA	NA		
108	110726	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	35.4	NA	NA	60	75	NA	NA	NA	NA	NA		
109	110726	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	35.8	NA	NA	58	DNR	NA	NA	NA	NA	NA		
110	110726	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	36.1	NA	NA	58	DNR	NA	NA	NA	NA	NA		
111	110726	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	36.5	NA	NA	58	DNR	NA	NA	NA	NA	NA		
112	110726	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	37.1	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
113	110726	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	37.3	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
114	110726	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	37.6	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA		
115	110726	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	37.8	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
116	110726	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	38.2	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
117	110726	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	38.5	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA		
118	110727	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	32.4	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
119	110727	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	32.8	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
120	110727	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	33.3	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA		
121	110727	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	45	PP	33.7	9.56	1.1852E+05	NA	NA	3	DNR	NA	NA			

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
133	110727	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	38.0	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
134	110727	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	38.3	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
135	110727	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	38.7	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
136	110727	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	39.0	8.77	1.0864E+05	NA	NA	2	DNR	NA	NA	NA	NA	
137	110727	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	39.3	8.77	1.0864E+05	NA	NA	2	DNR	NA	NA	NA	NA	
138	110727	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	39.5	8.77	1.0864E+05	NA	NA	2	DNR	NA	NA	NA	NA	
139	110727	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	39.8	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
140	110727	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	40.0	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
141	110727	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0.01042	90	PP	40.1	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
142	110728	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	34.0	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
143	110728	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	34.3	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
144	110728	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	34.6	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
145	110728	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	35.0	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
146	110728	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	35.3	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
147	110728	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	35.5	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
148	110728	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	35.9	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
149	110728	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	36.0	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
150	110728	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	36.2	7.18	8.8891E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
151	110728	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	36.5	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
152	110728	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	36.9	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
153	110728	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	37.2	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
154	110728	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	37.5	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA	NA	
155	110728	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	37.5	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA	NA	
156	110728	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	37.9	8.77	1.0864E+05	NA	NA	5	DNR	NA	NA	NA	NA	
157	110728	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	38.3	9.56	1.1852E+05	NA	NA	3	4	NA	NA	NA	NA	
158	110728	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	38.5	9.56	1.1852E+05	NA	NA	3	4	NA	NA	NA	NA	
159	110728	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	0	PP	38.3	9.56	1.1852E+05	NA	NA	3	4	NA	NA	NA	NA	
160	110728	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	38.4	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
161	110728	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	38.9	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
162	110729	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	39.2	NA	NA	60	75	NA	NA	NA	NA	NA	NA	
163	110729	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	32.9	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
164	110729	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	33.3	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
165	110729	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	33.7	NA	NA	58	DNR	NA	NA	NA	NA	NA	NA	
166	110729	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	34.1	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
167	110729	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	34.3	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
168	110729	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	34.6	7.97	9.8768E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
169	110729	1	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	34.9	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA	NA	
170	110729	2	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	35.3	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA	NA	
171	110729	3	Flow Maintain (55)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	35.8	8.77	1.0864E+05	NA	NA	6	DNR	NA	NA	NA	NA	
172	110729	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	36.2	9.56	1.1852E+05	NA	NA	2	DNR	NA	NA	NA	NA	
173	110729	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	36.3	9.56	1.1852E+05	NA	NA	2	DNR	NA	NA	NA	NA	
174	110729	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	45	PP	36.7	9.56	1.1852E+05	NA	NA	2	DNR	NA	NA	NA	NA	
175	110729	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	37.2	NA	NA	50	75	NA	NA	NA	NA	NA	NA	
176	110729	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	27.6	NA	NA	50	75	NA	NA	NA	NA	NA	NA	
177	110801	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	28.1	NA	NA	50	75	NA	NA	NA	NA	NA	NA	
178	110801	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	28.5	7.97	9.8768E+04	NA	NA	2	DNR	NA	NA	NA	NA	
179	110801	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	28.7	7.97	9.8768E+04	NA	NA	2	DNR	NA	NA	NA	NA	
180	110801	3	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	29.1	7.97	9.8768E+04	NA	NA	2	DNR	NA	NA	NA	NA	
181	110801	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	28.5	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
182	110801	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	28.7	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
183	110801	3	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	-0.0104	90	PP	29.1	9.56	1.1852E+05	NA	NA	1	3	NA	NA	NA	NA	
184	110801	1	Flow Maintain (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	29.3	9.86	1.8152E+05	NA	NA	3	6	NA	NA	NA	NA	
185	110801	2	Flow Maintain (verification, 60)	4	Straight	2	Horizontal	NA	NA	0	0	PP												

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
199	110802	1	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	45	PP	31.2	9.86	1.2033E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
200	110802	2	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	45	PP	31.6	9.86	1.2033E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
201	110802	3	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	45	PP	31.6	9.86	1.2033E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
202	110802	1	Flow Maintain (30)	3.375	Straight	2	Horizontal	NA	NA	0	90	PP	31.6	4.92	6.0163E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
203	110802	2	Flow Maintain (30)	3.375	Straight	2	Horizontal	NA	NA	0	90	PP	31.9	4.92	6.0163E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
204	110802	3	Flow Maintain (30)	3.375	Straight	2	Horizontal	NA	NA	0	90	PP	31.8	4.92	6.0163E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
205	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	25.4	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
206	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	25.9	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
207	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	26.3	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
208	110809	1	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	26.9	4.78	5.9261E+04	NA	NA	DNR	2	NA	NA	NA	NA	
209	110809	2	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.0	4.78	5.9261E+04	NA	NA	DNR	2	NA	NA	NA	NA	
210	110809	3	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.2	4.78	5.9261E+04	NA	NA	DNR	2	NA	NA	NA	NA	
211	110809	1	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.4	7.18	8.8891E+04	NA	NA	DNR	1.5	NA	NA	NA	NA	
212	110809	2	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.5	7.18	8.8891E+04	NA	NA	DNR	1.5	NA	NA	NA	NA	
213	110809	3	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.6	7.18	8.8891E+04	NA	NA	DNR	1.5	NA	NA	NA	NA	
214	110809	1	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.7	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
215	110809	2	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.8	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
216	110809	3	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	27.9	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
217	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	28.1	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
218	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	28.3	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
219	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	28.6	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
220	110809	1	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.0	4.78	5.9261E+04	NA	NA	DNR	1	NA	NA	NA	NA	
221	110809	2	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.0	4.78	5.9261E+04	NA	NA	DNR	1	NA	NA	NA	NA	
222	110809	3	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.1	4.78	5.9261E+04	NA	NA	DNR	1	NA	NA	NA	NA	
223	110809	1	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.2	7.18	8.8891E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
224	110809	2	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.2	7.18	8.8891E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
225	110809	3	Flow Maintain (45)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.3	7.18	8.8891E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
226	110809	1	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.4	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
227	110809	2	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.4	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
228	110809	3	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	-0.0104	0	PP	29.4	9.56	1.1852E+05	NA	NA	DNR	Imm	NA	NA	NA	NA	
229	110809	1	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0.01042	0	PP	29.6	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
230	110809	2	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0.01042	0	PP	30.0	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
231	110809	3	Flow Increase	4	Straight	2	Vertical	Top-Bottom	NA	0.01042	0	PP	30.2	NA	NA	DNR	45	NA	NA	NA	NA	NA	NA	
232	110812	1	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.3	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
233	110812	2	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.4	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
234	110812	3	Flow Increase (Initial)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	27.5	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
235	110812	1	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	28.2	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
236	110812	2	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	28.6	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
237	110812	3	Flow Increase (Selected)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	29.0	NA	NA	150	DNR	NA	NA	NA	NA	NA	NA	
238	110812	1	Flow Maintain (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	29.4	24.64	2.5908E+05	NA	NA	1	3	NA	NA	NA	NA	
239	110812	2	Flow Maintain (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	30.5	24.64	2.5908E+05	NA	NA	1	3	NA	NA	NA	NA	
240	110812	3	Flow Maintain (150)	4	Straight	2	Horizontal	NA	NA	0	0	PVC	31.0	24.64	2.5908E+05	NA	NA	1	3	NA	NA	NA	NA	
241	110812	1	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	31.8	NA	NA	DNR	90	NA	NA	NA	NA	NA	NA	
242	110812	2	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	32.2	NA	NA	DNR	90	NA	NA	NA	NA	NA	NA	
243	110812	3	Flow Increase	4	Straight	2	Horizontal	NA	NA	0	45	PVC	32.4	NA	NA	DNR	90	NA	NA	NA	NA	NA	NA	
244	110812	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	7.39	7.7724E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
245	110812	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	7.39	7.7724E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
246	110812	3	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PVC	32.7	7.39	7.7724E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
247	110812	1	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26.0	9.86	1.0136E+05	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
248	110812	2	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26.5	9.86	1.0136E+05	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
249	110812	3	Flow Maintain (60)	3.375	Straight	2	Horizontal	NA	NA	0	0	SS	26.8	9.86	1.0136E+05	NA	NA	2	4.5	NA	NA	NA	NA	Similar to PP tests
250	110818	1	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	0.01042	0	PP	24.3	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
251	110818	2	Flow Maintain (30)	4	Straight	2	Vertical	Top-Bottom	NA	0.01042	0	PP	24.4	4.78	5.9261E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
252	110818	3	Flow Maintain (30)	4																				

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
265	110819	1	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	28.3	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
266	110819	2	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	28.7	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
267	110819	3	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	28.9	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
268	110819	1	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	29.3	7.18	8.8891E+04	NA	NA	1	DNR	NA	NA	NA	NA	
269	110819	2	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	30.0	7.18	8.8891E+04	NA	NA	1	DNR	NA	NA	NA	NA	
270	110819	3	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	30.5	7.18	8.8891E+04	NA	NA	1	DNR	NA	NA	NA	NA	
271	110822	1	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	25.7	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
272	110822	2	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	26.0	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
273	110822	3	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	0.01042	0	PP	26.1	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
274	110822	1	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	26.3	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
275	110822	2	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	26.6	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
276	110822	3	Flow Increase	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	26.8	NA	NA	45	60	NA	NA	NA	NA	NA	NA	
277	110822	1	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	27.3	7.18	8.8891E+04	NA	NA	2	6	NA	NA	NA	NA	
278	110822	2	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	27.7	7.18	8.8891E+04	NA	NA	2	6	NA	NA	NA	NA	
279	110822	3	Flow Maintain (45)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	28.2	7.18	8.8891E+04	NA	NA	2	6	NA	NA	NA	NA	
280	110822	1	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	28.7	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
281	110822	2	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	28.7	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
282	110822	3	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	-0.0104	0	PP	28.9	9.56	1.1852E+05	NA	NA	1	1.5	NA	NA	NA	NA	
283	110823	1	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.4	NA	NA	35	40	NA	NA	NA	NA	NA	NA	
284	110823	2	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.6	NA	NA	35	40	NA	NA	NA	NA	NA	NA	
285	110823	3	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	27.7	NA	NA	35	40	NA	NA	NA	NA	NA	NA	
286	110823	1	Flow Maintain (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.0	5.01	6.0663E+04	NA	NA	5	DNR	NA	NA	NA	NA	
287	110823	2	Flow Maintain (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.3	5.01	6.0663E+04	NA	NA	5	DNR	NA	NA	NA	NA	
288	110823	3	Flow Maintain (30)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.5	5.01	6.0663E+04	NA	NA	5	DNR	NA	NA	NA	NA	
289	110823	1	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.7	6.68	8.0884E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
290	110823	2	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.8	6.68	8.0884E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
291	110823	3	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Up	0	0	PP	28.9	6.68	8.0884E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
292	110823	1	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.1	NA	NA	35	50	NA	NA	NA	NA	NA	NA	
293	110823	2	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.2	NA	NA	35	50	NA	NA	NA	NA	NA	NA	
294	110823	3	Flow Increase	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.5	NA	NA	35	50	NA	NA	NA	NA	NA	NA	
295	110823	1	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	29.9	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
296	110823	2	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.1	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
297	110823	3	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.4	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
298	110823	1	Flow Maintain (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	30.8	8.35	1.0110E+05	NA	NA	Imm	4.5	NA	NA	NA	NA	
299	110823	2	Flow Maintain (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	31.1	8.35	1.0110E+05	NA	NA	Imm	4.5	NA	NA	NA	NA	
300	110823	3	Flow Maintain (50)	4	Elbow	2	Vertical	Up, Horizontal	Horizontal	0	0	PP	31.3	8.35	1.0110E+05	NA	NA	Imm	4.5	NA	NA	NA	NA	
301	110824	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.1	NA	NA	15	30	NA	NA	NA	NA	NA	NA	
302	110824	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.3	NA	NA	15	30	NA	NA	NA	NA	NA	NA	
303	110824	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.5	NA	NA	15	30	NA	NA	NA	NA	NA	NA	
304	110824	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.5	NA	NA	30	45	NA	NA	NA	NA	NA	NA	
305	110824	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.6	NA	NA	30	45	NA	NA	NA	NA	NA	NA	
306	110824	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.8	NA	NA	30	45	NA	NA	NA	NA	NA	NA	
307	110824	1	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	28.9	5.01	6.0663E+04	NA	NA	1	2	NA	NA	NA	NA	
308	110824	2	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.1	5.01	6.0663E+04	NA	NA	1	2	NA	NA	NA	NA	
309	110824	3	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.1	5.01	6.0663E+04	NA	NA	1	2	NA	NA	NA	NA	
310	110824	1	Flow Maintain (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
311	110824	2	Flow Maintain (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
312	110824	3	Flow Maintain (45)	4	Elbow	2	Vertical	Horizontal, Up	Horizontal	0	0	PP	29.3	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
313	110825	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	27.7	NA	NA	100	120	NA	NA	NA	NA	NA	NA	
314	110825	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	28.3	NA	NA	100	120	NA	NA	NA	NA	NA	NA	
315	110825	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	28.7	NA	NA	100	120	NA	NA	NA	NA	NA	NA	
316	110825	1	Flow Maintain (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	29.2	15.03	1.8199E+05	NA	NA	4	DNR	NA	NA	NA	NA	
317	110825	2	Flow Maintain (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP	29.6	15.03	1.8199E+05	NA	NA	4	DNR	NA	NA	NA	NA	
318	110825	3	Flow Maintain (90)	4	Elbow	2	Vertical	Horizontal, Down	Up	0	0	PP												

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
331	110825	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.2	NA	NA	15	30	NA	NA	NA	NA	NA		
332	110825	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	NA	NA	15	30	NA	NA	NA	NA	NA		
333	110825	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	NA	NA	15	30	NA	NA	NA	NA	NA		
334	110825	1	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.1	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
335	110825	2	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
336	110825	3	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0	0	PP	33.3	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
337	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.6	NA	NA	15	30	NA	NA	NA	NA	NA		
338	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.8	NA	NA	15	30	NA	NA	NA	NA	NA		
339	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	24.0	NA	NA	15	30	NA	NA	NA	NA	NA		
340	110830	1	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	24.3	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
341	110830	2	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	24.3	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
342	110830	3	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	0.01042	0	PP	24.4	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
343	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	24.5	NA	NA	15	30	NA	NA	NA	NA	NA		
344	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	24.9	NA	NA	15	30	NA	NA	NA	NA	NA		
345	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	24.9	NA	NA	15	30	NA	NA	NA	NA	NA		
346	110830	1	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	25.1	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
347	110830	2	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	25.1	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
348	110830	3	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	25.2	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
349	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	25.5	NA	NA	45	50	NA	NA	NA	NA	NA		
350	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	25.8	NA	NA	45	50	NA	NA	NA	NA	NA		
351	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	26.2	NA	NA	45	50	NA	NA	NA	NA	NA		
352	110830	1	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	26.6	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
353	110830	2	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	27.1	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
354	110830	3	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	27.4	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
355	110830	1	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	27.7	7.52	9.0994E+04	NA	NA	Imm	4	NA	NA	NA	Hiccup, Dropped 10	
356	110830	2	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	28.4	7.52	9.0994E+04	NA	NA	Imm	4	NA	NA	NA	Hiccup, Dropped 10	
357	110830	3	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	-0.0104	0	PP	28.6	7.52	9.0994E+04	NA	NA	Imm	4	NA	NA	NA		
358	110830	1	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	29.0	NA	NA	45	50	NA	NA	NA	NA	NA		
359	110830	2	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	29.3	NA	NA	45	50	NA	NA	NA	NA	NA		
360	110830	3	Flow Increase	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	29.6	NA	NA	45	50	NA	NA	NA	NA	NA		
361	110831	1	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	27.2	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
362	110831	2	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	27.6	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
363	110831	3	Flow Maintain (30)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	27.9	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
364	110831	1	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	28.1	7.52	9.0994E+04	NA	NA	1	4	NA	NA	NA		
365	110831	2	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	28.3	7.52	9.0994E+04	NA	NA	1	4	NA	NA	NA		
366	110831	3	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0.01042	0	PP	28.7	7.52	9.0994E+04	NA	NA	1	4	NA	NA	NA		
367	110831	1	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	28.7	NA	NA	DNR	30	NA	NA	NA	NA	NA		
368	110831	2	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.0	NA	NA	DNR	30	NA	NA	NA	NA	NA		
369	110831	3	Flow Increase	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	NA	NA	DNR	30	NA	NA	NA	NA	NA		
370	110831	1	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
371	110831	2	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
372	110831	3	Flow Maintain (30)	4	Elbow	2	Vertical	Horizontal, Down	Horizontal	0	0	PP	29.2	5.01	6.0663E+04	NA	NA	DNR	Imm	NA	NA	NA		
373	110831	1	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.3	NA	NA	DNR	45	NA	NA	NA	NA	NA		
374	110831	2	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.5	NA	NA	DNR	45	NA	NA	NA	NA	NA		
375	110831	3	Flow Increase	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	29.7	NA	NA	DNR	45	NA	NA	NA	NA	NA		
376	110831	1	Flow Maintain (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.0	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
377	110831	2	Flow Maintain (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.2	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
378	110831	3	Flow Maintain (30)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.5	5.01	6.0663E+04	NA	NA	DNR	DNR	NA	NA	NA		
379	110831	1	Flow Maintain (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA		
380	110831	2	Flow Maintain (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA		
381	110831	3	Flow Maintain (45)	4	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.6	7.52	9.0994E+04	NA	NA	DNR	Imm	NA	NA	NA		
382	110831	1	Flow Maintain (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	5.03	6.0779E+04	NA	NA	DNR	Imm	NA	NA	NA		
383	110831	2	Flow Maintain (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	5.03	6.0779E+04	NA	NA	DNR	Imm	NA	NA	NA		
384	110831	3	Flow Maintain (30)	1.625	Elbow	2	Vertical	Down, Horizontal	Horizontal	0	0	PP	30.9	5.03	6.0779E+04	NA	NA	DNR	Imm	NA	NA	NA		
385	110913	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.7	NA	NA	10	12	NA	NA	NA	NA	NA		

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
397	110917	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	24.9	10.77	5.1340E+04	NA	NA	Imm	4.5	NA	NA	NA	NA	
398	110917	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.1	10.77	5.1340E+04	NA	NA	Imm	4.5	NA	NA	NA	NA	
399	110917	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.3	10.77	5.1340E+04	NA	NA	Imm	4.5	NA	NA	NA	NA	
400	110917	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.3	12.92	6.1608E+04	NA	NA	Imm	1	NA	NA	NA	NA	
401	110917	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.4	12.92	6.1608E+04	NA	NA	Imm	1	NA	NA	NA	NA	
402	110917	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	25.5	12.92	6.1608E+04	NA	NA	Imm	1	NA	NA	NA	NA	
403	110917	1	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.1			NA	NA	NA	NA	DNR	DNR	NA	NA	
404	110917	2	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.6			NA	NA	NA	NA	DNR	DNR	NA	NA	
405	110917	3	Pressure Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.0			NA	NA	NA	NA	DNR	DNR	NA	NA	
406	110922	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	22.6	NA	NA	10	12	NA	NA	NA	NA	NA	NA	Gasket Blocking Flow Meter
407	110922	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.0	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
408	110922	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.3	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
409	110922	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.4	10.77	5.1340E+04	NA	NA	0.5	1	NA	NA	NA	NA	
410	110922	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.4	10.77	5.1340E+04	NA	NA	0.5	2	NA	NA	NA	NA	
411	110922	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.5	10.77	5.1340E+04	NA	NA	0.5	3	NA	NA	NA	NA	
412	110922	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.5	12.92	6.1608E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
413	110922	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.6	12.92	6.1608E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
414	110922	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	23.7	12.92	6.1608E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
415	110923	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	24.5	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
416	110923	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	25.2	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
417	110923	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	25.8	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
418	110923	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.1	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
419	110923	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.4	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
420	110923	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.6	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
421	110923	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.7	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
422	110923	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.7	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
423	110923	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	0	PP	26.7	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
424	110926	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	24.3	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
425	110926	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	25.0	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
426	110926	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	25.7	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
427	110926	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	26.4	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
428	110926	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	26.6	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
429	110926	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	26.8	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
430	110926	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	27.0	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
431	110926	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	27.0	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
432	110926	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	45	PP	27.0	12.92	6.1608E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
433	110927	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	26.5	NA	NA	DNR	10	NA	NA	NA	NA	NA	NA	
434	110927	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	26.9	NA	NA	DNR	10	NA	NA	NA	NA	NA	NA	
435	110927	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	27.1	NA	NA	DNR	10	NA	NA	NA	NA	NA	NA	
436	110928	1	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	25.4	8.61	4.1072E+04	NA	NA	4	5	NA	NA	NA	NA	Tiny stationary bubbles clinging to branch leg wall
437	110928	2	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	25.7	8.61	4.1072E+04	NA	NA	4	5	NA	NA	NA	NA	
438	110928	3	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	26.0	8.61	4.1072E+04	NA	NA	4	5	NA	NA	NA	NA	
439	110928	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	24.5	10.77	5.1340E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
440	110928	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	25.0	10.77	5.1340E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
441	110928	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0.01042	90	PP	25.0	10.77	5.1340E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
442	110929	1	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	25.0	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
443	110929	2	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	25.3	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
444	110929	3	Flow Increase	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	25.8	NA	NA	10	12	NA	NA	NA	NA	NA	NA	
445	110929	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	25.8	10.77	5.1340E+04	NA	NA	Imm	5	NA	NA	NA	NA	
446	110929	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	26.0	10.77	5.1340E+04	NA	NA	Imm	5	NA	NA	NA	NA	
447	110929	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	26.2	10.77	5.1340E+04	NA	NA	Imm	5	NA	NA	NA	NA	
448	110929	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	0	PP	26.4											

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
463	110930	1	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	27.5	8.61	4.1072E+04	NA	NA	1	NA	NA	NA	NA	NA	Would Not Clear after 5 Seems like the threshold is about 8.25
464	110930	2	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	27.5	8.61	4.1072E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
465	110930	3	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	27.7	8.61	4.1072E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
466	110930	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	26.9	10.77	5.1340E+04	NA	NA	Imm	1	NA	NA	NA	NA	
467	110930	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	27.0	10.77	5.1340E+04	NA	NA	Imm	1	NA	NA	NA	NA	
468	110930	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	-0.0104	90	PP	27.1	10.77	5.1340E+04	NA	NA	Imm	1	NA	NA	NA	NA	
469	111001	1	Flow Maintain (8)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.3	8.61	4.0939E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
470	111001	2	Flow Maintain (8)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	25.8	8.61	4.0939E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
471	111001	1	Flow Maintain (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.0	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
472	111001	2	Flow Maintain (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.2	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
473	111001	1	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.5	12.92	6.1409E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
474	111001	2	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	26.8	12.92	6.1409E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
475	111001	1	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.3	16.15	7.6761E+04	NA	NA	Imm	2	NA	NA	NA	NA	
476	111001	2	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.4	16.15	7.6761E+04	NA	NA	Imm	2	NA	NA	NA	NA	
477	111001	3	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	0	PP	27.5	16.15	7.6761E+04	NA	NA	Imm	2	NA	NA	NA	NA	
478	111001	1	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.6	16.15	7.6761E+04	NA	NA	Imm	1	NA	NA	NA	NA	
479	111001	2	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.6	16.15	7.6761E+04	NA	NA	Imm	1	NA	NA	NA	NA	
480	111001	3	Flow Maintain (15)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.7	16.15	7.6761E+04	NA	NA	Imm	1	NA	NA	NA	NA	
481	111001	1	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	27.9	12.92	6.1409E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
482	111001	2	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.1	12.92	6.1409E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
483	111001	3	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	45	PP	28.4	12.92	6.1409E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
484	111001	1	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.0	12.92	6.1409E+04	NA	NA	Imm	2	NA	NA	NA	NA	
485	111001	2	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.1	12.92	6.1409E+04	NA	NA	Imm	2	NA	NA	NA	NA	
486	111001	3	Flow Maintain (12)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.3	12.92	6.1409E+04	NA	NA	Imm	2	NA	NA	NA	NA	
487	111001	1	Flow Maintain (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.5	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
488	111001	2	Flow Maintain (10)	1.125	Straight	0.75	Horizontal	NA	NA	0	90	PP	29.7	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
489	111003	1	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	23.9	NA	NA	14	18	NA	NA	NA	NA	NA	NA	
490	111003	2	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	24.7	NA	NA	14	18	NA	NA	NA	NA	NA	NA	
491	111003	3	Flow Increase	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.2	NA	NA	14	18	NA	NA	NA	NA	NA	NA	
492	111003	1	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.5	10.66	6.4624E+04	NA	NA	Imm	2	NA	NA	NA	NA	
493	111003	2	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.6	10.66	6.4624E+04	NA	NA	Imm	2	NA	NA	NA	NA	
494	111003	3	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	0	PP	25.8	10.66	6.4624E+04	NA	NA	Imm	2	NA	NA	NA	NA	
495	111003	1	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	0	PP	26.3	9.33	5.6546E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
496	111003	2	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	0	PP	26.5	9.33	5.6546E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
497	111003	1	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.6	10.66	6.4624E+04	NA	NA	Imm	3	NA	NA	NA	NA	
498	111003	2	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.7	10.66	6.4624E+04	NA	NA	Imm	3	NA	NA	NA	NA	
499	111003	3	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	45	PP	26.9	10.66	6.4624E+04	NA	NA	Imm	3	NA	NA	NA	NA	
500	111003	1	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	45	PP	27.2	9.33	5.6546E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
501	111003	2	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	45	PP	27.5	9.33	5.6546E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
502	111003	1	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	10.66	6.4624E+04	NA	NA	Imm	1	NA	NA	NA	NA	
503	111003	2	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	10.66	6.4624E+04	NA	NA	Imm	1	NA	NA	NA	NA	
504	111003	3	Flow Maintain (16)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.6	10.66	6.4624E+04	NA	NA	Imm	1	NA	NA	NA	NA	
505	111003	1	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.8	9.33	5.6546E+04	NA	NA	Imm	2	NA	NA	NA	NA	
506	111003	2	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	27.9	9.33	5.6546E+04	NA	NA	Imm	2	NA	NA	NA	NA	
507	111003	3	Flow Maintain (14)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.0	9.33	5.6546E+04	NA	NA	Imm	2	NA	NA	NA	NA	
508	111003	1	Flow Maintain (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.2	8.00	4.8468E+04	NA	NA	Imm	3	NA	NA	NA	NA	
509	111003	2	Flow Maintain (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.3	8.00	4.8468E+04	NA	NA	Imm	3	NA	NA	NA	NA	
510	111003	3	Flow Maintain (12)	2	Straight	1	Horizontal	NA	NA	0	90	PP	28.4	8.00	4.8468E+04	NA	NA	Imm	3	NA	NA	NA	NA	
511	111004	1	Flow Maintain (16)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.0	10.58	6.4378E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
512	111004	1	Flow Maintain (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.3	11.90	7.2425E+04	NA	NA	Imm	5	NA	NA	NA	NA	
513	111004	2	Flow Maintain (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.6	11.90	7.2425E+04	NA	NA	Imm	5	NA	NA	NA	NA	
514	111004	3	Flow Maintain (18)	1.125	Straight	1	Horizontal	NA	NA	0	0	PP	25.8	11.90	7.2425E+04	NA	NA	Imm	5	NA	NA	NA	NA	
515	111004	1	Flow Maintain (18)	1.125	Straight	1	Horizontal	NA	NA	0	45	PP	26.0	11.90	7.2425E+04	NA	NA	3	5	NA	NA	NA		

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
529	111007	3	Flow Maintain (10)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	21.9	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
530	111007	1	Flow Maintain (10)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.2	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
531	111007	2	Flow Maintain (10)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.4	10.77	5.1174E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
532	111007	1	Flow Maintain (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.6	12.92	6.1409E+04	NA	NA	Imm	4	NA	NA	NA	NA	
533	111007	2	Flow Maintain (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	22.9	12.92	6.1409E+04	NA	NA	Imm	6	NA	NA	NA	NA	
534	111007	3	Flow Maintain (12)	1.125	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	23.1	12.92	6.1409E+04	NA	NA	Imm	5	NA	NA	NA	NA	
535	111011	1	Flow Maintain (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.5	10.66	6.4624E+04	NA	NA	1	2	NA	NA	NA	NA	
536	111011	2	Flow Maintain (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.7	10.66	6.4624E+04	NA	NA	1	2	NA	NA	NA	NA	
537	111011	3	Flow Maintain (16)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	21.9	10.66	6.4624E+04	NA	NA	1	2	NA	NA	NA	NA	
538	111011	1	Flow Maintain (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.1	9.99	6.0585E+04	NA	NA	1	4	NA	NA	NA	NA	
539	111011	2	Flow Maintain (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.4	9.99	6.0585E+04	NA	NA	1	4	NA	NA	NA	NA	
540	111011	3	Flow Maintain (15)	2	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	22.6	9.99	6.0585E+04	NA	NA	1	4	NA	NA	NA	NA	
541	111011	1	Flow Maintain (15)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	23.0	9.92	6.0354E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
542	111011	1	Flow Maintain (19)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	23.7	12.56	7.6448E+04	NA	NA	4	NA	NA	NA	NA	NA	
543	111011	1	Flow Maintain (20)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	24.0	13.22	8.0472E+04	NA	NA	3	4	NA	NA	NA	NA	
544	111011	2	Flow Maintain (20)	1.125	Straight	1	Vertical	Bottom-Top	NA	0	0	PP	24.2	13.22	8.0472E+04	NA	NA	3	4	NA	NA	NA	NA	
545	111014	1	Flow Maintain (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.5	6.66	4.0390E+04	NA	NA	Imm	1	NA	NA	NA	NA	
546	111014	2	Flow Maintain (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.6	6.66	4.0390E+04	NA	NA	Imm	1	NA	NA	NA	NA	
547	111014	3	Flow Maintain (10)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	21.8	6.66	4.0390E+04	NA	NA	Imm	1	NA	NA	NA	NA	
548	111017	1	Flow Maintain (8)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.2	5.33	9.2312E+04	NA	NA	1	DNR	NA	NA	NA	NA	
549	111017	2	Flow Maintain (8)	2	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.6	5.33	9.2312E+04	NA	NA	1	DNR	NA	NA	NA	NA	
550	111017	1	Flow Maintain (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.8	5.29	3.2189E+04	NA	NA	Imm	1	NA	NA	NA	NA	
551	111017	2	Flow Maintain (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.7	5.29	3.2189E+04	NA	NA	Imm	1	NA	NA	NA	NA	
552	111017	3	Flow Maintain (8)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	24.7	5.29	3.2189E+04	NA	NA	Imm	1	NA	NA	NA	NA	
553	111017	1	Flow Maintain (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.3	3.97	2.4142E+04	NA	NA	1	DNR	NA	NA	NA	NA	
554	111017	2	Flow Maintain (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.6	3.97	2.4142E+04	NA	NA	1	5	NA	NA	NA	NA	
555	111017	3	Flow Maintain (6)	1.125	Straight	1	Vertical	Top-Bottom	NA	0	0	PP	25.7	3.97	2.4142E+04	NA	NA	1	5	NA	NA	NA	NA	
556	111019	1	Flow Maintain (6)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.5	6.46	3.0804E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
557	111019	2	Flow Maintain (6)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.7	6.46	3.0804E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
558	111019	1	Flow Maintain (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.6	8.61	4.1072E+04	NA	NA	Imm	1	NA	NA	NA	NA	
559	111019	2	Flow Maintain (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.8	8.61	4.1072E+04	NA	NA	Imm	2	NA	NA	NA	NA	
560	111019	3	Flow Maintain (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.8	8.61	4.1072E+04	NA	NA	Imm	1	NA	NA	NA	NA	
561	111020	1	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	25.6	NA	NA	4	10	NA	NA	NA	NA	NA	NA	
562	111020	2	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.0	NA	NA	4	10	NA	NA	NA	NA	NA	NA	
563	111020	3	Flow Increase	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.2	NA	NA	4	10	NA	NA	NA	NA	NA	NA	
564	111020	1	Flow Maintain (6)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.4	6.46	3.0704E+04	NA	NA	1	NA	NA	NA	NA	NA	
565	111020	1	Flow Maintain (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.3	8.61	4.0939E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
566	111020	2	Flow Maintain (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.4	8.61	4.0939E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
567	111020	3	Flow Maintain (8)	1.125	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	26.6	8.61	4.0939E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
568	111021	1	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.6	4.31	2.0569E+04	NA	NA	Imm	1	NA	NA	NA	NA	
569	111021	2	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.6	4.31	2.0569E+04	NA	NA	Imm	1	NA	NA	NA	NA	
570	111021	3	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	24.7	4.31	2.0569E+04	NA	NA	Imm	1	NA	NA	NA	NA	
571	111021	1	Flow Maintain (2)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	26.2	2.15	1.0285E+04	NA	NA	1	2	NA	NA	NA	NA	
572	111021	2	Flow Maintain (2)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Horizontal	0	0	PP	26.0	2.15	1.0285E+04	NA	NA	1	2	NA	NA	NA	NA	
573	111024	1	Flow Maintain (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	22.8	15.07	7.1993E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
574	111024	2	Flow Maintain (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.0	15.07	7.1993E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
575	111024	3	Flow Maintain (14)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.3	15.07	7.1993E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
576	111024	1	Flow Maintain (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.8	17.22	8.2278E+04	NA	NA	Imm	2	NA	NA	NA	NA	
577	111024	2	Flow Maintain (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	23.9	17.22	8.2278E+04	NA	NA	Imm	2	NA	NA	NA	NA	
578	111024	3	Flow Maintain (16)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	24.0	17.22	8.2278E+04	NA	NA	Imm	2	NA	NA	NA	NA	
579	111026	1	Flow Maintain (6)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.6	6.46	3.0704E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
580	111026	2	Flow Maintain (6)	1	Elbow	0.75	Vertical	Horizontal, Down	Up	0	0	PP	26.9	6.46										

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Place	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
595	111103	1	Flow Maintain (8)	1.125	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	19.6	5.30	3.2230E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
596	111103	2	Flow Maintain (8)	1.125	Elbow	1	Vertical	Horizontal, Down	Horizontal	0	0	PP	19.9	5.30	3.2230E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
597	111103	1	Flow Maintain (18)	1.125	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	20.1	11.93	7.2517E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
598	111103	2	Flow Maintain (18)	1.125	Elbow	1	Vertical	Horizontal, Down	Up	0	0	PP	20.2	11.93	7.2517E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
599	111103	1	Flow Increase	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.0	NA	NA	DNR	4	NA	NA	NA	NA	NA	NA	
600	111103	2	Flow Increase	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.3	NA	NA	DNR	4	NA	NA	NA	NA	NA	NA	
601	111103	1	Flow Maintain (2)	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.6	2.15	1.0235E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Air out of tube in 30 sec
602	111103	2	Flow Maintain (2)	1	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	21.8	2.15	1.0235E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Air out of tube in 30 sec
603	111104	1	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	22.7	4.31	2.0569E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
604	111104	2	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.0	4.31	2.0569E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
605	111104	1	Flow Maintain (6)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.0	6.46	3.0854E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
606	111104	2	Flow Maintain (6)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.3	6.46	3.0854E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
607	111104	1	Flow Maintain (8)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.6	8.61	4.1139E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
608	111104	2	Flow Maintain (8)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.9	8.61	4.1139E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
609	111107	1	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	24.2	10.77	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
610	111107	2	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	24.5	10.77	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
611	111107	1	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.0	12.92	6.1708E+04	NA	NA	Imm	3	NA	NA	NA	NA	
612	111107	2	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.2	12.92	6.1708E+04	NA	NA	Imm	3	NA	NA	NA	NA	
613	111107	3	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Down, Horizontal	Horizontal	0	0	PP	25.3	12.92	6.1708E+04	NA	NA	Imm	3	NA	NA	NA	NA	
614	111108	1	Flow Maintain (14)	2	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.4	9.26	5.6330E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
615	111108	2	Flow Maintain (14)	2	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.4	9.26	5.6330E+04	NA	NA	Imm	0.8	NA	NA	NA	NA	
616	111108	1	Flow Maintain (8)	1.125	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.5	5.30	3.2230E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
617	111108	2	Flow Maintain (8)	1.125	Elbow	1	Vertical	Down, Horizontal	Horizontal	0	0	PP	23.7	5.30	3.2230E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
618	111109	1	Flow Increase	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	24.7	NA	NA	DNR	4	NA	NA	NA	NA	NA	NA	
619	111109	2	Flow Increase	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	25.2	NA	NA	4	8	NA	NA	NA	NA	NA	NA	
620	111109	3	Flow Increase	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	25.6	NA	NA	2	8	NA	NA	NA	NA	NA	NA	
621	111109	1	Flow Maintain (2)	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	25.8	2.15	1.0285E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
622	111109	2	Flow Maintain (2)	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	26.0	2.15	1.0285E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
623	111109	3	Flow Maintain (2)	1.5	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	26.0	2.15	1.0285E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
624	111110	1	Flow Maintain (2)	1	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	25.6	2.15	1.0235E+04	NA	NA	DNR	2	NA	NA	NA	NA	
625	111110	2	Flow Maintain (2)	1	Elbow	0.75	Vertical	Horizontal, Up	Horizontal	0	0	PP	25.9	2.15	1.0235E+04	NA	NA	1	2	NA	NA	NA	NA	
626	111115	1	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	23.0	NA	NA	8	10	NA	NA	NA	NA	NA	NA	
627	111115	2	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	23.3	NA	NA	6	10	NA	NA	NA	NA	NA	NA	
628	111115	3	Flow Increase	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	23.6	NA	NA	6	10	NA	NA	NA	NA	NA	NA	
629	111115	1	Flow Maintain (8)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.1	8.61	4.1139E+04	NA	NA	1	DNR	NA	NA	NA	NA	
630	111115	2	Flow Maintain (8)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.3	8.61	4.1139E+04	NA	NA	1	DNR	NA	NA	NA	NA	
631	111115	1	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.5	10.77	5.1424E+04	NA	NA	Imm	4	NA	NA	NA	NA	
632	111115	2	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.7	10.77	5.1424E+04	NA	NA	Imm	4	NA	NA	NA	NA	
633	111115	3	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.8	10.77	5.1424E+04	NA	NA	Imm	4	NA	NA	NA	NA	
634	111116	1	Flow Maintain (6)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.5	6.46	3.0704E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
635	111116	2	Flow Maintain (6)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.7	6.46	3.0704E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
636	111116	3	Flow Maintain (6)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	24.8	6.46	3.0704E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
637	111116	1	Flow Maintain (4)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.0	4.31	2.0470E+04	NA	NA	1	DNR	NA	NA	NA	NA	
638	111116	2	Flow Maintain (4)	1	Elbow	0.75	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.3	4.31	2.0470E+04	NA	NA	1	DNR	NA	NA	NA	NA	
639	111116	1	Flow Maintain (12)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.5	7.93	4.8283E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
640	111116	2	Flow Maintain (12)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.8	7.93	4.8283E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
641	111117	1	Flow Maintain (14)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.6	9.26	5.6330E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
642	111117	2	Flow Maintain (14)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	25.9	9.26	5.6330E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
643	111117	1	Flow Maintain (16)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	26.1	10.58	6.4378E+04	NA	NA	Imm	3	NA	NA	NA	NA	
644	111117	2	Flow Maintain (16)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	26.2	10.58	6.4378E+04	NA	NA	Imm	3	NA	NA	NA	NA	
645	111117	3	Flow Maintain (16)	2	Elbow	1	Vertical	Up, Horizontal	Horizontal	0	0	PP	26.2	10.58	6.4378E+04	NA	NA	Imm	3	NA	NA	NA	NA	
646	111117	1	Flow Maintain (8)	2	Elbow	1	Vertical	Up, Horizontal	Up	0	0	PP	26.8	5.29	3.2189E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
647	111117	2	Flow Maintain																					

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
661	111118	1	Flow Maintain (2)	1	Elbow	0.75	Vertical	Up, Horizontal	Up	0	0	PP	30.0	2.15	1.0235E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
662	111118	2	Flow Maintain (2)	1	Elbow	0.75	Vertical	Up, Horizontal	Up	0	0	PP	30.2	2.15	1.0235E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
663	111122	1	Flow Maintain (4)	1	Elbow	0.75	Vertical	Up, Horizontal	Up	0	0	PP	25.3	4.31	2.0470E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
664	111122	2	Flow Maintain (4)	1	Elbow	0.75	Vertical	Up, Horizontal	Up	0	0	PP	25.3	4.31	2.0470E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
665	111122	3	Flow Maintain (4)	1	Elbow	0.75	Vertical	Up, Horizontal	Up	0	0	PP	25.4	4.31	2.0470E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
666	111129	1	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	22.0	NA	NA	2	4	NA	NA	NA	NA	NA	NA	
667	111129	2	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	21.8	NA	NA	2	4	NA	NA	NA	NA	NA	NA	
668	111129	3	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	22.0	NA	NA	2	4	NA	NA	NA	NA	NA	NA	
669	111129	1	Flow Maintain (2)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	23.9	2.15	1.0285E+04	NA	NA	1	DNR	NA	NA	NA	NA	
670	111129	2	Flow Maintain (2)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	23.9	2.15	1.0285E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
671	111129	1	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	22.4	4.31	2.0569E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
672	111129	2	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	22.6	4.31	2.0569E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
673	111129	3	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	22.8	4.31	2.0569E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
674	111129	1	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	22.8	4.31	2.0569E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
675	111129	2	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	22.9	4.31	2.0569E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
676	111129	3	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	-0.0104	0	PP	22.9	4.31	2.0569E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
677	111130	1	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.6	4.31	2.0569E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
678	111130	2	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.8	4.31	2.0569E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
679	111130	3	Flow Maintain (4)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	24.0	4.31	2.0569E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
680	111130	1	Flow Maintain (6)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.7	6.46	3.0854E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
681	111130	2	Flow Maintain (6)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.8	6.46	3.0854E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
682	111130	3	Flow Maintain (6)	1.5	Elbow	0.75	Horizontal	NA	Parallel to Flow	0.01042	0	PP	23.8	6.46	3.0854E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
683	111130	1	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.0	NA	NA	2	14	NA	NA	NA	NA	NA	NA	
684	111130	2	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.2	NA	NA	2	12	NA	NA	NA	NA	NA	NA	
685	111130	3	Flow Increase	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.4	NA	NA	2	12	NA	NA	NA	NA	NA	NA	
686	111201	1	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.3	10.77	5.1424E+04	NA	NA	Imm	3	NA	NA	NA	NA	
687	111201	2	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.5	10.77	5.1424E+04	NA	NA	Imm	2.5	NA	NA	NA	NA	
688	111201	3	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	24.6	10.77	5.1424E+04	NA	NA	Imm	3	NA	NA	NA	NA	
689	111201	1	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	-0.0104	0	PP	24.8	10.77	5.1424E+04	NA	NA	Imm	3	NA	NA	NA	NA	
690	111201	2	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	-0.0104	0	PP	25.0	10.77	5.1424E+04	NA	NA	Imm	3	NA	NA	NA	NA	
691	111201	3	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	-0.0104	0	PP	25.1	10.77	5.1424E+04	NA	NA	Imm	3.5	NA	NA	NA	NA	
692	111201	1	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0.01042	0	PP	25.2	10.77	5.1424E+04	NA	NA	Imm	2.5	NA	NA	NA	NA	
693	111201	2	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0.01042	0	PP	25.3	10.77	5.1424E+04	NA	NA	Imm	3.5	NA	NA	NA	NA	
694	111201	3	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0.01042	0	PP	25.4	10.77	5.1424E+04	NA	NA	Imm	3	NA	NA	NA	NA	
695	111201	1	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	27.1	2.15	1.0235E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
696	111201	2	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	27.1	2.15	1.0235E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
697	111201	3	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	27.2	2.15	1.0235E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
698	111201	1	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	26.0	2.15	1.0235E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
699	111201	2	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	27.6	2.15	1.0235E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
700	111201	3	Flow Maintain (2)	1	Elbow	0.75	Horizontal	NA	Parallel to Flow	0	0	PP	27.4	2.15	1.0235E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
701	111202	1	Flow Maintain (6)	2	Elbow	1	Horizontal	NA	Parallel to Flow	0	0	PP	24.8	3.97	2.4142E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
702	111202	2	Flow Maintain (6)	2	Elbow	1	Horizontal	NA	Parallel to Flow	0	0	PP	25.0	3.97	2.4142E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
703	111202	1	Flow Maintain (8)	2	Elbow	1	Horizontal	NA	Parallel to Flow	0	0	PP	25.0	5.29	3.2189E+04	NA	NA	Imm	3	NA	NA	NA	NA	
704	111202	2	Flow Maintain (8)	2	Elbow	1	Horizontal	NA	Parallel to Flow	0	0	PP	25.2	5.29	3.2189E+04	NA	NA	Imm	2.5	NA	NA	NA	NA	
705	111202	3	Flow Maintain (8)	2	Elbow	1	Horizontal	NA	Parallel to Flow	0	0	PP	25.3	5.29	3.2189E+04	NA	NA	Imm	2	NA	NA	NA	NA	
706	111205	1	Flow Maintain (10)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	22.0	6.61	4.0236E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
707	111205	2	Flow Maintain (10)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	22.2	6.61	4.0236E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
708	111205	1	Flow Maintain (12)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	22.4	7.93	4.8283E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
709	111205	2	Flow Maintain (12)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	22.6	7.93	4.8283E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
710	111205	1	Flow Maintain (14)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	22.8	9.26	5.6330E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
711	111205	2	Flow Maintain (14)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0	PP	23.1	9.26	5.6330E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
712	111205	1	Flow Maintain (16)	2	Elbow	1	Horizontal	NA	Perp to Flow	0	0													

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
727	111212	3	Flow Maintain (40)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	21.0	10.36	1.0072E+05	NA	NA	1	5	NA	NA	NA	NA	
728	111212	1	Flow Maintain (42)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	21.5	10.88	1.0575E+05	NA	Imm	3	NA	NA	NA	NA	NA	
729	111212	2	Flow Maintain (42)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	21.7	10.88	1.0575E+05	NA	NA	Imm	3	NA	NA	NA	NA	
730	111212	3	Flow Maintain (42)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	21.8	10.88	1.0575E+05	NA	NA	Imm	3	NA	NA	NA	NA	
731	111213	1	Flow Maintain (35)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	19.1	9.06	8.8128E+04	NA	NA	3	DNR	NA	NA	NA	NA	
732	111213	2	Flow Maintain (35)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	19.4	9.06	8.8128E+04	NA	NA	3	DNR	NA	NA	NA	NA	
733	111213	1	Flow Maintain (40)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	19.6	10.36	1.0072E+05	NA	Imm	3	NA	NA	NA	NA	NA	
734	111213	2	Flow Maintain (40)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	19.9	10.36	1.0072E+05	NA	NA	Imm	5	NA	NA	NA	NA	
735	111213	3	Flow Maintain (40)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	20.1	10.36	1.0072E+05	NA	Imm	5	NA	NA	NA	NA	NA	
736	111213	1	Flow Maintain (35)	3	Straight	1.5	Horizontal	NA	NA	0	90	PP	20.5	9.06	8.8128E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
737	111213	2	Flow Maintain (35)	3	Straight	1.5	Horizontal	NA	NA	0	90	PP	20.6	9.06	8.8128E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
738	111213	3	Flow Maintain (35)	3	Straight	1.5	Horizontal	NA	NA	0	90	PP	20.7	9.06	8.8128E+04	NA	Imm	1.5	NA	NA	NA	NA	NA	
739	111213	1	Flow Maintain (30)	1.375	Straight	1.5	Horizontal	NA	NA	0	0	PP	20.9	7.87	7.6023E+04	NA	Imm	3.5	NA	NA	NA	NA	NA	
740	111213	2	Flow Maintain (30)	1.375	Straight	1.5	Horizontal	NA	NA	0	0	PP	21.2	7.87	7.6023E+04	NA	Imm	3.5	NA	NA	NA	NA	NA	
741	111214	1	Flow Maintain (24)	3	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	20.7	6.19	6.0287E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
742	111214	2	Flow Maintain (24)	3	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.0	6.19	6.0287E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
743	111214	1	Flow Maintain (26)	3	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.3	6.70	6.5311E+04	NA	Imm	2	NA	NA	NA	NA	NA	
744	111214	2	Flow Maintain (26)	3	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.4	6.70	6.5311E+04	NA	Imm	3	NA	NA	NA	NA	NA	
745	111214	3	Flow Maintain (26)	3	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.8	6.70	6.5311E+04	NA	Imm	2	NA	NA	NA	NA	NA	
746	111214	1	Flow Maintain (68)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	22.6	17.52	1.7081E+05	NA	Imm	5	NA	NA	NA	NA	NA	
747	111214	2	Flow Maintain (68)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	23.0	17.52	1.7081E+05	NA	Imm	5	NA	NA	NA	NA	NA	
748	111216	1	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	22.8	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
749	111216	2	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	23.3	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
750	111216	3	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	23.5	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
751	111216	1	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	24.0	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
752	111216	2	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	24.6	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
753	111216	3	Flow Maintain (66)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	25.1	17.09	1.6579E+05	NA	Imm	DNR	NA	NA	NA	NA	NA	
754	111216	1	Flow Maintain (22)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	25.8	5.62	5.5044E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
755	111216	2	Flow Maintain (22)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	26.0	5.62	5.5044E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
756	111216	1	Flow Maintain (24)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	26.3	6.14	6.0048E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
757	111216	2	Flow Maintain (24)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	26.5	6.14	6.0048E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
758	111216	1	Flow Maintain (26)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	26.7	6.65	6.5052E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
759	111216	2	Flow Maintain (26)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	27.0	6.65	6.5052E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
760	111219	1	Flow Maintain (28)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	21.2	7.16	7.0056E+04	NA	Imm	1	NA	NA	NA	NA	NA	
761	111219	2	Flow Maintain (28)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	21.2	7.16	7.0056E+04	NA	Imm	1	NA	NA	NA	NA	NA	
762	111219	3	Flow Maintain (28)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	21.3	7.16	7.0056E+04	NA	Imm	1	NA	NA	NA	NA	NA	
763	111219	1	Flow Maintain (22)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.5	5.62	5.5044E+04	NA	Imm	3	NA	NA	NA	NA	NA	
764	111219	2	Flow Maintain (22)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.7	5.62	5.5044E+04	NA	Imm	3	NA	NA	NA	NA	NA	
765	111219	3	Flow Maintain (22)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	21.8	5.62	5.5044E+04	NA	Imm	3	NA	NA	NA	NA	NA	
766	111219	1	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	22.0	5.11	5.0040E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
767	111219	2	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	22.3	5.11	5.0040E+04	NA	Imm	DNR	NA	NA	NA	NA	NA	
768	111221	1	Flow Maintain (62)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	22.5	15.98	1.5574E+05	NA	Imm	3	NA	NA	NA	NA	NA	Fluctuations In Flow
769	111221	2	Flow Maintain (62)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	22.8	15.98	1.5574E+05	NA	Imm	3	NA	NA	NA	NA	NA	Fluctuations In Flow
770	111221	3	Flow Maintain (62)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	23.2	15.98	1.5574E+05	NA	Imm	3	NA	NA	NA	NA	NA	Fluctuations In Flow
771	111221	1	Flow Maintain (60)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	23.6	16.46	1.5072E+05	NA	Imm	4	NA	NA	NA	NA	NA	
772	111221	2	Flow Maintain (60)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.0	16.46	1.5072E+05	NA	Imm	4	NA	NA	NA	NA	NA	
773	111221	3	Flow Maintain (60)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.0	16.46	1.5072E+05	NA	Imm	4	NA	NA	NA	NA	NA	
774	111221	1	Flow Maintain (58)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.3	14.95	1.4569E+05	NA	Imm	2	NA	NA	NA	NA	NA	
775	111221	2	Flow Maintain (58)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.6	14.95	1.4569E+05	NA	Imm	2	NA	NA	NA	NA	NA	
776	111221	1	Flow Maintain (56)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.7	14.43	1.4067E+05	NA	Imm	5	NA	NA	NA	NA	NA	
777	111221	2	Flow Maintain (56)	3	Elbow	1.5	Vertical	Down, Horizontal	Perp to Flow	0	0	PP	24.7	14.43	1.4067E+05	NA	Imm	5						

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4 (gpm)	5 (gpm)	4 (min)	5 (min)	4 (psig)	5 (psig)	4 (min)	5 (min)	
793	111228	2	Flow Maintain (45)	3	Straight	1.5	Vertical	Bottom-Top	NA	0	0	PP	14.7	11.65	1.1331E+05	NA	NA	Imm	4	NA	NA	NA	NA	Mid-test Flow Drop
794	111228	3	Flow Maintain (45)	3	Straight	1.5	Vertical	Bottom-Top	NA	0	0	PP	14.9	11.65	1.1331E+05	NA	NA	Imm	3.5	NA	NA	NA	NA	
795	111228	1	Flow Maintain (35)	1.375	Straight	1.5	Vertical	Bottom-Top	NA	0	0	PP	15.4	9.18	8.8693E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
796	111228	2	Flow Maintain (35)	1.375	Straight	1.5	Vertical	Bottom-Top	NA	0	0	PP	15.4	9.18	8.8693E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
797	111228	3	Flow Maintain (35)	1.375	Straight	1.5	Vertical	Bottom-Top	NA	0	0	PP	15.5	9.18	8.8693E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	
798	111228	1	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	16.0	6.44	6.2799E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
799	111228	2	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	16.0	6.44	6.2799E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
800	111228	3	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	16.1	6.44	6.2799E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	
801	111228	1	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	16.7	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	
802	111228	2	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	16.9	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	
803	111228	3	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	17.1	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	
804	111228	1	Flow Maintain (30)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	17.4	7.67	7.5060E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
805	111228	2	Flow Maintain (30)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	17.5	7.67	7.5060E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
806	111228	3	Flow Maintain (30)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	17.5	7.67	7.5060E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
807	111228	1	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	17.8	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
808	111228	2	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	17.8	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
809	111228	3	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	17.8	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	
810	111230	1	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	20.2	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Metal Tank Confirmation Tests
811	111230	2	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	20.4	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Metal Tank Confirmation Tests
812	111230	3	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	19.6	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Metal Tank Confirmation Tests
813	111230	4	Flow Maintain (20)	1.375	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	20.7	5.11	5.0040E+04	NA	NA	DNR	Imm	NA	NA	NA	NA	Metal Tank Confirmation Tests
814	111230	1	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	21.0	6.44	6.2799E+04	NA	NA	Imm	0.5	NA	NA	NA	NA	Metal Tank Confirmation Tests
815	111230	2	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	21.2	6.44	6.2799E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	Metal Tank Confirmation Tests
816	111230	3	Flow Maintain (25)	3	Elbow	1.5	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	21.4	6.44	6.2799E+04	NA	NA	DNR	0.5	NA	NA	NA	NA	Metal Tank Confirmation Tests
817	111230	1	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	22.6	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	Metal Tank Confirmation Tests
818	111230	2	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	23.1	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	Metal Tank Confirmation Tests
819	111230	3	Flow Maintain (50)	3	Elbow	1.5	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	24.8	12.89	1.2560E+05	NA	NA	Imm	2	NA	NA	NA	NA	Metal Tank Confirmation Tests
1031	120301	1	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	45	PP	13.5	14.34	1.7778E+05	NA	NA	Imm	NA	NA	NA	NA	NA	
1032	120301	2	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	45	PP	14.1	14.34	1.7778E+05	NA	NA	Imm	NA	NA	NA	NA	NA	
1033	120301	1	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	45	PP	15.5	15.14	1.8766E+05	NA	NA	Imm	NA	NA	NA	NA	NA	
1034	120301	2	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	45	PP	16.6	15.14	1.8766E+05	NA	NA	Imm	NA	NA	NA	NA	NA	
1035	120301	1	Flow Maintain (100)	4	Straight	2	Horizontal	NA	NA	0	45	PP	18.3	15.94	1.9754E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1036	120301	2	Flow Maintain (100)	4	Straight	2	Horizontal	NA	NA	0	45	PP	18.8	15.94	1.9754E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1037	120301	3	Flow Maintain (100)	4	Straight	2	Horizontal	NA	NA	0	45	PP	19.4	15.94	1.9754E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1038	120301	1	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	90	PP	20.2	11.95	1.4815E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1039	120301	2	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	90	PP	20.6	11.95	1.4815E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1040	120301	3	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	90	PP	21.1	11.95	1.4815E+05	NA	NA	Imm	1	NA	NA	NA	NA	

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Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4	5	4 (min)	5 (min)	4	5	4	5	
820	120102	1	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	63.7	6.68	8.0884E+04	NA	NA	f	2.5	NA	NA	NA	NA	
821	120102	2	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	63.8	6.68	8.0884E+04	NA	NA	1	2.5	NA	NA	NA	NA	
822	120102	3	Flow Maintain (40)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	63.9	6.68	8.0884E+04	NA	NA	1	2.5	NA	NA	NA	NA	
823	120102	1	Flow Maintain (45)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	59.6	7.52	9.0994E+04	NA	NA	DNR	1	NA	NA	NA	NA	
824	120102	2	Flow Maintain (45)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	59.6	7.52	9.0994E+04	NA	NA	DNR	0.75	NA	NA	NA	NA	
825	120102	3	Flow Maintain (45)	4	Elbow	2	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	59.5	7.52	9.0994E+04	NA	NA	Imm	0.75	NA	NA	NA	NA	
826	120102	1	Flow Maintain (50)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	58.5	8.35	1.0110E+05	NA	NA	2	DNR	NA	NA	NA	NA	
827	120102	1	Flow Maintain (55)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	62.0	9.19	1.1121E+05	NA	NA	1	DNR	NA	NA	NA	NA	
828	120102	1	Flow Maintain (60)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	62.9	10.02	1.2133E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
829	120102	1	Flow Maintain (65)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	64.6	10.85	1.3144E+05	NA	NA	Imm	1.5	NA	NA	NA	NA	
830	120102	2	Flow Maintain (65)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	65.2	10.85	1.3144E+05	NA	NA	Imm	1.5	NA	NA	NA	NA	
831	120102	3	Flow Maintain (65)	4	Elbow	2	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	65.2	10.85	1.3144E+05	NA	NA	Imm	1.5	NA	NA	NA	NA	
832	120104	1	Flow Maintain (3)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	63.3	3.24	1.5427E+04	NA	NA	0.5	1	NA	NA	NA	NA	
833	120104	2	Flow Maintain (3)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	63.1	3.24	1.5427E+04	NA	NA	0.5	1	NA	NA	NA	NA	
834	120104	3	Flow Maintain (3)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Parallel to Flow	0	0	PP	62.9	3.24	1.5427E+04	NA	NA	0.5	1	NA	NA	NA	NA	
835	120104	1	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	64.0	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
836	120104	1	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	63.7	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
837	120104	2	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	63.6	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
838	120104	3	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Up, Horizontal	Perp to Flow	0	0	PP	63.5	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
839	120105	1	Flow Maintain (10)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	65.3	10.77	5.1340E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
840	120105	1	Flow Maintain (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	64.9	12.91	6.1608E+04	NA	NA	Imm	1.5	NA	NA	NA	NA	
841	120105	2	Flow Maintain (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	64.8	12.91	6.1608E+04	NA	NA	Imm	2	NA	NA	NA	NA	
842	120105	3	Flow Maintain (12)	1.5	Straight	0.75	Vertical	Bottom-Top	NA	0	0	PP	64.8	12.91	6.1608E+04	NA	NA	Imm	2	NA	NA	NA	NA	
843	120105	1	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	65.2	9.56	1.1852E+05	NA	NA	1	DNR	NA	NA	NA	NA	
844	120105	2	Flow Maintain (60)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	64.1	9.56	1.1852E+05	NA	NA	1	DNR	NA	NA	NA	NA	
845	120105	1	Flow Maintain (72)	4	Straight	2	Vertical	Bottom-Top	NA	0	0	PP	58.6	11.47	1.4223E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Limited by Configuration, Cavitation occurred
846	120106	1	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	65.9	9.56	1.1852E+05	NA	NA	5	DNR	NA	NA	NA	NA	
847	120106	2	Flow Maintain (60)	4	Straight	2	Horizontal	NA	NA	0	0	PP	66.4	9.56	1.1852E+05	NA	NA	5	DNR	NA	NA	NA	NA	
848	120106	1	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	0	PP	67.7	11.16	1.3827E+05	NA	NA	2	DNR	NA	NA	NA	NA	
849	120106	2	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	0	PP	67.7	11.16	1.3827E+05	NA	NA	2	DNR	NA	NA	NA	NA	
850	120106	1	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	45	PP	67.7	11.16	1.3827E+05	NA	NA	DNR	DNR	NA	NA	NA	NA	
851	120106	2	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	45	PP	68.0	11.16	1.3827E+05	NA	NA	DNR	DNR	NA	NA	NA	NA	
852	120106	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	63.7	12.91	6.1608E+04	NA	NA	2	2.5	NA	NA	NA	NA	
853	120106	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	63.6	12.91	6.1608E+04	NA	NA	2	2.5	NA	NA	NA	NA	
854	120106	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	63.6	12.91	6.1608E+04	NA	NA	2	2.5	NA	NA	NA	NA	
855	120106	1	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	63.1	12.91	6.1608E+04	NA	NA	0.5	1	NA	NA	NA	NA	
856	120106	2	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	63.3	12.91	6.1608E+04	NA	NA	0.5	1	NA	NA	NA	NA	
857	120106	3	Flow Maintain (12)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	63.2	12.91	6.1608E+04	NA	NA	0.5	1	NA	NA	NA	NA	
858	120110	1	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.4	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
859	120110	2	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.2	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
860	120110	3	Flow Maintain (12)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	65.4	12.96	6.1708E+04	NA	NA	Imm	1	NA	NA	NA	NA	
861	120110	1	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	64.8	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
862	120110	2	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	64.7	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
863	120110	3	Flow Maintain (10)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	64.5	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
864	120110	1	Flow Maintain (69)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.9	11.69	1.4155E+05	NA	NA	DNR	DNR	NA	NA	NA	NA	
865	120110	2	Flow Maintain (69)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.4	11.69	1.4155E+05	NA	NA	DNR	DNR	NA	NA	NA	NA	
866	120110	1	Flow Maintain (69), With Back Pressure (30 psi)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.1	11.69	1.4155E+05	NA	NA	NA	NA	NA	NA	NA	DNR	DNR
867	120110	2	Flow Maintain (69), With Back Pressure (40 psi)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.6	11.69	1.4155E+05	NA	NA	NA	NA	NA	NA	NA	DNR	DNR
868	120112	1	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	69.8	7.52	9.0994E+04	NA	NA	Imm	2	NA	NA	NA	NA	
869	120112	2	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	67.7	7.52	9.0994E+04	NA	NA	Imm	2.5	NA	NA	NA	NA	
870	120112	3	Flow Maintain (45)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	66.8	7.52	9.0994E+04	NA	NA	Imm	2	NA	NA	NA	NA	
871	120112	1	Flow Maintain (40)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	66.3	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
872	120112	2	Flow Maintain (40)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	65.8	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
873	120112	3	Flow Maintain (40)	4	Elbow	2	Horizontal	NA	Perp to Flow	0	0	PP	65.2	6.68	8.0884E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
874	120112	1	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	64.6	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
875	120112	2	Flow Maintain (10)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	63.3	10.80	5.1424E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
876	120112	1	Flow Maintain (12)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	62.9	12.96	6.1708E+04	NA	NA	Imm	2	NA	NA	NA	NA	
877	120112	2	Flow Maintain (12)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	62.8	12.96	6.1708E+04	NA	NA	Imm	2	NA	NA	NA	NA	
878	120112	3	Flow Maintain (12)	1.5	Elbow	0.75	Horizontal	NA	Perp to Flow	0	0	PP	62.6	12.96	6.1708E+04	NA	NA	Imm	2	NA	NA	NA	NA	
879	120113	1	Flow Maintain (65)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	66.9	16.83	1.6367E+05	NA	NA	1	5	NA	NA	NA	NA	Inconsistent fill times

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4	5	4 (min)	5 (min)	4	5	4	5	
880	120113	2	Flow Maintain (65)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.4	16.83	1.6367E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Inconsistent fill times
881	120113	3	Flow Maintain (65)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.7	16.83	1.6367E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Inconsistent fill times
882	120113	1	Flow Maintain (68)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.7	17.61	1.7122E+05	NA	NA	Imm	3	NA	NA	NA	NA	Inconsistent fill times
883	120113	2	Flow Maintain (68)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.8	17.61	1.7122E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Inconsistent fill times
884	120113	3	Flow Maintain (68)	3	Elbow	1.5	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	68.1	17.61	1.7122E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Inconsistent fill times
885	120113	1	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	65.2	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	Inconsistent fill times
886	120113	2	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	65.5	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
887	120113	3	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	0	PP	66.0	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
888	120113	1	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	65.8	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
889	120113	2	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	45	PP	66.3	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
890	120113	1	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	90	PP	65.6	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
891	120113	2	Flow Maintain (69)	3	Straight	1.5	Horizontal	NA	NA	0	90	PP	66.2	17.87	1.7374E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
892	120113	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.5	10.77	5.1340E+04	NA	NA	Imm	4	NA	NA	NA	NA	
893	120113	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.3	10.77	5.1340E+04	NA	NA	Imm	5	NA	NA	NA	NA	
894	120113	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.3	10.77	5.1340E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
895	120113	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.5	10.77	5.1340E+04	NA	NA	Imm	3	NA	NA	NA	NA	
896	120113	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.3	10.77	5.1340E+04	NA	NA	Imm	1	NA	NA	NA	NA	
897	120113	3	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	61.1	10.77	5.1340E+04	NA	NA	Imm	1	NA	NA	NA	NA	
898	120116	1	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	70.7	8.61	4.1072E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
899	120116	2	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	69.4	8.61	4.1072E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
900	120116	3	Flow Maintain (8)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	68.7	8.61	4.1072E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
901	120116	1	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	65.3	11.95	1.4815E+05	NA	NA	Imm	4	NA	NA	NA	NA	
902	120116	2	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	65.7	11.95	1.4815E+05	NA	NA	Imm	4	NA	NA	NA	NA	
903	120116	3	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	0	PP	66.1	11.95	1.4815E+05	NA	NA	Imm	4	NA	NA	NA	NA	
904	120116	1	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	0	PP	66.7	11.16	1.3827E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
905	120116	2	Flow Maintain (70)	4	Straight	2	Horizontal	NA	NA	0	0	PP	66.8	11.16	1.3827E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
906	120116	1	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	45	PP	65.5	11.95	1.4815E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
907	120116	2	Flow Maintain (75)	4	Straight	2	Horizontal	NA	NA	0	45	PP	65.8	11.95	1.4815E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
908	120116	1	Flow Maintain (80)	4	Straight	2	Horizontal	NA	NA	0	45	PP	66.4	12.75	1.5803E+05	NA	NA	Imm	3	NA	NA	NA	NA	
909	120116	2	Flow Maintain (80)	4	Straight	2	Horizontal	NA	NA	0	45	PP	66.8	12.75	1.5803E+05	NA	NA	Imm	4	NA	NA	NA	NA	
910	120116	3	Flow Maintain (80)	4	Straight	2	Horizontal	NA	NA	0	45	PP	67.3	12.75	1.5803E+05	NA	NA	Imm	4	NA	NA	NA	NA	
911	120117	1	Flow Maintain (80)	4	Straight	2	Horizontal	NA	NA	0	90	PP	71.7	12.75	1.5803E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
912	120117	2	Flow Maintain (80)	4	Straight	2	Horizontal	NA	NA	0	90	PP	71.9	12.75	1.5803E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
913	120117	1	Flow Maintain (85)	4	Straight	2	Horizontal	NA	NA	0	90	PP	72.2	13.55	1.6791E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
914	120117	2	Flow Maintain (85)	4	Straight	2	Horizontal	NA	NA	0	90	PP	72.4	13.55	1.6791E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
915	120117	1	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	90	PP	72.7	14.34	1.7778E+05	NA	NA	Imm	3	NA	NA	NA	NA	
916	120117	2	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	90	PP	72.5	14.34	1.7778E+05	NA	NA	Imm	3	NA	NA	NA	NA	
917	120117	3	Flow Maintain (90)	4	Straight	2	Horizontal	NA	NA	0	90	PP	72.7	14.34	1.7778E+05	NA	NA	Imm	3	NA	NA	NA	NA	
918	120117	1	Flow Maintain (110)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.8	18.37	2.2243E+05	NA	NA	Imm	2	NA	NA	NA	NA	
919	120117	2	Flow Maintain (110)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	68.2	18.37	2.2243E+05	NA	NA	Imm	3	NA	NA	NA	NA	
920	120117	3	Flow Maintain (110)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.3	18.37	2.2243E+05	NA	NA	Imm	3	NA	NA	NA	NA	
921	120117	1	Flow Maintain (105)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.5	17.53	2.1232E+05	NA	NA	Imm	3	NA	NA	NA	NA	
922	120117	2	Flow Maintain (105)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	68.0	17.53	2.1232E+05	NA	NA	Imm	4	NA	NA	NA	NA	
923	120117	3	Flow Maintain (105)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	67.7	17.53	2.1232E+05	NA	NA	Imm	3	NA	NA	NA	NA	
924	120117	1	Flow Maintain (100)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	68.4	16.70	2.0221E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
925	120117	2	Flow Maintain (100)	4	Elbow	2	Vertical	Horizontal, Down	Perp to Flow	0	0	PP	68.8	16.70	2.0221E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
926	120117	1	Flow Maintain (65)	4	Elbow	2	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	68.5	10.85	1.3144E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
927	120117	2	Flow Maintain (65)	4	Elbow	2	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	67.7	10.85	1.3144E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
928	120117	1	Flow Maintain (70)	4	Elbow	2	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	67.9	11.69	1.4155E+05	NA	NA	Imm	3	NA	NA	NA	NA	
929	120117	2	Flow Maintain (70)	4	Elbow	2	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	68.0	11.69	1.4155E+05	NA	NA	Imm	3	NA	NA	NA	NA	
930	120117	3	Flow Maintain (70)	4	Elbow	2	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	67.5	11.69	1.4155E+05	NA	NA	Imm	3	NA	NA	NA	NA	
931	120118	1	Flow Maintain (6)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	69.1	6.48	3.0854E+04	NA	NA	Imm	3	NA	NA	NA	NA	
932	120118	2	Flow Maintain (6)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	67.9	6.48	3.0854E+04	NA	NA	Imm	3	NA	NA	NA	NA	
933	120118	3	Flow Maintain (6)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	67.5	6.48	3.0854E+04	NA	NA	Imm	2	NA	NA	NA	NA	
934	120118	1	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	66.7	4.32	2.0569E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
935	120118	2	Flow Maintain (4)	1.5	Elbow	0.75	Vertical	Horizontal, Down	Parallel to Flow	0	0	PP	66.3	4.32	2.0569E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
936	120118	1	Flow Maintain (10)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	58.6	10.77	5.1340E+04	NA	NA	Imm	2	NA	NA	NA	NA	
937	120118	2	Flow Maintain (10)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	70.9	10.77	5.1340E+04	NA	NA	Imm	3	NA	NA	NA	NA	
938	120118	3	Flow Maintain (10)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	69.8	10.77	5.1340E+04	NA	NA	Imm	3	NA	NA	NA	NA	
939	120118	1	Flow Maintain (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	69.2	8.61	4.1072E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	

Experiment	Date	Run	Description	Branch Size (in) (measured from outer wall of tube)	Piece	Spool Size (in)	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (FI)		BPI Visual Grade (FM)		BPI Visual Grade (PI)		BPI Visual Grade (PM)		Notes
																4	5	4 (min)	5 (min)	4	5	4	5	
940	120118	2	Flow Maintain (8)	1.5	Straight	0.75	Vertical	Top-Bottom	NA	0	0	PP	68.7	8.61	4.1072E+04	NA	NA	Imm	DNR	NA	NA	NA	NA	
941	120119	1	Flow Maintain (55)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	73.3	8.77	1.0864E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
942	120119	2	Flow Maintain (55)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	72.6	8.77	1.0864E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
943	120119	1	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	70.5	9.56	1.1852E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
944	120119	2	Flow Maintain (60)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	61.9	9.56	1.1852E+05	NA	NA	Imm	DNR	NA	NA	NA	NA	
945	120119	1	Flow Maintain (65)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	74.2	10.36	1.2840E+04	NA	NA	Imm	1	NA	NA	NA	NA	
946	120119	2	Flow Maintain (65)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	73.3	10.36	1.2840E+04	NA	NA	Imm	1	NA	NA	NA	NA	
947	120119	3	Flow Maintain (65)	4	Straight	2	Vertical	Top-Bottom	NA	0	0	PP	73.0	10.36	1.2840E+04	NA	NA	Imm	1	NA	NA	NA	NA	
1041	120306	1	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	90	PP	64.5	15.14	1.8766E+05	NA	NA	Imm	0.5	NA	NA	NA	NA	
1042	120306	2	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	90	PP	64.3	15.14	1.8766E+05	NA	NA	Imm	0.5	NA	NA	NA	NA	
1043	120306	3	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	90	PP	63.6	15.14	1.8766E+05	NA	NA	Imm	0.5	NA	NA	NA	NA	
1044	120306	1	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	63.6	7.17	8.8891E+04	NA	NA	3	DNR	NA	NA	NA	NA	
1045	120306	2	Flow Maintain (45)	4	Straight	2	Horizontal	NA	NA	0	90	PP	63.7	7.17	8.8891E+04	NA	NA	3	DNR	NA	NA	NA	NA	
1046	120306	1	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	63.4	7.97	9.8768E+04	NA	NA	1	DNR	NA	NA	NA	NA	
1047	120306	2	Flow Maintain (50)	4	Straight	2	Horizontal	NA	NA	0	90	PP	63.3	7.97	9.8768E+04	NA	NA	1	DNR	NA	NA	NA	NA	
1048	120306	1	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	45	PP	64.9	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1049	120306	2	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	45	PP	65.0	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1050	120306	3	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	45	PP	65.0	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1051	120308	1	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	0	PP	64.7	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1052	120308	2	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	0	PP	64.4	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1053	120308	3	Flow Maintain (95)	4	Straight	2	Horizontal	NA	NA	0	0	PP	64.1	15.14	1.8766E+05	NA	NA	Imm	1	NA	NA	NA	NA	
1054	120308	1	Flow Maintain (14)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	64.7	15.07	7.1876E+04	NA	NA	0.5	1	NA	NA	NA	NA	
1055	120308	2	Flow Maintain (14)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	64.5	15.07	7.1876E+04	NA	NA	0.5	1	NA	NA	NA	NA	
1056	120308	3	Flow Maintain (14)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	64.2	15.07	7.1876E+04	NA	NA	0.5	1	NA	NA	NA	NA	
1057	120308	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	62.7	10.77	5.1340E+04	NA	NA	4	DNR	NA	NA	NA	NA	
1058	120308	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	0	PP	62.6	10.77	5.1340E+04	NA	NA	4	DNR	NA	NA	NA	NA	
1059	120308	1	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	62.0	10.77	5.1340E+04	NA	NA	3	DNR	NA	NA	NA	NA	
1060	120308	2	Flow Maintain (10)	1.5	Straight	0.75	Horizontal	NA	NA	0	45	PP	61.8	10.77	5.1340E+04	NA	NA	3	DNR	NA	NA	NA	NA	
1061	120308	1	Flow Maintain (4)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	60.9	4.31	2.0536E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	
1062	120308	2	Flow Maintain (4)	1.5	Straight	0.75	Horizontal	NA	NA	0	90	PP	60.8	4.31	2.0536E+04	NA	NA	DNR	DNR	NA	NA	NA	NA	

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Experiment	Date	Run	Tee Plus Spool Tests				Spool and Tee Size (in)	Placement of Tee	Orientation	Flow Direction	Tee Plus Spool Tests				Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	Ambient Tests				Notes										
			Description	Branch Sizes (in) (measured from outer wall of tube)	Pieces						Branch Leg Position	Slope (in)	Rotation (deg)							BPI Visual Grade (Spool)		BPI Visual Grade (Tee)											
													4 (min)	5 (min)					4 (min)	5 (min)													
948	120119	1	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	63.2	12.30	1.5025E+05	Imm	DNR	Imm	3													
949	120119	2	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	63.9	12.30	1.5025E+05	Imm	DNR	Imm	3													
950	120119	3	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	64.4	12.30	1.5025E+05	Imm	DNR	Imm	3													
951	120119	1	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	65.2	13.11	1.6026E+05	Imm	3	Imm	2													
952	120119	2	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	65.8	13.11	1.6026E+05	Imm	4	Imm	2													
953	120119	3	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	66.2	13.11	1.6026E+05	Imm	3	Imm	2													
954	120119	1	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	67.5	11.48	1.4023E+05	Imm	DNR	Imm	4													
955	120119	2	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	67.9	11.48	1.4023E+05	Imm	DNR	Imm	4													
956	120119	3	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	68.4	11.48	1.4023E+05	Imm	DNR	Imm	5													
957	120119	1	Flow Maintain (65)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	69.0	10.66	1.3022E+05	DNR	DNR	Imm	DNR													
958	120119	2	Flow Maintain (65)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	69.3	10.66	1.3022E+05	DNR	DNR	Imm	DNR													
959	120119	3	Flow Maintain (65)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	0	PP	70.0	10.66	1.3022E+05	DNR	DNR	1	DNR													
960	120120	1	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	35.7	12.30	1.5025E+05	Imm	DNR	Imm	4													
961	120120	2	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	37.4	12.30	1.5025E+05	Imm	DNR	Imm	3													
962	120120	3	Flow Maintain (75)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	38.4	12.30	1.5025E+05	Imm	DNR	Imm	3													
963	120120	1	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	40.6	13.11	1.6026E+05	Imm	4	Imm	3													
964	120120	2	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	44.6	13.11	1.6026E+05	Imm	3	Imm	2													
965	120120	3	Flow Maintain (80)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	45.3	13.11	1.6026E+05	Imm	3	Imm	2													
966	120120	1	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	46.6	11.48	1.4023E+05	Imm	DNR	Imm	DNR													
967	120120	2	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	47.7	11.48	1.4023E+05	Imm	DNR	Imm	DNR													
968	120120	3	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	45	PP	48.8	11.48	1.4023E+05	Imm	DNR	Imm	DNR													
969	120124	1	Flow Maintain (55)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	14.8	9.02	1.1018E+05	5	DNR	DNR	DNR													
970	120124	2	Flow Maintain (55)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	16.6	9.02	1.1018E+05	4	DNR	DNR	DNR													
971	120124	1	Flow Maintain (60)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	17.9	9.84	1.2020E+05	3	DNR	DNR	DNR													
972	120124	2	Flow Maintain (60)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	19.8	9.84	1.2020E+05	3	DNR	DNR	DNR													
973	120124	1	Flow Maintain (65)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	22.6	10.66	1.3022E+05	1	DNR	3	DNR													
974	120124	2	Flow Maintain (65)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	24.6	10.66	1.3022E+05	1	5	3	DNR													
975	120124	1	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	25.5	11.48	1.4023E+05	Imm	2	1	2	Swirling Air, nearly imperceptible												
976	120124	2	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	26.1	11.48	1.4023E+05	Imm	2	1	2	Swirling Air, nearly imperceptible												
977	120124	3	Flow Maintain (70)	4	Straight + Tee	2	Before Spool	Horizontal	NA	NA	0	90	PP	26.9	11.48	1.4023E+05	Imm	2	Imm	2	Swirling Air, nearly imperceptible												
978	120125	1	Flow Maintain (70)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	21.9	11.48	1.4023E+05	Imm	DNR	4	DNR													
979	120125	2	Flow Maintain (70)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	23.9	11.48	1.4023E+05	Imm	DNR	4	DNR													
980	120125	3	Flow Maintain (70)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	25.3	11.48	1.4023E+05	Imm	DNR	4	DNR													
981	120125	1	Flow Maintain (75)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	28.0	12.30	1.5025E+05	Imm	DNR	Imm	DNR													
982	120125	2	Flow Maintain (75)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	29.2	12.30	1.5025E+05	Imm	DNR	Imm	DNR													
983	120125	3	Flow Maintain (75)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	30.6	12.30	1.5025E+05	Imm	DNR	Imm	DNR													
984	120125	1	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	32.8	13.11	1.6026E+05	Imm	3	Imm	4													
985	120125	2	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	33.9	13.11	1.6026E+05	Imm	3	Imm	4													
986	120125	3	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	0	PP	35.2	13.11	1.6026E+05	Imm	3	Imm	4													
987	120126	1	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	24.6	13.11	1.6026E+05	Imm	3	Imm	4.5													
988	120126	2	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	26.0	13.11	1.6026E+05	Imm	3	Imm	4.5													
989	120126	3	Flow Maintain (80)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	27.5	13.11	1.6026E+05	Imm	3	Imm	4.5													
990	120126	1	Flow Maintain (75)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	27.1	12.30	1.5025E+05	Imm	4	Imm	DNR													
991	120126	2	Flow Maintain (75)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	27.9	12.30	1.5025E+05	Imm	5	Imm	DNR													
992	120126	1	Flow Maintain (70)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	29.9	11.48	1.4023E+05	DNR	DNR	4	DNR													
993	120126	2	Flow Maintain (70)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	45	PP	31.2	11.48	1.4023E+05	DNR	DNR	4	DNR													
994	120127	1	Flow Maintain (55)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	25.7	9.02	1.1018E+05	Imm	5	Imm	DNR													

			Tee Plus Spool Tests							Tee Plus Spool Tests							Ambient Tests					
Experiment	Date	Run	Description	Branch Sizes (in) (measured from outer wall of tube)	Pieces	Spool and Tee Size (in)	Placement of Tee	Orientation	Flow Direction	Branch Leg Position	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	BPI Visual Grade (Spool)		BPI Visual Grade (Tee)		Notes	
																	4 (min)	5 (min)	4 (min)	5 (min)		
995	120127	2	Flow Maintain (55)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	27.1	9.02	1.1018E+05	Imm	DNR	Imm	DNR		
996	120127	3	Flow Maintain (55)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	28.7	9.02	1.1018E+05	Imm	5	Imm	DNR		
997	120127	1	Flow Maintain (60)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	31.0	9.84	1.2020E+05	Imm	4	Imm	5		
998	120127	2	Flow Maintain (60)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	32.1	9.84	1.2020E+05	Imm	4	Imm	DNR		
999	120127	3	Flow Maintain (60)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	33.0	9.84	1.2020E+05	Imm	3	Imm	DNR		
1000	120127	1	Flow Maintain (65)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	35.2	10.66	1.3022E+05	Imm	2	Imm	4	Swirling Air, nearly imperceptible	
1001	120127	2	Flow Maintain (65)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	36.0	10.66	1.3022E+05	Imm	2	Imm	3	Swirling Air, nearly imperceptible	
1002	120127	3	Flow Maintain (65)	4	Straight + Tee	2	After Spool	Horizontal	NA	NA	0	90	PP	36.7	10.66	1.3022E+05	Imm	2	Imm	3	Swirling Air, nearly imperceptible	

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Air Scale Tests																
Experiment	Date	Run	Description	Flow Rate (GPM)	Branch Size (in)	Piece	Spool Size (in)	Slope (in)	Rotation (deg)	Material	Temperature (°C)	Velocity (ft/s)	Reynolds Number	Volume of Air in Tee (mL)		
1003	120131	1	Air Scale 1 Test	33.08	4	Tee	2	0	0	PP	15.0	5.27	6.5345E+04	73	Average Velocity (ft/s)	5.29 ± 0.02
1004	120131	2	Air Scale 1 Test	33.32	4	Tee	2	0	0	PP	15.9	5.31	6.5819E+04	69	Average Re	6.5628E+04 ± 2.50E+02
1005	120131	3	Air Scale 1 Test	33.27	4	Tee	2	0	0	PP	16.5	5.30	6.5720E+04	74	Average Volume (mL)	72 ± 2.65
1006	120131	1	Air Scale 2 Test	50.30	4	Tee	2	0	0	PP	17.9	8.02	9.9361E+04	48	Average Velocity (ft/s)	7.90 ± 0.10
1007	120131	2	Air Scale 2 Test	49.26	4	Tee	2	0	0	PP	18.5	7.85	9.7306E+04	44	Average Re	9.7905E+04 ± 1.27E+03
1008	120131	3	Air Scale 2 Test	49.13	4	Tee	2	0	0	PP	18.8	7.83	9.7049E+04	46	Average Volume (mL)	46 ± 2.00
1009	120131	1	Air Scale 3 Test	60.86	4	Tee	2	0	0	PP	19.8	9.70	1.2022E+05	30	Average Velocity (ft/s)	9.53 ± 0.14
1010	120131	2	Air Scale 3 Test	59.33	4	Tee	2	0	0	PP	19.9	9.46	1.1720E+05	34	Average Re	1.1818E+05 ± 1.77E+03
1011	120131	3	Air Scale 3 Test	59.29	4	Tee	2	0	0	PP	20.2	9.45	1.1712E+05	30	Average Volume (mL)	31.33 ± 2.31
1012	120201	1	Air Scale 4 Test	71.14	4	Tee	2	0	0	PP	19.2	11.34	1.4053E+05	20	Average Velocity (ft/s)	11.41 ± 0.09
1013	120201	2	Air Scale 4 Test	72.37	4	Tee	2	0	0	PP	20.6	11.53	1.4296E+05	11	Average Re	1.4141E+05 ± 1.07E+03
1014	120201	3	Air Scale 4 Test	71.51	4	Tee	2	0	0	PP	21.2	11.40	1.4126E+05	10	Average Volume (mL)	14.5 ± 4.80
1015	120201	4	Air Scale 4 Test	71.33	4	Tee	2	0	0	PP	22.1	11.37	1.4090E+05	17		
1016	120202	1	Air Scale 0 Test	23.82	4	Tee	2	0	0	PP	17.8	3.80	4.7053E+04	94	Average Velocity (ft/s)	3.82 ± 0.02
1017	120202	2	Air Scale 0 Test	23.98	4	Tee	2	0	0	PP	18.1	3.82	4.7369E+04	96	Average Re	4.7310E+04 ± 2.33E+02
1018	120202	3	Air Scale 0 Test	24.05	4	Tee	2	0	0	PP	18.1	3.83	4.7507E+04	93	Average Volume (mL)	94.33 ± 1.53
1019	120202	1	Air Scale 1 Test	30.79	4	Tee	2	0	45	PP	18.3	4.91	6.0821E+04	80	Average Velocity (ft/s)	4.87 ± 0.03
1020	120202	2	Air Scale 1 Test	30.54	4	Tee	2	0	45	PP	18.6	4.87	6.0327E+04	75	Average Re	6.0420E+04 ± 3.64E+02
1021	120202	3	Air Scale 1 Test	30.43	4	Tee	2	0	45	PP	19.1	4.85	6.0110E+04	78	Average Volume (mL)	77.67 ± 2.52
1022	120203	1	Air Scale 2 Test	38.11	4	Tee	2	0	45	PP	15.7	6.07	7.5281E+04	38	Average Velocity (ft/s)	6.00 ± 0.09
1023	120203	2	Air Scale 2 Test	37.85	4	Tee	2	0	45	PP	16.3	6.03	7.4767E+04	43	Average Re	7.4425E+04 ± 1.07E+03
1024	120203	3	Air Scale 2 Test	37.07	4	Tee	2	0	45	PP	19.2	5.91	7.3227E+04	45	Average Volume (mL)	42.00 ± 3.61
1025	120206	1	Air Scale 3 Test	57.57	4	Tee	2	0	45	PP	12.1	9.17	1.1372E+05	19	Average Velocity (ft/s)	9.08 ± 0.09
1026	120206	2	Air Scale 3 Test	56.62	4	Tee	2	0	45	PP	13.7	9.02	1.1184E+05	21	Average Re	1.1250E+05 ± 1.06E+03
1027	120206	3	Air Scale 3 Test	56.66	4	Tee	2	0	45	PP	15.0	9.03	1.1192E+05	22	Average Volume (mL)	20.67 ± 1.53
1028	120206	1	Air Scale 4 Test	70.31	4	Tee	2	0	45	PP	17.7	11.21	1.3889E+05	11	Average Velocity (ft/s)	11.29 ± 0.11
1029	120206	2	Air Scale 4 Test	71.67	4	Tee	2	0	45	PP	19.3	11.42	1.4157E+05	5	Average Re	1.3996E+05 ± 1.42E+03
1030	120206	3	Air Scale 4 Test	70.58	4	Tee	2	0	45	PP	19.1	11.25	1.3942E+05	8	Average Volume (mL)	8.00 ± 3.00
			Total Volume (in³)	Total Volume (mL)												
			6.04	98.97												

Sorted Data BPI Visual Grade in (Flow Increase)													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
1	110718	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	0	PP	33.5	55 gpm	60 gpm
2	110718	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.7	55 gpm	60 gpm
3	110718	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	0	PP	35.8	55 gpm	60 gpm
4	110718	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.3	52 gpm	58 gpm
5	110718	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.9	52 gpm	58 gpm
6	110719	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.6	52 gpm	58 gpm
46	110721	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	45	PP	34.4	55 gpm	65 gpm
47	110721	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	45	PP	34.9	55 gpm	65 gpm
48	110721	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0	45	PP	35.3	55 gpm	65 gpm
49	110721	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	45	PP	35.8	60 gpm	65 gpm
50	110721	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	45	PP	36.3	60 gpm	65 gpm
51	110721	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0	45	PP	36.8	60 gpm	65 gpm
67	110725	1	Flow Increase	L/D of 2	Straight	2	Horizontal	0	90	PP	28.7	55 gpm	75 gpm
68	110725	2	Flow Increase	L/D of 2	Straight	2	Horizontal	0	90	PP	29.2	55 gpm	75 gpm
69	110725	3	Flow Increase	L/D of 2	Straight	2	Horizontal	0	90	PP	29.7	55 gpm	75 gpm
88	110726	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	28.8	60 gpm	75 gpm
89	110726	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	29.3	60 gpm	75 gpm
90	110726	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	29.7	60 gpm	75 gpm
91	110726	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	30.1	58 gpm	NA
92	110726	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	30.5	58 gpm	NA
93	110726	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	30.8	58 gpm	NA
106	110726	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	34.9	60 gpm	75 gpm
107	110726	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	34.4	60 gpm	75 gpm
108	110726	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	35.4	60 gpm	75 gpm
109	110726	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	35.8	58 gpm	NA
110	110726	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	36.1	58 gpm	NA
111	110726	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	36.5	58 gpm	NA
124	110727	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	35.3	60 gpm	75 gpm
125	110727	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	36.2	60 gpm	75 gpm
126	110727	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	36.5	60 gpm	75 gpm
127	110727	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	36.9	56 gpm	NA
128	110727	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	37.1	56 gpm	NA
129	110727	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	37.5	56 gpm	NA
142	110728	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	34	60 gpm	75 gpm
143	110728	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	34.3	60 gpm	75 gpm
144	110728	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	34.6	60 gpm	75 gpm
145	110728	1	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	35	58 gpm	NA
146	110728	2	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	35.3	58 gpm	NA
147	110728	3	Flow Increase (Selected)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	35.5	58 gpm	NA
160	110728	1	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	38.4	60 gpm	75 gpm
161	110728	2	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	38.9	60 gpm	75 gpm
162	110729	3	Flow Increase (Initial)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	39.2	60 gpm	75 gpm
175	110729	1	Flow Increase	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	37.2	50 gpm	75 gpm
176	110729	2	Flow Increase	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	27.6	50 gpm	75 gpm
177	110801	3	Flow Increase	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	28.1	50 gpm	75 gpm
205	110809	1	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	25.4	NA	45 gpm
206	110809	2	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	25.9	NA	45 gpm
207	110809	3	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	26.3	NA	45 gpm
217	110809	1	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.1	NA	45 gpm
218	110809	2	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.3	NA	45 gpm
219	110809	3	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.6	NA	45 gpm
229	110809	1	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	29.6	NA	45 gpm
230	110809	2	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	30	NA	45 gpm
231	110809	3	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	30.2	NA	45 gpm
241	110812	1	Flow Increase	L/D of 2	Straight	2	Horizontal	0	45	PVC	31.8	NA	90 gpm
242	110812	2	Flow Increase	L/D of 2	Straight	2	Horizontal	0	45	PVC	32.2	NA	90 gpm
243	110812	3	Flow Increase	L/D of 2	Straight	2	Horizontal	0	45	PVC	32.4	NA	90 gpm
256	110819	1	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	25.2	45 gpm	60 gpm

257	110819	2	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	25.7	45 gpm	60 gpm
258	110819	3	Flow Increase	L/D of 2	Straight	2	Vertical	0	0	PP	26	45 gpm	60 gpm
265	110819	1	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	28.3	45 gpm	60 gpm
266	110819	2	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	28.7	45 gpm	60 gpm
267	110819	3	Flow Increase	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	28.9	45 gpm	60 gpm
274	110822	1	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	26.3	45 gpm	60 gpm
275	110822	2	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	26.6	45 gpm	60 gpm
276	110822	3	Flow Increase	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	26.8	45 gpm	60 gpm
283	110823	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	27.4	35 gpm	40 gpm
284	110823	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	27.6	35 gpm	40 gpm
285	110823	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	27.7	35 gpm	40 gpm
292	110823	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.1	35 gpm	50 gpm
293	110823	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	35 gpm	50 gpm
294	110823	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.5	35 gpm	50 gpm
301	110824	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.1	15 gpm	30 gpm
302	110824	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.3	15 gpm	30 gpm
303	110824	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.5	15 gpm	30 gpm
304	110824	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.5	30 gpm	45 gpm
305	110824	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.6	30 gpm	45 gpm
306	110824	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.8	30 gpm	45 gpm
313	110825	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	27.7	100 gpm	120 gpm
314	110825	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.3	100 gpm	120 gpm
315	110825	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.7	100 gpm	120 gpm
322	110825	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	31.1	20 gpm	45 gpm
323	110825	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	31.4	20 gpm	45 gpm
324	110825	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	31.8	20 gpm	45 gpm
331	110825	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.2	15 gpm	30 gpm
332	110825	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.3	15 gpm	30 gpm
333	110825	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.3	15 gpm	30 gpm
337	110830	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	23.6	15 gpm	30 gpm
338	110830	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	23.8	15 gpm	30 gpm
339	110830	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	24	15 gpm	30 gpm
343	110830	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	24.5	15 gpm	30 gpm
344	110830	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	24.9	15 gpm	30 gpm
345	110830	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	24.9	15 gpm	30 gpm
349	110830	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	25.5	45 gpm	50 gpm
350	110830	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	25.8	45 gpm	50 gpm
351	110830	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	26.2	45 gpm	50 gpm
358	110830	1	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	29	45 gpm	50 gpm
359	110830	2	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	29.3	45 gpm	50 gpm
360	110830	3	Flow Increase	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	29.6	45 gpm	50 gpm
367	110831	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	28.7	NA	30 gpm
368	110831	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29	NA	30 gpm
369	110831	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	NA	30 gpm
373	110831	1	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.3	NA	45 gpm
374	110831	2	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.5	NA	45 gpm
375	110831	3	Flow Increase	L/D of 2	Elbow	2	Vertical	0	0	PP	29.7	NA	45 gpm
385	110913	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	25.7	10 gpm	12 gpm
386	110913	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26	10 gpm	12 gpm
387	110913	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26.5	10 gpm	12 gpm
394	110917	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	45	PP	23.4	10 gpm	12 gpm
395	110917	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	45	PP	23.8	10 gpm	12 gpm
396	110917	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	45	PP	24.5	10 gpm	12 gpm
406	110922	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	90	PP	22.6	10 gpm	12 gpm
407	110922	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23	10 gpm	12 gpm
408	110922	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.3	10 gpm	12 gpm
415	110923	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	24.5	10 gpm	12 gpm
416	110923	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	25.2	10 gpm	12 gpm
417	110923	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	25.8	10 gpm	12 gpm
424	110926	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	24.3	10 gpm	12 gpm
425	110926	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	25	10 gpm	12 gpm
426	110926	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	25.7	10 gpm	12 gpm

433	110927	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	26.5	NA	10 gpm
434	110927	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	26.9	NA	10 gpm
435	110927	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	27.1	NA	10 gpm
442	110929	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	25	10 gpm	12 gpm
443	110929	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	25.3	10 gpm	12 gpm
444	110929	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	25.8	10 gpm	12 gpm
451	110929	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	27	10 gpm	12 gpm
452	110929	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	27.4	10 gpm	12 gpm
453	110929	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	27.7	10 gpm	12 gpm
460	110930	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	25.6	8 gpm	12 gpm
461	110930	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	26.3	8 gpm	12 gpm
462	110930	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	26.8	8 gpm	12 gpm
489	111003	1	Flow Increase	L/D of 2	Straight	1	Horizontal	0	0	PP	23.9	14 gpm	18 gpm
490	111003	2	Flow Increase	L/D of 2	Straight	1	Horizontal	0	0	PP	24.7	14 gpm	18 gpm
491	111003	3	Flow Increase	L/D of 2	Straight	1	Horizontal	0	0	PP	25.2	14 gpm	18 gpm
521	111006	1	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	22.6	8 gpm	12 gpm
522	111006	2	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	22.8	8 gpm	12 gpm
523	111006	3	Flow Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	23	8 gpm	12 gpm
BPI Visual Grade 4 & 5 NA				MISC									
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
7	110719	1	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.1	NA	NA
8	110719	2	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.2	NA	NA
9	110719	3	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.5	NA	NA
10	110719	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.4	NA	NA
11	110719	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.6	NA	NA
12	110719	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.6	NA	NA
13	110719	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.8	NA	NA
14	110719	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	35.3	NA	NA
15	110720	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	35.6	NA	NA
28	110720	1	Increase Back Pressure with Maintained Flow (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	31.5	NA	NA
29	110720	2	Increase Back Pressure with Maintained Flow (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	31.8	NA	NA
30	110720	3	Increase Back Pressure with Maintained Flow (30)	L/D of 2	Straight	2	Horizontal	0	0	PP	32.2	NA	NA
70	110725	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PP	30	NA	NA
71	110725	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PP	30.3	NA	NA
72	110725	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PP	30.5	NA	NA
73	110725	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	90	PP	30.8	NA	NA
74	110725	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	90	PP	31	NA	NA
75	110725	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0	90	PP	31.3	NA	NA
94	110726	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	31.1	NA	NA
95	110726	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	31.4	NA	NA
96	110726	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	31.7	NA	NA
97	110726	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	32	NA	NA
98	110726	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	32.4	NA	NA
99	110726	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	32.7	NA	NA
112	110726	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	37.1	NA	NA
113	110726	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	37.3	NA	NA
114	110726	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	37.6	NA	NA
115	110726	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	37.8	NA	NA
116	110726	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	38.2	NA	NA
117	110726	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	38.5	NA	NA
130	110727	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	37.7	NA	NA
131	110727	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	38	NA	NA
132	110727	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	38.2	NA	NA
133	110727	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	38	NA	NA
134	110727	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	38.3	NA	NA
135	110727	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	38.7	NA	NA
148	110728	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	35.9	NA	NA
149	110728	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	36	NA	NA
150	110728	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	36.2	NA	NA

151	110728	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	36.5	NA	NA
152	110728	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	36.9	NA	NA
153	110728	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	37.2	NA	NA
166	110729	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	34.1	NA	NA
167	110729	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	34.3	NA	NA
168	110729	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	34.6	NA	NA
352	110830	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	26.6	NA	NA
353	110830	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	27.1	NA	NA
354	110830	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	27.4	NA	NA
361	110831	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	27.2	NA	NA
362	110831	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	27.6	NA	NA
363	110831	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	27.9	NA	NA
376	110831	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	30	NA	NA
377	110831	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.2	NA	NA
378	110831	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.5	NA	NA
403	110917	1	Pressure Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26.1	NA	NA
404	110917	2	Pressure Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26.6	NA	NA
405	110917	3	Pressure Increase	L/D of 2	Straight	0.75	Horizontal	0	0	PP	27	NA	NA
541	111011	1	Flow Start-Up (15)	SO	Straight	1	Vertical	0	0	PP	23	NA	NA
Sorted Data BPI Visual Grade 4 Data in Min													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
16	110720	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	0	PP	36	5 min	NA
17	110720	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.3	5 min	NA
18	110720	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.1	5 min	NA
58	110721	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	45	PP	39.2	5 min	NA
59	110721	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	45	PP	39.6	5 min	NA
60	110721	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	45	PP	39.9	5 min	NA
76	110725	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	90	PP	31.6	3 min	NA
77	110725	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	90	PP	32	3 min	NA
78	110725	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0	90	PP	32.3	3 min	NA
100	110726	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	33.2	6 min	NA
101	110726	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	33.6	6 min	NA
102	110726	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	34	6 min	NA
118	110727	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	32.4	6 min	NA
119	110727	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	32.8	6 min	NA
120	110727	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	33.3	6 min	NA
121	110727	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	33.7	3 min	NA
122	110727	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	34.2	3 min	NA
123	110727	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	45	PP	34.6	3 min	NA
136	110727	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	39	2 min	NA
137	110727	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	39.3	2 min	NA
138	110727	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	39.5	2 min	NA
154	110728	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	37.5	5 min	NA
155	110728	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	37.5	5 min	NA
156	110728	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	37.9	5 min	NA
169	110729	1	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	34.9	6 min	NA
170	110729	2	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	35.3	6 min	NA
171	110729	3	Flow Start-Up (55)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	35.8	6 min	NA
172	110729	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	36.2	2 min	NA
173	110729	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	36.3	2 min	NA
174	110729	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	45	PP	36.7	2 min	NA
178	110801	1	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	28.5	2 min	NA
179	110801	2	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	28.7	2 min	NA
180	110801	3	Flow Start-Up (50)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	29.1	2 min	NA
259	110819	1	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0	0	PP	26.3	2 min	NA
260	110819	2	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0	0	PP	26.9	2 min	NA
261	110819	3	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0	0	PP	27.3	2 min	NA
268	110819	1	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	29.3	1 min	NA
269	110819	2	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	30	1 min	NA
270	110819	3	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	30.5	1 min	NA

286	110823	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	28	5 min	NA
287	110823	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.3	5 min	NA
288	110823	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.5	5 min	NA
316	110825	1	Flow Start-Up (90)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	4 min	NA
317	110825	2	Flow Start-Up (90)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.6	4 min	NA
318	110825	3	Flow Start-Up (90)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.1	4 min	NA
325	110825	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	31.9	1 min	NA
326	110825	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	32.2	1 min	NA
327	110825	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	32.6	1 min	NA
463	110930	1	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	27.5	1 min	NA
542	111011	1	Flow Start-Up (19)	SO	Straight	1	Vertical	0	0	PP	23.7	4 min	NA
548	111017	1	Flow Start-Up (8)	L/D of 2	Straight	1	Vertical	0	0	PP	24.2	1 min	NA
549	111017	2	Flow Start-Up (8)	L/D of 2	Straight	1	Vertical	0	0	PP	24.6	1 min	NA
553	111017	1	Flow Start-Up (6)	SO	Straight	1	Vertical	0	0	PP	25.3	1 min	NA
BPI Visual Grade 4 and 5 Data in Min													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
19	110720	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.3	1.5 min	2.5 min
20	110720	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.5	1.5 min	2.5 min
21	110720	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.7	1.5 min	2.5 min
22	110720	1	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.8	0.25 min	0.5 min
23	110720	2	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	0	PP	36.9	0.25 min	0.5 min
24	110720	3	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	0	PP	37	0.25 min	0.5 min
40	110720	1	Maintain Back Pressure with Maintained Flow (30, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.8	2 min	3 min
41	110720	2	Maintain Back Pressure with Maintained Flow (30, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	38	2 min	3 min
42	110720	3	Maintain Back Pressure with Maintained Flow (30, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	38.1	2 min	3 min
43	110720	1	Maintain Back Pressure with Maintained Flow (60, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.1	1.5 min	3 min
44	110720	2	Maintain Back Pressure with Maintained Flow (60, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.3	1.5 min	4 min
45	110720	3	Maintain Back Pressure with Maintained Flow (60, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.4	1.5 min	5 min
61	110721	1	Flow Start-Up (65)	L/D of 2	Straight	2	Horizontal	0	45	PP	40.3	1 min	5 min
62	110721	2	Flow Start-Up (65)	L/D of 2	Straight	2	Horizontal	0	45	PP	40.5	1 min	5 min
63	110721	3	Flow Start-Up (65)	L/D of 2	Straight	2	Horizontal	0	45	PP	40.7	1 min	5 min
64	110721	1	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	45	PP	40.9	0.25 min	1.5 min
65	110721	2	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	45	PP	41	0.25 min	1.5 min
66	110721	3	Flow Start-Up (75)	L/D of 2	Straight	2	Horizontal	0	45	PP	41.1	0.25 min	1.5 min
79	110725	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	90	PP	32.6	1 min	4 min
80	110725	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	90	PP	32.9	1 min	4 min
81	110725	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0	90	PP	33.1	1 min	4 min
103	110726	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	34.4	3 min	5 min
104	110726	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	34.7	3 min	5 min
105	110726	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	0	PP	34.9	3 min	5 min
139	110727	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	39.8	1 min	3 min
140	110727	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	40	1 min	3 min
141	110727	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	0.010416667	90	PP	40.1	1 min	3 min
157	110728	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	38.3	3 min	4 min
158	110728	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	38.5	3 min	4 min
159	110728	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	0	PP	38.3	3 min	4 min
181	110801	1	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	28.5	1 min	3 min
182	110801	2	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	28.7	1 min	3 min
183	110801	3	Flow Start-Up (60)	L/D of 2	Straight	2	Horizontal	-0.0104166	90	PP	29.1	1 min	3 min
184	110801	1	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	29.3	3 min	6 min
185	110801	2	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	29.5	3 min	6 min
186	110801	3	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	29.7	3 min	6 min
187	110801	1	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	30.1	3 min	6 min
188	110801	2	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	30.5	3 min	6 min
189	110801	3	Flow Increase (verification, 60)	L/D of 2	Straight	2	Horizontal	0	0	PP	30.8	3 min	6 min
190	110802	1	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	0	PP	30.1	0.25 min	2 min
191	110802	2	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	0	PP	30.2	0.25 min	2 min
192	110802	3	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	0	PP	30.3	0.25 min	2 min
196	110802	1	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	45	PP	30.8	2 min	5.5 min
197	110802	2	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	45	PP	31.2	2 min	5.5 min

198	110802	3	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	45	PP	31.5	2 min	5.5 min
238	110812	1	Flow Start-Up (150)	L/D of 2	Straight	2	Horizontal	0	0	PVC	29.4	1 min	3 min
239	110812	2	Flow Start-Up (150)	L/D of 2	Straight	2	Horizontal	0	0	PVC	30.5	1 min	3 min
240	110812	3	Flow Start-Up (150)	L/D of 2	Straight	2	Horizontal	0	0	PVC	31	1 min	3 min
247	110812	1	Flow Start-Up (60)	Standard	Straight	2	Horizontal	0	0	SS	26	2 min	4.5 min
248	110812	2	Flow Start-Up (60)	Standard	Straight	2	Horizontal	0	0	SS	26.5	2 min	4.5 min
249	110812	3	Flow Start-Up (60)	Standard	Straight	2	Horizontal	0	0	SS	26.8	2 min	4.5 min
262	110819	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	27.7	1 min	1.5 min
263	110819	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	27.8	1 min	1.5 min
264	110819	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	28	1 min	1.5 min
271	110822	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	25.7	1 min	1.5 min
272	110822	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	26	1 min	1.5 min
273	110822	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	26.1	1 min	1.5 min
277	110822	1	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	27.3	2 min	6 min
278	110822	2	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	27.7	2 min	6 min
279	110822	3	Flow Start-Up (45)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.2	2 min	6 min
280	110822	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.7	1 min	1.5 min
281	110822	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.7	1 min	1.5 min
282	110822	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	28.9	1 min	1.5 min
307	110824	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.9	1 min	2 min
308	110824	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.1	1 min	2 min
309	110824	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.1	1 min	2 min
364	110831	1	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	28.1	1 min	4 min
365	110831	2	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	28.3	1 min	4 min
366	110831	3	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	28.7	1 min	4 min
409	110922	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.4	0.5 min	1 min
410	110922	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.4	0.5 min	2 min
411	110922	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.5	0.5 min	3 min
436	110928	1	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	25.4	4 min	5 min
437	110928	2	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	25.7	4 min	5 min
438	110928	3	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	26	4 min	5 min
515	111004	1	Flow Start-Up (18)	SO	Straight	1	Horizontal	0	45	PP	26	3 min	5 min
516	111004	2	Flow Start-Up (18)	SO	Straight	1	Horizontal	0	45	PP	26.2	3 min	5 min
519	111004	1	Flow Start-Up (19)	SO	Straight	1	Horizontal	0	90	PP	27	1 min	5 min
520	111004	2	Flow Start-Up (19)	SO	Straight	1	Horizontal	0	90	PP	27.3	1 min	5 min
535	111011	1	Flow Start-Up (16)	L/D of 2	Straight	1	Vertical	0	0	PP	21.5	1 min	2 min
536	111011	2	Flow Start-Up (16)	L/D of 2	Straight	1	Vertical	0	0	PP	21.7	1 min	2 min
537	111011	3	Flow Start-Up (16)	L/D of 2	Straight	1	Vertical	0	0	PP	21.9	1 min	2 min
538	111011	1	Flow Start-Up (15)	L/D of 2	Straight	1	Vertical	0	0	PP	22.1	1 min	4 min
539	111011	2	Flow Start-Up (15)	L/D of 2	Straight	1	Vertical	0	0	PP	22.4	1 min	4 min
540	111011	3	Flow Start-Up (15)	L/D of 2	Straight	1	Vertical	0	0	PP	22.6	1 min	4 min
543	111011	1	Flow Start-Up (20)	SO	Straight	1	Vertical	0	0	PP	24	3 min	4 min
544	111011	2	Flow Start-Up (20)	SO	Straight	1	Vertical	0	0	PP	24.2	3 min	4 min
554	111017	2	Flow Start-Up (6)	SO	Straight	1	Vertical	0	0	PP	25.6	1 min	5 min
555	111017	3	Flow Start-Up (6)	SO	Straight	1	Vertical	0	0	PP	25.7	1 min	5 min
Sorted Data for BPI Visual Grade 4 as NA and BPI Visual Grade 5 1mm													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
25	110720	1	Flow Start-Up (90)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.2	NA	Imm
26	110720	2	Flow Start-Up (90)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.2	NA	Imm
27	110720	3	Flow Start-Up (90)	L/D of 2	Straight	2	Horizontal	0	0	PP	37.2	NA	Imm
82	110725	1	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	135	PP	32.6	NA	Imm
83	110725	2	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	135	PP	32.5	NA	Imm
84	110725	3	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	135	PP	32.5	NA	Imm
85	110725	1	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	180	PP	32.2	NA	Imm
86	110725	2	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	180	PP	32.2	NA	Imm
87	110725	3	Flow Start-Up (30)	L/D of 2	Straight	2	Horizontal	0	180	PP	32.2	NA	Imm
193	110802	1	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	0	PP	30.3	NA	Imm
194	110802	2	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	0	PP	30.5	NA	Imm
195	110802	3	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	0	PP	30.5	NA	Imm
199	110802	1	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	45	PP	31.2	NA	Imm

200	110802	2	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	45	PP	31.6	NA	Imm
201	110802	3	Flow Start-Up (60)	SO	Straight	2	Horizontal	0	45	PP	31.6	NA	Imm
202	110802	1	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	90	PP	31.6	NA	Imm
203	110802	2	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	90	PP	31.9	NA	Imm
204	110802	3	Flow Start-Up (30)	SO	Straight	2	Horizontal	0	90	PP	31.8	NA	Imm
214	110809	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	27.7	NA	Imm
215	110809	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	27.8	NA	Imm
216	110809	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0	0	PP	27.9	NA	Imm
226	110809	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	29.4	NA	Imm
227	110809	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	29.4	NA	Imm
228	110809	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	-0.0104166	0	PP	29.4	NA	Imm
244	110812	1	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PVC	32.7	NA	Imm
245	110812	2	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PVC	32.7	NA	Imm
246	110812	3	Flow Start-Up (45)	L/D of 2	Straight	2	Horizontal	0	90	PVC	32.7	NA	Imm
251	110818	2	Flow Start-Up (30)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	24.4	NA	Imm
252	110818	3	Flow Start-Up (30)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	24.4	NA	Imm
253	110818	1	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	24.5	NA	Imm
254	110818	2	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	24.6	NA	Imm
255	110818	3	Flow Start-Up (60)	L/D of 2	Straight	2	Vertical	0.0104166	0	PP	24.7	NA	Imm
310	110824	1	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.3	NA	Imm
311	110824	2	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.3	NA	Imm
312	110824	3	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.3	NA	Imm
334	110825	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.1	NA	Imm
335	110825	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.3	NA	Imm
336	110825	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0	0	PP	33.3	NA	Imm
340	110830	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	24.3	NA	Imm
341	110830	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	24.3	NA	Imm
342	110830	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	0.0104166	0	PP	24.4	NA	Imm
346	110830	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	25.1	NA	Imm
347	110830	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	25.1	NA	Imm
348	110830	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	25.2	NA	Imm
370	110831	1	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	NA	Imm
371	110831	2	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	NA	Imm
372	110831	3	Flow Start-Up (30)	L/D of 2	Elbow	2	Vertical	0	0	PP	29.2	NA	Imm
379	110831	1	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.6	NA	Imm
380	110831	2	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.6	NA	Imm
381	110831	3	Flow Start-Up (45)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.6	NA	Imm
382	110831	1	Flow Start-Up (30)	SO	Elbow	2	Vertical	0	0	PP	30.9	NA	Imm
383	110831	2	Flow Start-Up (30)	SO	Elbow	2	Vertical	0	0	PP	30.9	NA	Imm
384	110831	3	Flow Start-Up (30)	SO	Elbow	2	Vertical	0	0	PP	30.9	NA	Imm
412	110922	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.5	NA	Imm
413	110922	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.6	NA	Imm
414	110922	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	90	PP	23.7	NA	Imm
439	110928	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	24.5	NA	Imm
440	110928	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	25	NA	Imm
441	110928	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	90	PP	25	NA	Imm
Sorted Data for BPI Visual Grade 4 in psig and BPI Visual Grade 5 NA													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
31	110720	1	Increase Back Pressure with Maintained Flow (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	32.4	45 psig	NA
32	110720	2	Increase Back Pressure with Maintained Flow (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	32.7	45 psig	NA
33	110720	3	Increase Back Pressure with Maintained Flow (45)	L/D of 2	Straight	2	Horizontal	0	0	PP	33.2	45 psig	NA
34	110720	1	Increase Back Pressure with Maintained Flow (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	33.5	30 psig	NA
35	110720	2	Increase Back Pressure with Maintained Flow (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	33.9	30 psig	NA
36	110720	3	Increase Back Pressure with Maintained Flow (50)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.2	30 psig	NA
Sorted Data for BPI Visual Grade 4 in psig and BPI Visual Grade 5 in psig													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
37	110720	1	Increase Back Pressure with Maintained Flow (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.6	2 psig	30 psig
38	110720	2	Increase Back Pressure with Maintained Flow (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	34.9	2 psig	30 psig

39	110720	3	Increase Back Pressure with Maintained Flow (60)	L/D of 2	Straight	2	Horizontal	0	0	PP	35.3	2 psig	30 psig
Sorted Data for BPI Visual Grade 4 in mm and BPI Visual Grade 5 in min and NA													
Experiment	Date	Run	Description	Branch Size	Piece	Size (in)	Orientation	Slope (in)	Rotation (deg)	Material	Temperature (°C)	BPI Visual Grade 4	BPI Visual Grade 5
289	110823	1	Flow Start-Up (40)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.7	Imm	0.75 min
290	110823	2	Flow Start-Up (40)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.8	Imm	0.75 min
291	110823	3	Flow Start-Up (40)	L/D of 2	Elbow	2	Vertical	0	0	PP	28.9	Imm	0.75 min
296	110823	2	Flow Start-Up (40)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.1	Imm	NA
297	110823	3	Flow Start-Up (40)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.4	Imm	NA
298	110823	1	Flow Start-Up (50)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.8	Imm	4.5 min
299	110823	2	Flow Start-Up (50)	L/D of 2	Elbow	2	Vertical	0	0	PP	31.1	Imm	4.5 min
300	110823	3	Flow Start-Up (50)	L/D of 2	Elbow	2	Vertical	0	0	PP	31.3	Imm	4.5 min
319	110825	1	Flow Start-Up (110)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.5	Imm	2 min
320	110825	2	Flow Start-Up (110)	L/D of 2	Elbow	2	Vertical	0	0	PP	30.7	Imm	2 min
321	110825	3	Flow Start-Up (110)	L/D of 2	Elbow	2	Vertical	0	0	PP	31	Imm	2 min
328	110825	1	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0	0	PP	32.7	Imm	1 min
329	110825	2	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0	0	PP	32.8	Imm	1 min
330	110825	3	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	0	0	PP	32.9	Imm	1 min
355	110830	1	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	27.7	Imm	4 min
356	110830	2	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	28.4	Imm	4 min
357	110830	3	Flow Start-Up (45)	L/D of 2	Elbow	2	Horizontal	-0.0104166	0	PP	28.6	Imm	4 min
388	110913	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26.5	Imm	NA
389	110913	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	26.7	Imm	NA
390	110913	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	27	Imm	NA
391	110913	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	27.1	Imm	1 min
392	110913	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	27.2	Imm	1 min
393	110913	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	0	PP	27.2	Imm	1 min
397	110917	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	24.9	Imm	4.5 min
398	110917	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	25.1	Imm	4.5 min
399	110917	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	25.3	Imm	4.5 min
400	110917	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	25.3	Imm	1 min
401	110917	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	25.4	Imm	1 min
402	110917	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0	45	PP	25.5	Imm	1 min
418	110923	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.1	Imm	4 min
419	110923	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.4	Imm	4 min
420	110923	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.6	Imm	4 min
421	110923	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.7	Imm	0.75 min
422	110923	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.7	Imm	0.75 min
423	110923	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	0	PP	26.7	Imm	0.75 min
427	110926	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	26.4	Imm	4 min
428	110926	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	26.6	Imm	4 min
429	110926	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	26.8	Imm	4 min
430	110926	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	27	Imm	0.75 min
431	110926	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	27	Imm	0.75 min
432	110926	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	0.0104166	45	PP	27	Imm	0.75 min
445	110929	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	25.8	Imm	5 min
446	110929	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	26	Imm	5 min
447	110929	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	26.2	Imm	5 min
448	110929	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	26.4	Imm	1 min
449	110929	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	26.5	Imm	1 min
450	110929	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	0	PP	26.5	Imm	1 min
454	110930	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	24.5	Imm	4 min
455	110930	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	24.7	Imm	4 min
456	110930	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	24.9	Imm	4 min
457	110930	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	25	Imm	1 min
458	110930	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	25.1	Imm	1 min
459	110930	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	45	PP	25.1	Imm	1 min
464	110930	2	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	27.5	Imm	1.5 min
465	110930	3	Flow Start-Up (8)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	27.7	Imm	1.5 min
466	110930	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	26.9	Imm	1 min
467	110930	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	27	Imm	1 min

468	110930	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Horizontal	-0.0104166	90	PP	27.1	Imm	1 min
469	111001	1	Flow Start-Up (8)	SO	Straight	0.75	Horizontal	0	0	PP	25.3	Imm	NA
470	111001	2	Flow Start-Up (8)	SO	Straight	0.75	Horizontal	0	0	PP	25.8	Imm	NA
471	111001	1	Flow Start-Up (10)	SO	Straight	0.75	Horizontal	0	0	PP	26	Imm	NA
472	111001	2	Flow Start-Up (10)	SO	Straight	0.75	Horizontal	0	0	PP	26.2	Imm	NA
473	111001	1	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	0	PP	26.5	Imm	NA
474	111001	2	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	0	PP	26.8	Imm	NA
475	111001	1	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	0	PP	27.3	Imm	2 min
476	111001	2	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	0	PP	27.4	Imm	2 min
477	111001	3	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	0	PP	27.5	Imm	2 min
478	111001	1	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	45	PP	28.6	Imm	1 min
479	111001	2	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	45	PP	28.6	Imm	1 min
480	111001	3	Flow Start-Up (15)	SO	Straight	0.75	Horizontal	0	45	PP	28.7	Imm	1 min
481	111001	1	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	45	PP	27.9	Imm	NA
482	111001	2	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	45	PP	28.1	Imm	NA
483	111001	3	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	45	PP	28.4	Imm	NA
484	111001	1	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	90	PP	29	Imm	2 min
485	111001	2	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	90	PP	29.1	Imm	2 min
486	111001	3	Flow Start-Up (12)	SO	Straight	0.75	Horizontal	0	90	PP	29.3	Imm	2 min
487	111001	1	Flow Start-Up (10)	SO	Straight	0.75	Horizontal	0	90	PP	289.5	Imm	NA
488	111001	2	Flow Start-Up (10)	SO	Straight	0.75	Horizontal	0	90	PP	29.7	Imm	NA
492	111003	1	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	0	PP	25.5	Imm	2 min
493	111003	2	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	0	PP	25.6	Imm	2 min
494	111003	3	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	0	PP	25.8	Imm	2 min
495	111003	1	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	0	PP	26.3	Imm	NA
496	111003	2	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	0	PP	26.5	Imm	NA
497	111003	1	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	45	PP	26.6	Imm	3 min
498	111003	2	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	45	PP	26.7	Imm	3 min
499	111003	3	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	45	PP	26.9	Imm	3 min
500	111003	1	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	45	PP	27.2	Imm	NA
501	111003	2	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	45	PP	27.5	Imm	NA
502	111003	1	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	90	PP	27.6	Imm	1 min
503	111003	2	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	90	PP	27.6	Imm	1 min
504	111003	3	Flow Start-Up (16)	L/D of 2	Straight	1	Horizontal	0	90	PP	27.6	Imm	1 min
505	111003	1	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	90	PP	27.8	Imm	2 min
506	111003	2	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	90	PP	27.9	Imm	2 min
507	111003	3	Flow Start-Up (14)	L/D of 2	Straight	1	Horizontal	0	90	PP	28	Imm	2 min
508	111003	1	Flow Start-Up (12)	L/D of 2	Straight	1	Horizontal	0	90	PP	28.2	Imm	3 min
509	111003	2	Flow Start-Up (12)	L/D of 2	Straight	1	Horizontal	0	90	PP	28.3	Imm	3 min
510	111003	3	Flow Start-Up (12)	L/D of 2	Straight	1	Horizontal	0	90	PP	28.4	Imm	3 min
511	111004	1	Flow Start-Up (16)	SO	Straight	1	Horizontal	0	0	PP	25	Imm	NA
512	111004	1	Flow Start-Up (18)	SO	Straight	1	Horizontal	0	0	PP	25.3	Imm	5 min
513	111004	2	Flow Start-Up (18)	SO	Straight	1	Horizontal	0	0	PP	25.6	Imm	5 min
514	111004	3	Flow Start-Up (18)	SO	Straight	1	Horizontal	0	0	PP	25.8	Imm	5 min
524	111007	1	Flow Start-Up (12)	L/D of 2	Straight	0.75	Vertical	0	0	PP	20.7	Imm	1 min
525	111007	2	Flow Start-Up (12)	L/D of 2	Straight	0.75	Vertical	0	0	PP	21	Imm	1 min
526	111007	3	Flow Start-Up (12)	L/D of 2	Straight	0.75	Vertical	0	0	PP	21.1	Imm	1 min
527	111007	1	Flow Start-Up (10)	L/D of 2	Straight	0.75	Vertical	0	0	PP	21.5	Imm	4 min
528	111007	2	Flow Start-Up (10)	L/D of 2	Straight	0.75	Vertical	0	0	PP	21.7	Imm	4 min
529	111007	3	Flow Start-Up (10)	L/D of 2	Straight	0.75	Vertical	0	0	PP	21.9	Imm	4 min
530	111007	1	Flow Start-Up (10)	SO	Straight	0.75	Vertical	0	0	PP	22.2	Imm	NA
531	111007	2	Flow Start-Up (10)	SO	Straight	0.75	Vertical	0	0	PP	22.4	Imm	NA
532	111007	1	Flow Start-Up (12)	SO	Straight	0.75	Vertical	0	0	PP	22.6	Imm	4 min
533	111007	2	Flow Start-Up (12)	SO	Straight	0.75	Vertical	0	0	PP	22.9	Imm	6 min
534	111007	3	Flow Start-Up (12)	SO	Straight	0.75	Vertical	0	0	PP	23.1	Imm	5 min
545	111014	1	Flow Start-Up (10)	L/D of 2	Straight	1	Vertical	0	0	PP	21.5	Imm	1 min
546	111014	2	Flow Start-Up (10)	L/D of 2	Straight	1	Vertical	0	0	PP	21.6	Imm	1 min
547	111014	3	Flow Start-Up (10)	L/D of 2	Straight	1	Vertical	0	0	PP	21.8	Imm	1 min
550	111017	1	Flow Start-Up (8)	SO	Straight	1	Vertical	0	0	PP	24.8	Imm	1 min
551	111017	2	Flow Start-Up (8)	SO	Straight	1	Vertical	0	0	PP	24.7	Imm	1 min
552	111017	3	Flow Start-Up (8)	SO	Straight	1	Vertical	0	0	PP	24.7	Imm	1 min

Spool Component	Nominal Size		Outside Diameter		Inside Diameter		Wall Thickness	
	(inch)	(mm)	(inch)	(mm)	(inch)	(mm)	(inch)	(mm)
Polypropylene Straight Tee (2" L/D of 2)	1.97	50	1.982	50.343	1.601	40.672	0.190	4.836
Polypropylene Elbow (2" L/D of 2)	1.97	50	1.978	50.248	1.564	39.719	0.207	5.264
Polypropylene Straight Tee (2" SO)	1.97	50	1.979	50.260	1.577	40.056	0.201	5.102
Polypropylene Elbow (2" SO)	1.97	50	1.978	50.229	1.561	39.637	0.209	5.296
Polypropylene Straight Tee (0.75" L/D of 2)	0.79	20	0.788	20.003	0.616	15.640	0.086	2.181
Polypropylene Elbow (0.75" L/D of 2)	0.79	20	0.795	20.187	0.615	15.608	0.090	2.289
Polypropylene Straight Tee (0.75" SO)	0.79	20	0.790	20.060	0.618	15.697	0.086	2.181
Polypropylene Elbow (0.75" SO)	0.79	20	0.794	20.174	0.618	15.685	0.088	2.245
Polypropylene Straight Tee (1" L/D of 2)	0.98	25	0.990	25.146	0.783	19.895	0.103	2.626
Polypropylene Elbow (1" L/D of 2)	0.98	25	0.990	25.152	0.786	19.964	0.102	2.594
Polypropylene Straight Tee (1" SO)	0.98	25	0.990	25.152	0.786	19.958	0.102	2.597
Polypropylene Elbow (1" SO)	0.98	25	0.990	25.146	0.785	19.945	0.102	2.600
Polypropylene Straight Tee (1.5" L/D of 2)	1.57	40	1.574	39.980	1.256	31.890	0.159	4.045
Polypropylene Elbow (1.5" L/D of 2)	1.57	40	1.582	40.183	1.259	31.979	0.162	4.102
Polypropylene Straight Tee (1.5" SO)	1.57	40	1.571	39.897	1.248	31.687	0.162	4.105
Polypropylene Elbow (1.5" SO)	1.57	40	1.582	40.176	1.264	32.099	0.159	4.039
Polypropylene Tee (2")	1.97	50	1.952	49.572	1.557	39.535	0.198	5.019
PVC Straight Tube	1.5	38.1	1.900	48.266	1.573	39.948	0.164	4.159
PVC Tee	1.5	38.1	2.236	56.782	1.831	46.507	0.202	5.137
Stainless Steel Pipe	2	50.8	2.004	50.889	1.863	47.320	0.070	1.784
Stainless Steel Tee (Standard)	2	50.8	1.998	50.743	1.872	47.536	0.063	1.603

APPENDIX G: REPRESENTATIVE TEST GRAPHS

The following graphs are the committee's test results:

- 3/4 inch graphs
- 1 inch graphs
- 1.5 inch graphs
- 2 inch graphs

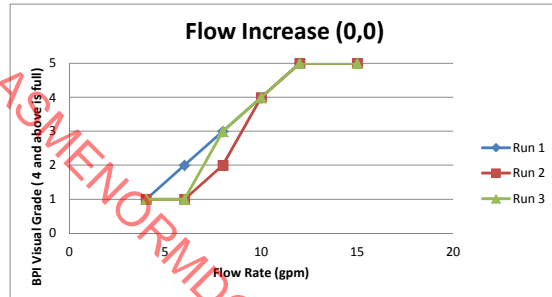
- 2 inch Horizontal Air Scale Test graphs
- Hot Test graphs
- Tee-Plus graphs
- Time to Clear

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3/4 in 2D Horizontal Flow Increase

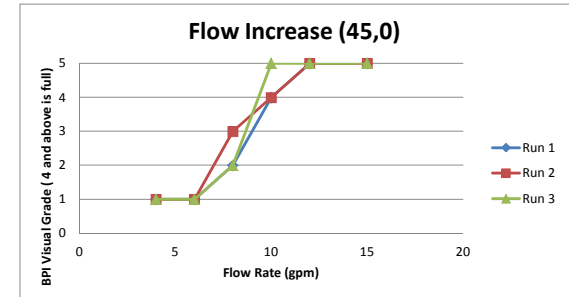
Experiement 385-387

Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	2	1	1
8	3	2	3
10	4	4	4
12	5	5	5
15	5	5	5



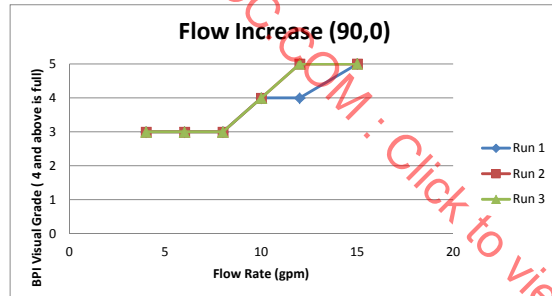
Experiement 394-396

Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	1	1	1
8	2	3	2
10	4	4	5
12	5	5	5
15	5	5	5



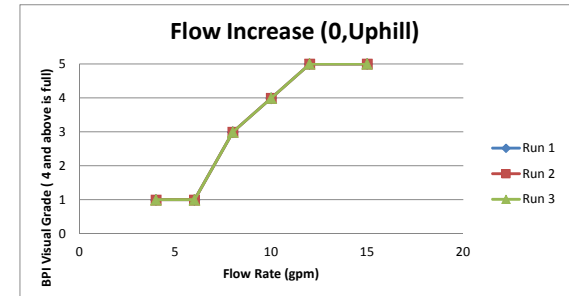
Experiement 406-408

Flow Rate	Run 1	Run 2	Run 3
4	3	3	3
6	3	3	3
8	3	3	3
10	4	4	4
12	4	5	5
15	5	5	5



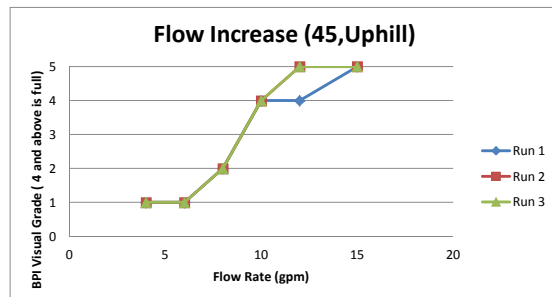
Experiement 415-417

Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	1	1	1
8	3	3	3
10	4	4	4
12	5	5	5
15	5	5	5



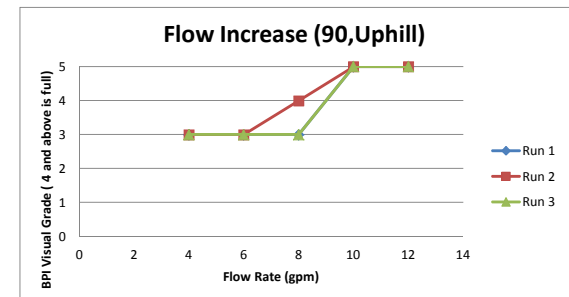
Experiement 424-426

Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	1	1	1
8	2	2	2
10	4	4	4
12	4	5	5
15	5	5	5



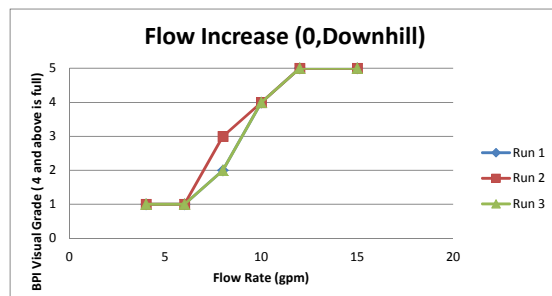
Experiement 433-435

Flow Rate	Run 1	Run 2	Run 3
4	3	3	3
6	3	3	3
8	3	4	3
10	5	5	5
12	5	5	5



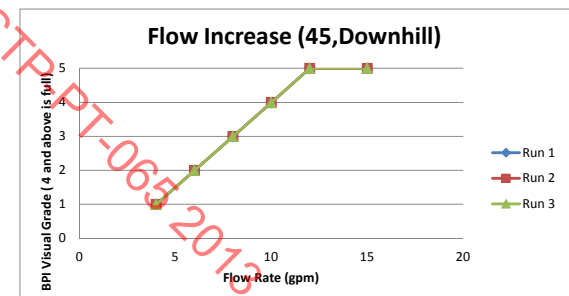
Experiement 442-444

Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	1	1	1
8	2	3	2
10	4	4	4
12	5	5	5
15	5	5	5



Experiement 451-453

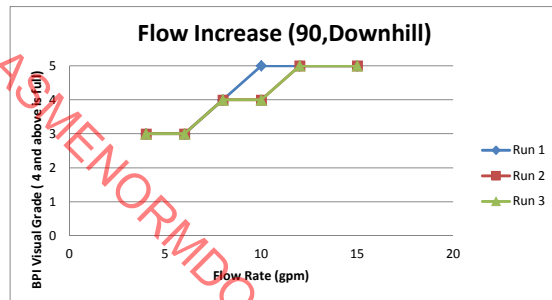
Flow Rate	Run 1	Run 2	Run 3
4	1	1	1
6	2	2	2
8	3	3	3
10	4	4	4
12	5	5	5
15	5	5	5



3/4 in 2D Horizontal Flow Increase

Experiment 460-462

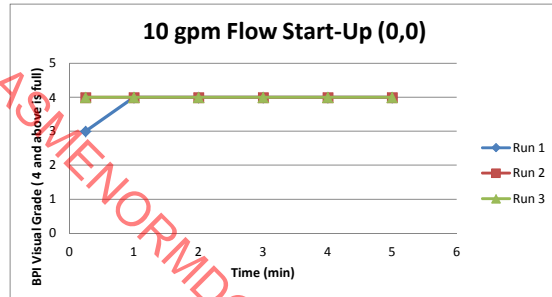
Flow Rate	Run 1	Run 2	Run 3
4	3	3	3
6	3	3	3
8	4	4	4
10	5	4	4
12	5	5	5
15	5	5	5



3/4 inch 2D Horizontal Flow Maintain

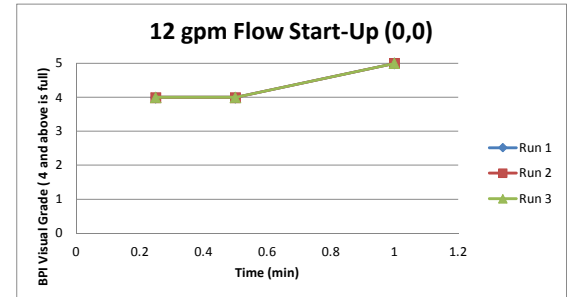
Experiement 388-390

Time	Run 1	Run 2	Run 3
0.25	3	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



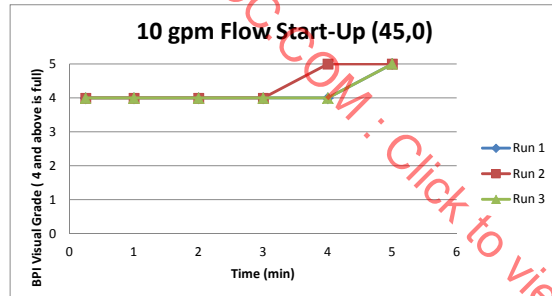
Experiement 391-393

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



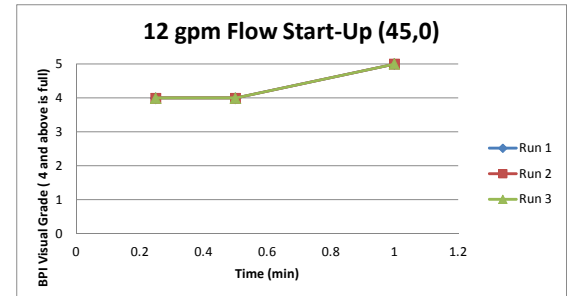
Experiement 397-399

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	5	4
5	5	5	5



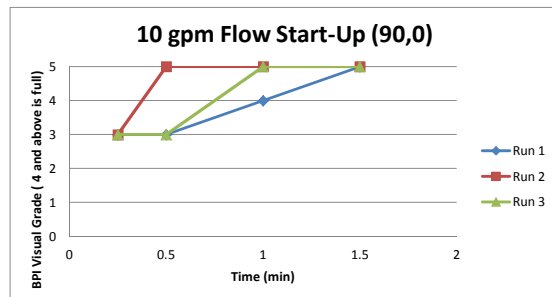
Experiement 400-402

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



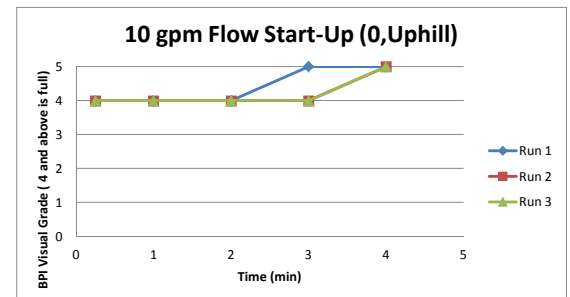
Experiement 409-411

Time	Run 1	Run 2	Run 3
0.25	3	3	3
0.5	3	5	3
1	4	5	5
1.5	5	5	5



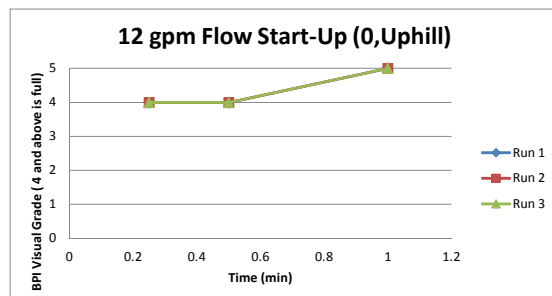
Experiement 418-420

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	4	4
4	5	5	5



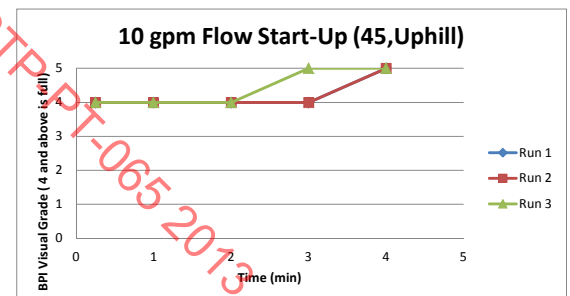
Experiement 421-423

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



Experiement 427-429

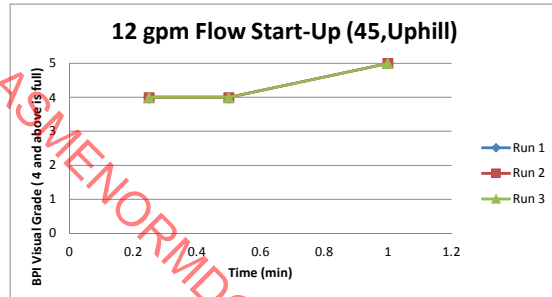
Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	5
4	5	5	5



3/4 inch 2D Horizontal Flow Maintain

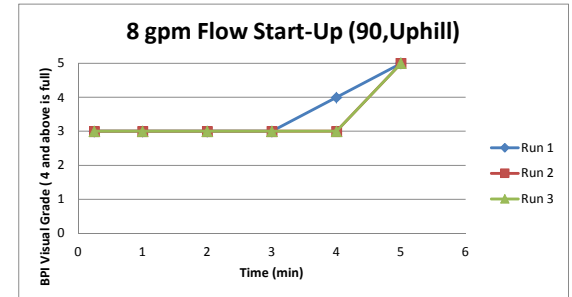
Experiement 430-432

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



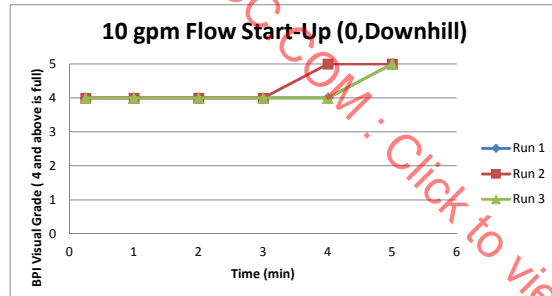
Experiement 436-438

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	4	3	3
5	5	5	5



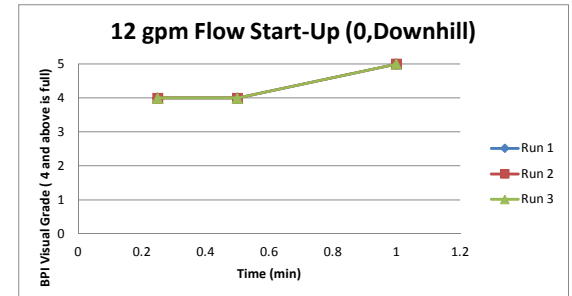
Experiement 445-447

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	5	4
5	5	5	5



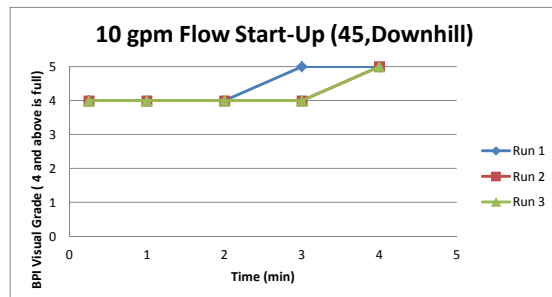
Experiement 448-450

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



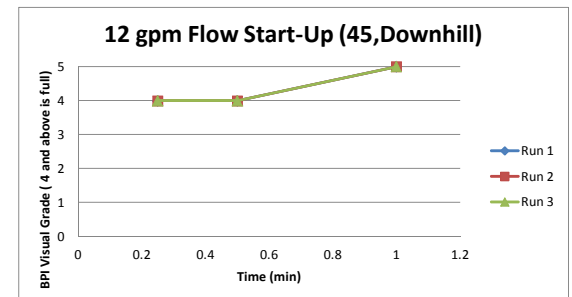
Experiement 454-456

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	4	4
4	5	5	5



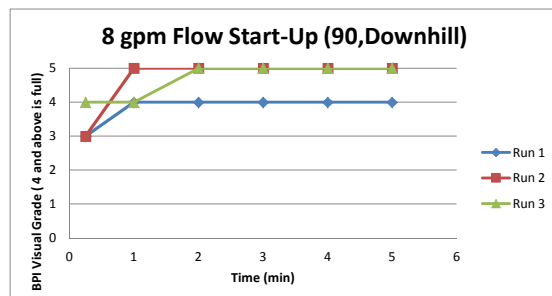
Experiement 457-459

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



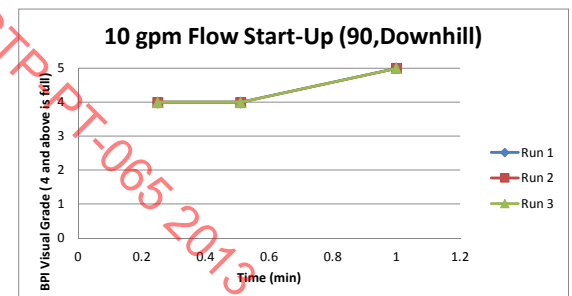
Experiement 463-465

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	5	4
2	4	5	5
3	4	5	5
4	4	5	5
5	4	5	5



Experiement 466-468

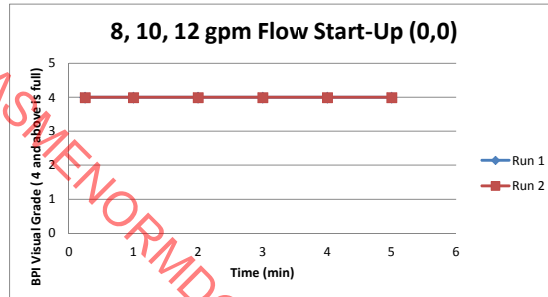
Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.51	4	4	4
1	5	5	5



3/4 inch SO Horizontal Tests

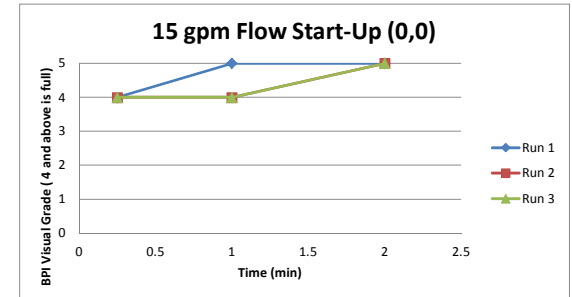
Experiement 469-474

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



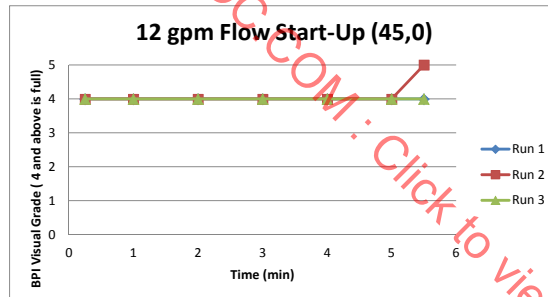
Experiement 475-477

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	5	4	4
2	5	5	5



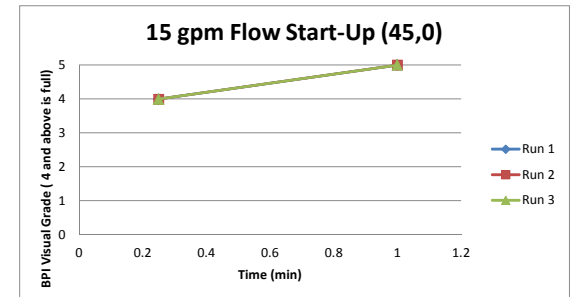
Experiement 478-480

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
5.5	4	5	4



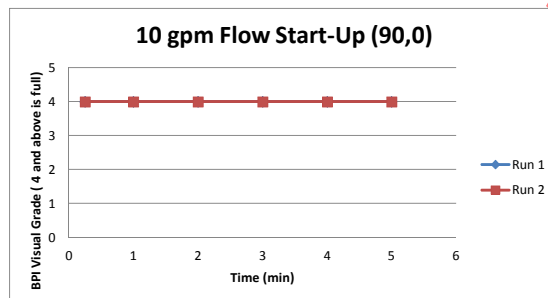
Experiement 481-483

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	5	5	5



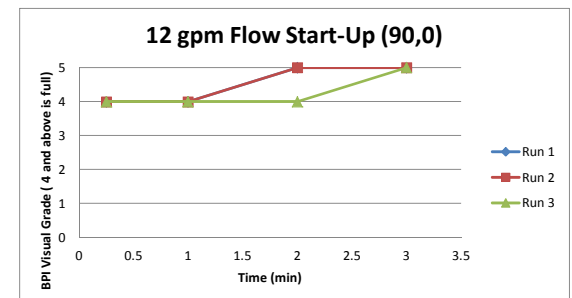
Experiement 487-488

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



Experiement 484-486

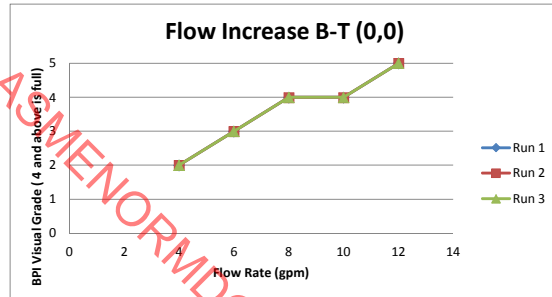
Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	5	5	4
3	5	5	5



3/4 inch 2D Vertical Flow Increase

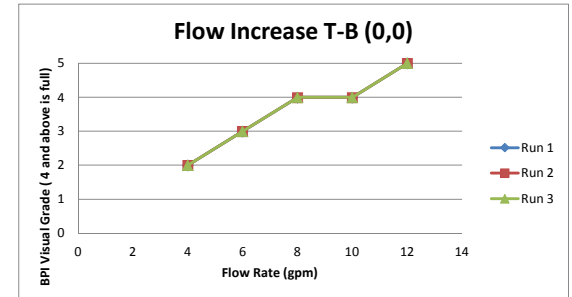
Experiement 521-523

Flow Rate	Run 1	Run 2	Run 3
4	2	2	2
6	3	3	3
8	4	4	4
10	4	4	4
12	5	5	5



Experiement 561-563

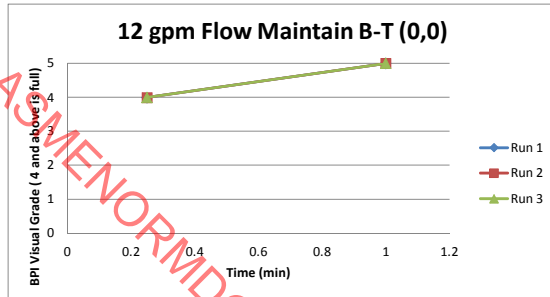
Flow Rate	Run 1	Run 2	Run 3
4	4	4	4
6	4	4	4
8	4	4	4
10	5	5	5



3/4 inch 2D Vertical Flow Maintain

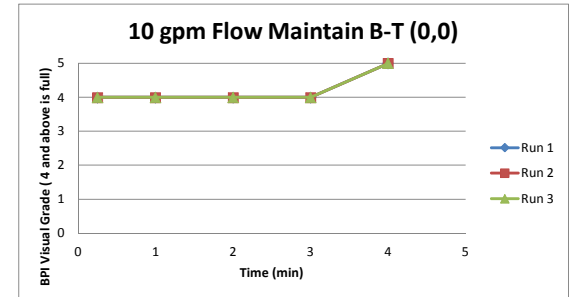
Experiement 524-526

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	5	5	5



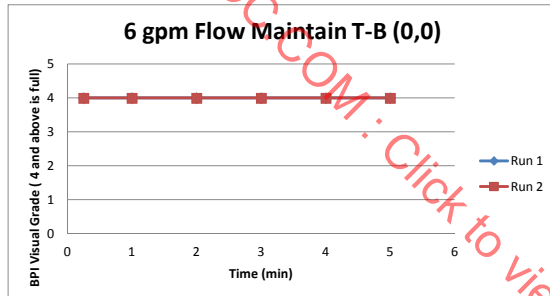
Experiement 527-529

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	5	5



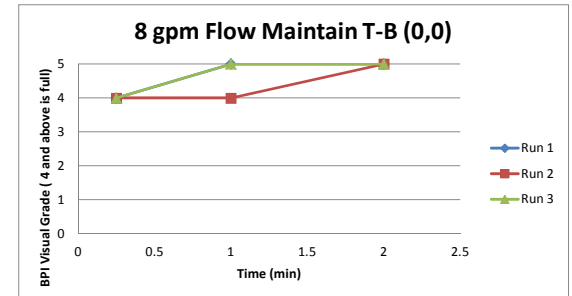
Experiement 556-557

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



Experiement 558-560

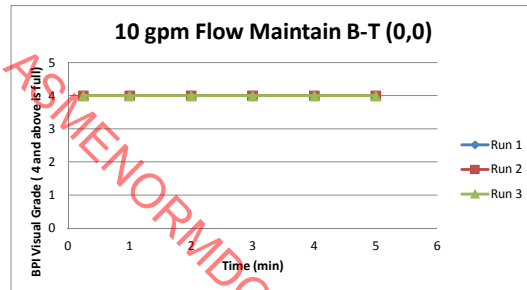
Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	5	4	5
2	5	5	5



3/4 inch SO Vertical Tests

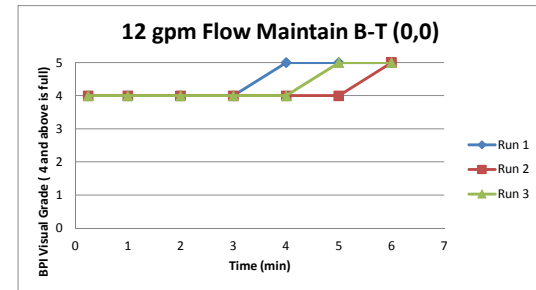
Experiement 530-531

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



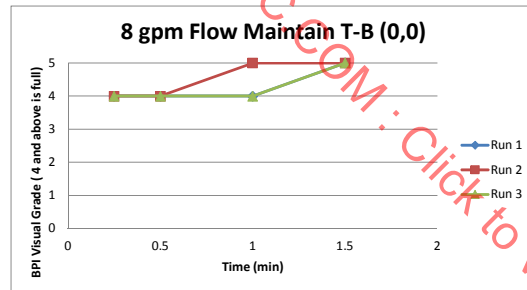
Experiement 532-534

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	4	4
5	5	4	5
6	5	5	5



Experiement 565-567

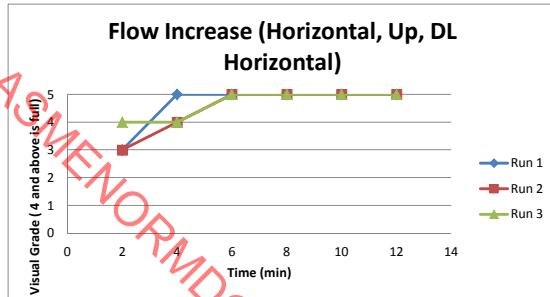
Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	4	5	4
1.5	5	5	5



3/4 inch 2D Elbow Flow Increase

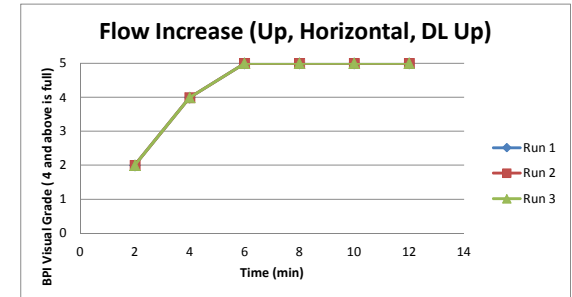
Experiement 618-620

Flow	Run 1	Run 2	Run 3
2	3	3	4
4	5	4	4
6	5	5	5
8	5	5	5
10	5	5	5
12	5	5	5



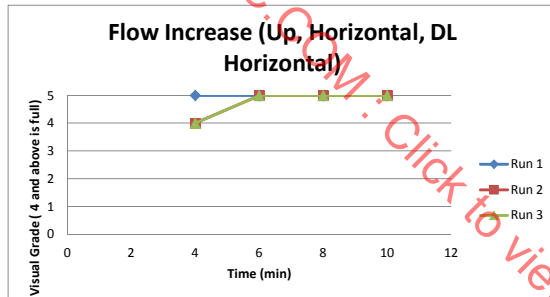
Experiement 655-657

Flow	Run 1	Run 2	Run 3
2	2	2	2
4	4	4	4
6	5	5	5
8	5	5	5
10	5	5	5
12	5	5	5



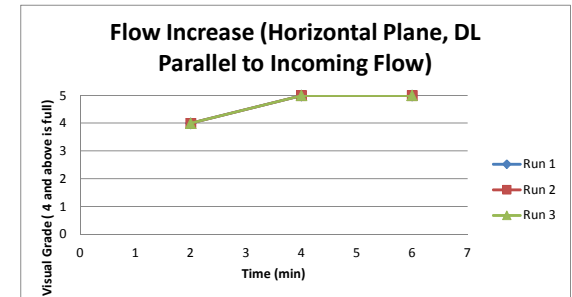
Experiement 626-628

Flow	Run 1	Run 2	Run 3
4	5	4	4
6	5	5	5
8	5	5	5
10	5	5	5



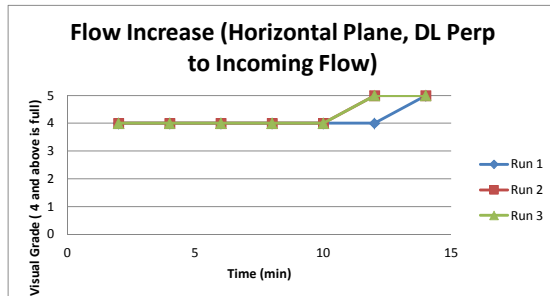
Experiement 666-668

Flow	Run 1	Run 2	Run 3
2	4	4	4
4	5	5	5
6	5	5	5



Experiement 683-685

Flow	Run 1	Run 2	Run 3
2	4	4	4
4	4	4	4
6	4	4	4
8	4	4	4
10	4	4	4
12	4	5	5
14	5	5	5

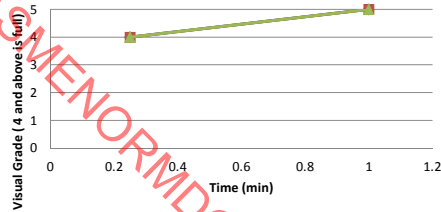


3/4 inch 2D Elbow Flow Maintain

Experiement 568-570

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	5	5	5

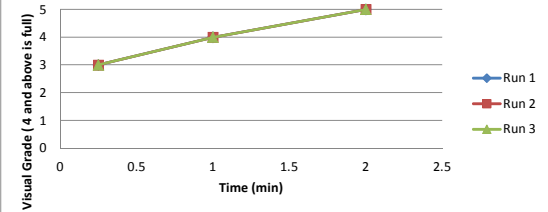
4 gpm Flow Maintain (Horizontal, Down, DL Horizontal)



Experiement 571-572

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
2	5	5	5

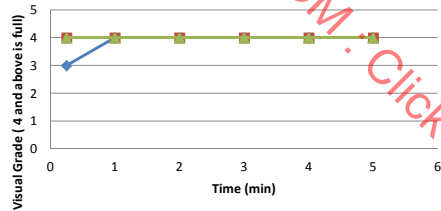
2 gpm Flow Maintain (Horizontal, Down, DL Horizontal)



Experiement 573-575

Time	Run 1	Run 2	Run 3
0.25	3	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4

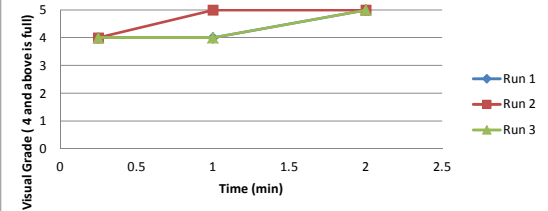
14 gpm Flow Maintain (Horizontal, Down, DL Vertical)



Experiement 576-578

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	5	4
2	5	5	5

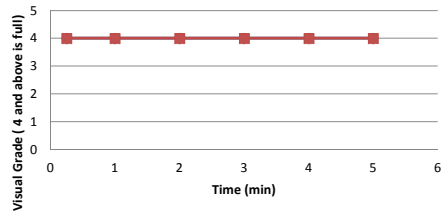
16 gpm Flow Maintain (Horizontal, Down, DL Vertical)



Experiement 609-610

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4

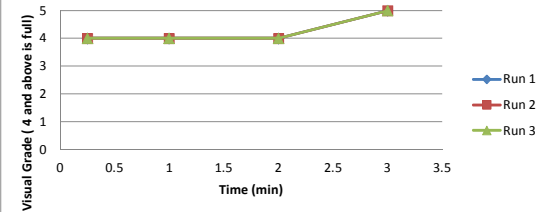
10 gpm Flow Maintain (Down, Horizontal, DL Horizontal)



Experiement 611-613

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5

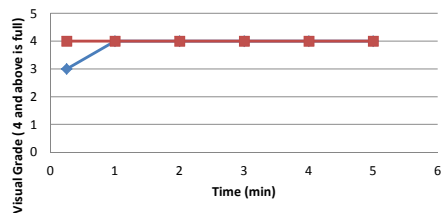
12 gpm Flow Maintain (Down, Horizontal, DL Horizontal)



Experiement 629-630

Time	Run 1	Run 2
0.25	3	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4

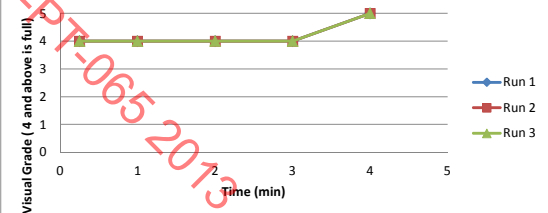
8 gpm Flow Maintain (Up, Horizontal, DL Horizontal)



Experiement 631-633

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	5	5

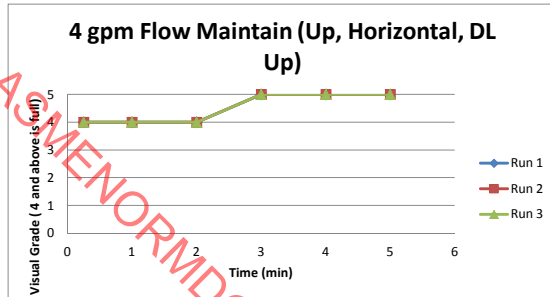
10 gpm Flow Maintain (Up, Horizontal, DL Horizontal)



3/4 inch 2D Elbow Flow Maintain

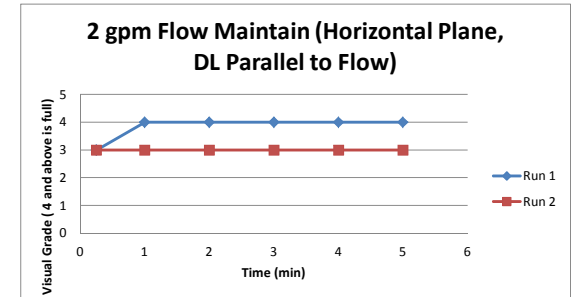
Experiement 658-660

Time	Run 1	Run 2	Run 3	
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
3	5	5	5	5
4	5	5	5	5
5	5	5	5	5



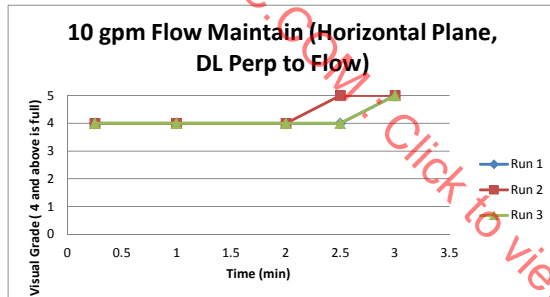
Experiement 669-670

Time	Run 1	Run 2	
0.25	3	3	
1	4	3	
2	4	3	
3	4	3	
4	4	3	
5	4	3	



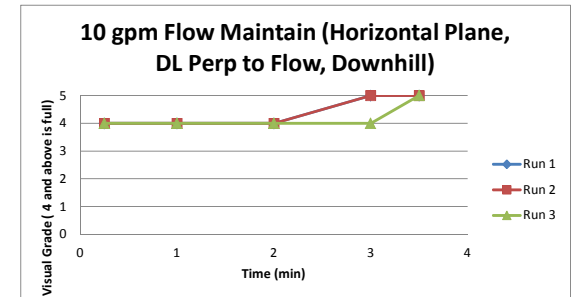
Experiement 686-688

Time	Run 1	Run 2	Run 3	
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
2.5	4	5	4	4
3	5	5	5	5



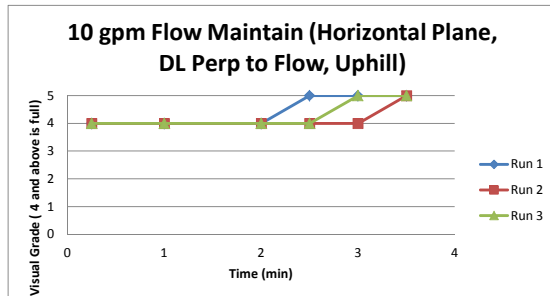
Experiement 689-691

Time	Run 1	Run 2	Run 3	
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
3	5	5	4	4
3.5	5	5	5	5



Experiement 692-694

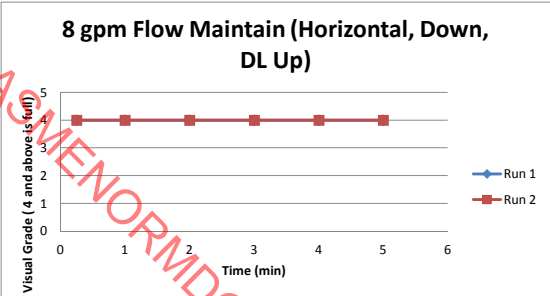
Time	Run 1	Run 2	Run 3	
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
2.5	5	4	4	4
3	5	4	5	5
3.5	5	5	5	5



3/4 inch SO Elbow Tests

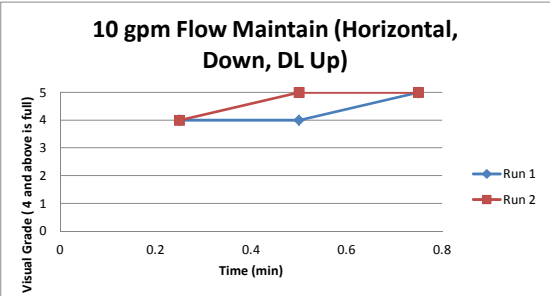
Experiement 581-582

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



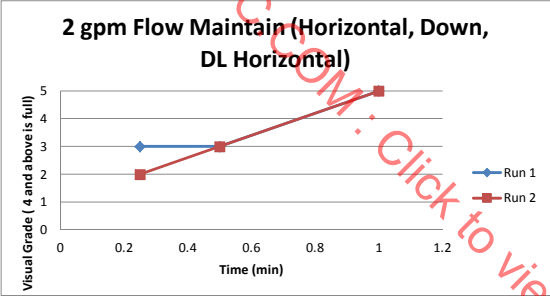
Experiement 583-584

Time	Run 1	Run 2
0.25	4	4
0.5	4	5
0.75	5	5



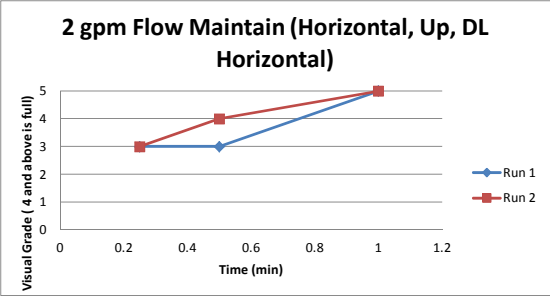
Experiement 585-586

Time	Run 1	Run 2
0.25	3	2
0.5	3	3
1	5	5



Experiement 624-625

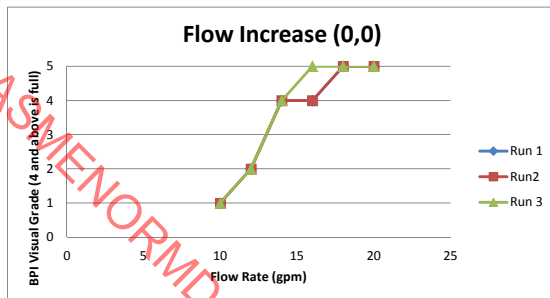
Time	Run 1	Run 2
0.25	3	3
0.5	3	4
1	5	5



1 inch 2D Horizontal Tests

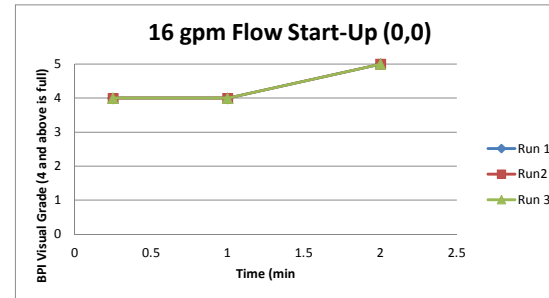
Experiment 489-491

Flow Rate	Run 1	Run2	Run 3
10	1	1	1
12	2	2	2
14	4	4	4
16	4	4	5
18	5	5	5
20	5	5	5



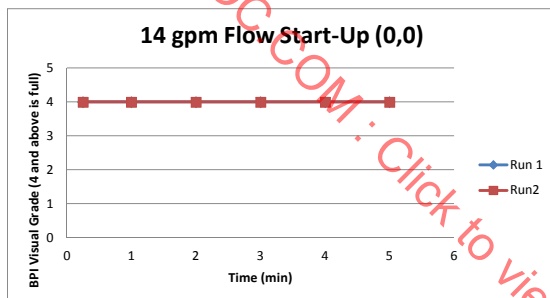
Experiment 492-494

Time	Run 1	Run2	Run 3
0.25	4	4	4
1	4	4	4
2	5	5	5



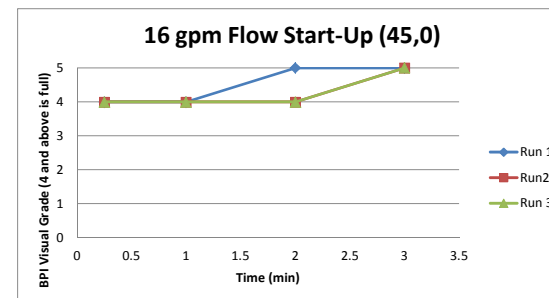
Experiment 495-496

Time	Run 1	Run2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



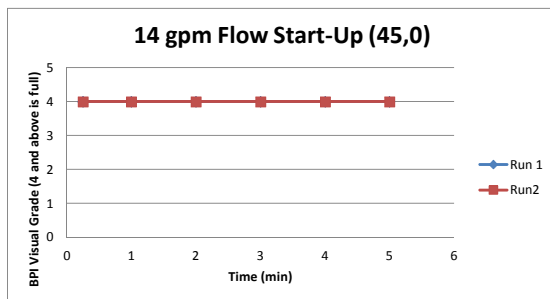
Experiment 497-499

Time	Run 1	Run2	Run 3
0.25	4	4	4
1	4	4	4
2	5	4	4
3	5	5	5



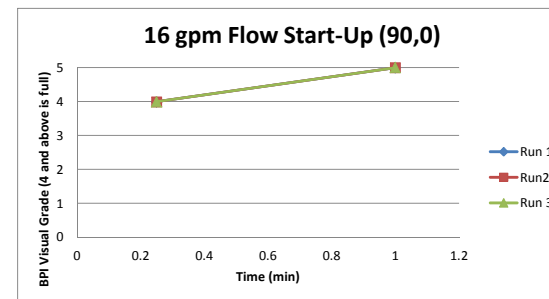
Experiment 500-501

Time	Run 1	Run2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



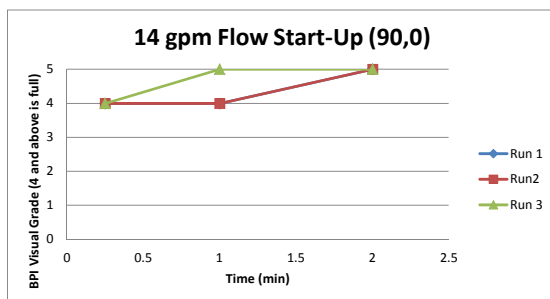
Experiment 502-504

Time	Run 1	Run2	Run 3
0.25	4	4	4
1	5	5	5



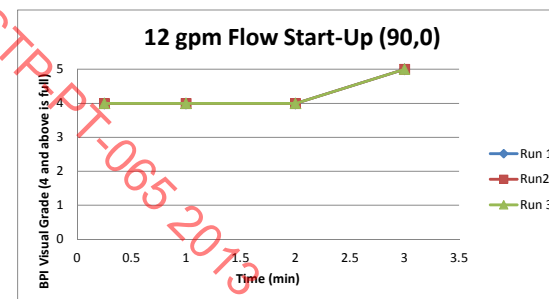
Experiment 505-507

Time	Run 1	Run2	Run 3
0.25	4	4	4
1	4	4	5
2	5	5	5



Experiment 508-510

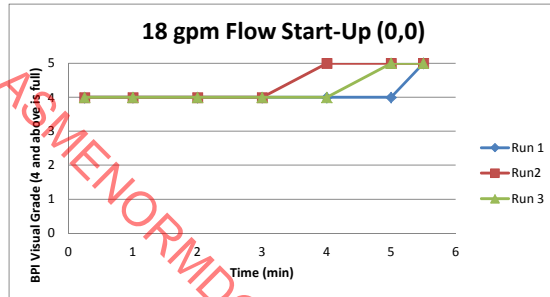
Time	Run 1	Run2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



1 inch SO Horizontal Tests

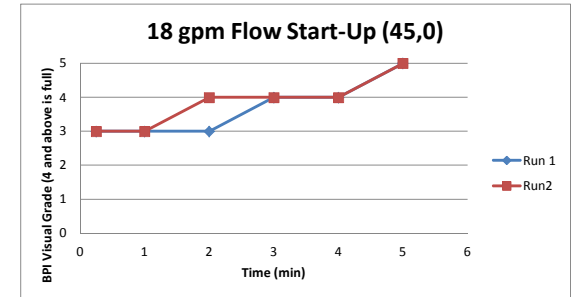
Experiment 512-514

Time	Run 1	Run2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	5	4
5	4	5	5
5.5	5	5	5



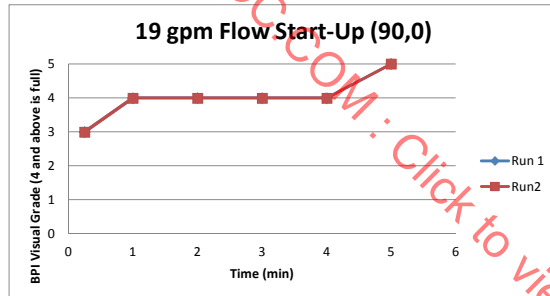
Experiment 515-516

Time	Run 1	Run2
0.25	3	3
1	3	3
2	3	4
3	4	4
4	4	4
5	5	5



Experiment 519-520

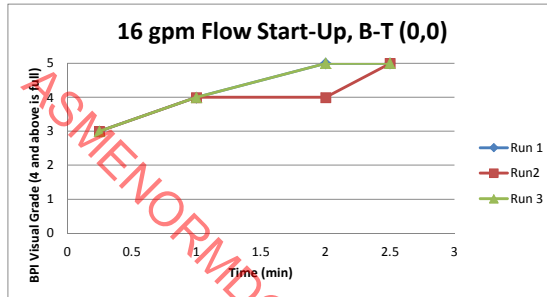
Time	Run 1	Run2
0.25	3	3
1	4	4
2	4	4
3	4	4
4	4	4
5	5	5



1 inch 2D Vertical Tests

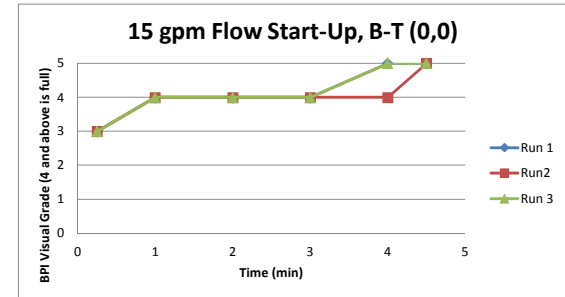
Experiment 535-537

Time	Run 1	Run2	Run 3
0.25	3	3	3
1	4	4	4
2	5	4	5
2.5	5	5	5



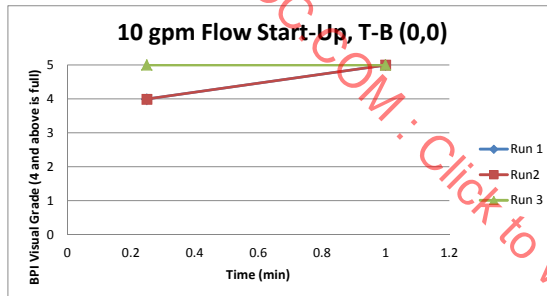
Experiment 538-540

Time	Run 1	Run2	Run 3
0.25	3	3	3
1	4	4	4
2	4	4	4
3	4	4	4
4	5	4	5
4.5	5	5	5



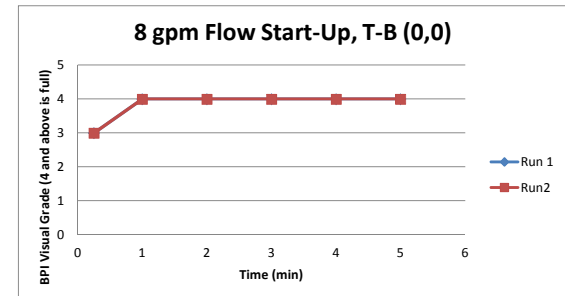
Experiment 545-547

Time	Run 1	Run2	Run 3
0.25	4	4	5
1	5	5	5



Experiment 548-549

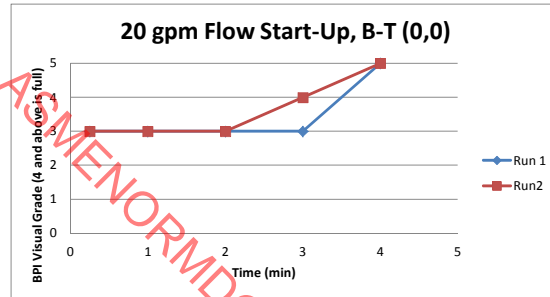
Time	Run 1	Run2
0.25	3	3
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



1 inch SO Vertical Tests

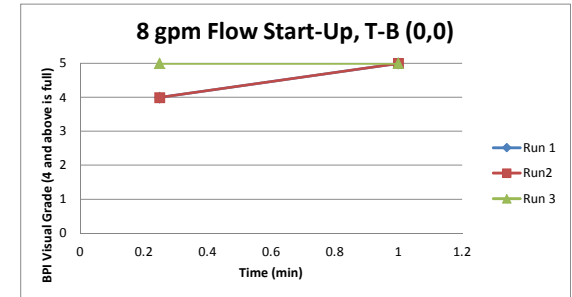
Experiment 543-544

Time	Run 1	Run2
0.25	3	3
1	3	3
2	3	3
3	3	4
4	5	5



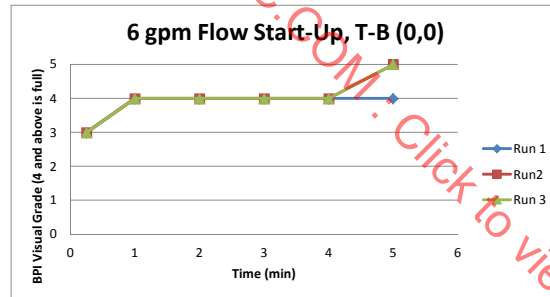
Experiment 550-552

Time	Run 1	Run2	Run 3
0.25	4	4	5
1	5	5	5



Experiment 553-555

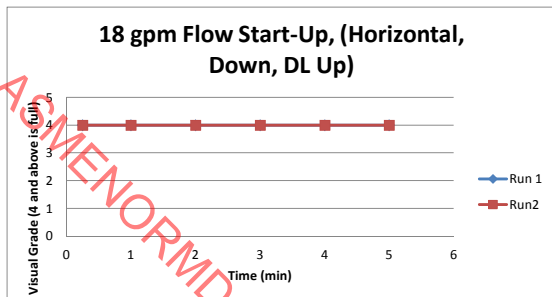
Time	Run 1	Run2	Run 3
0.25	3	3	3
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	5	5



1 inch 2D Elbow Tests

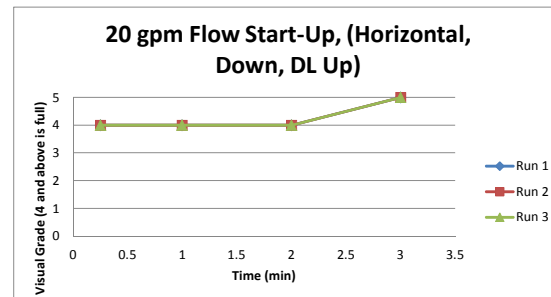
Experiment 587-588

Time	Run 1	Run2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



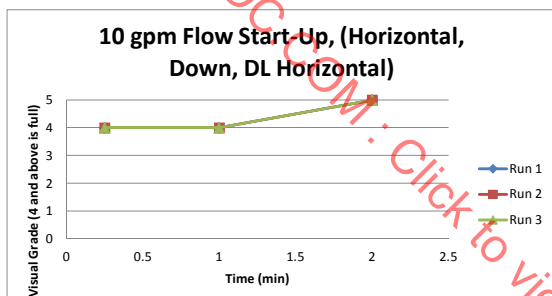
Experiment 589-591

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



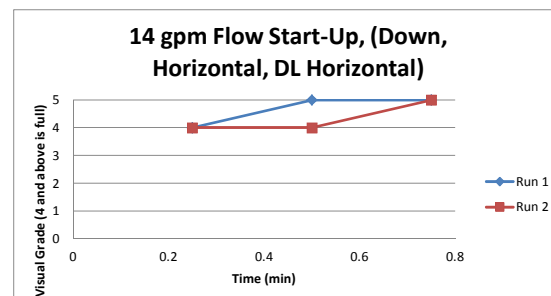
Experiment 592-594

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	5	5	5



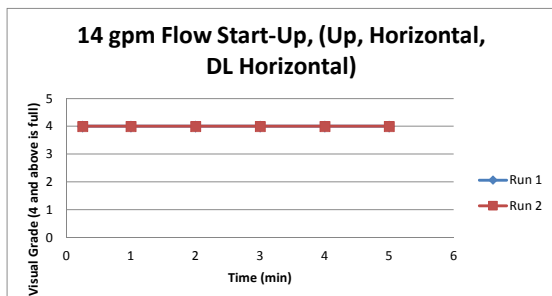
Experiment 614-615

Time	Run 1	Run 2
0.25	4	4
0.5	5	4
0.75	5	5



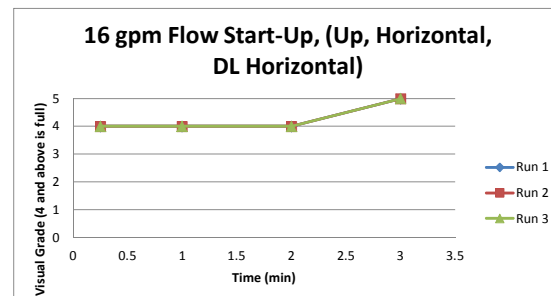
Experiment 641-642

Time	Run 1	Run 2
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



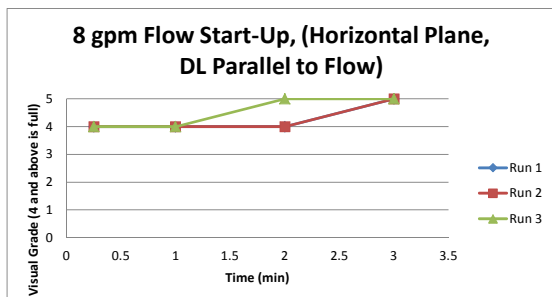
Experiment 643-645

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



Experiment 703-705

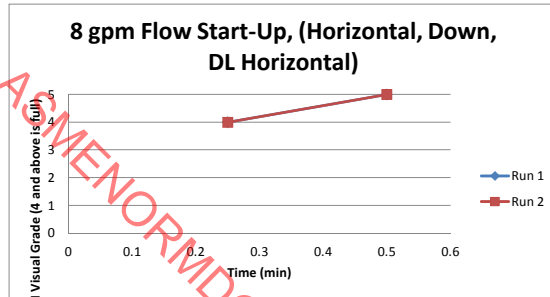
Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	5
3	5	5	5



1 inch SO Elbow Tests

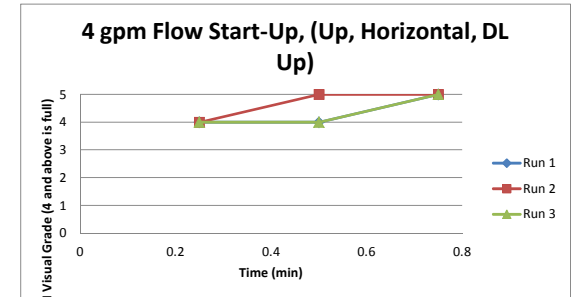
Experiment 595-596

Time	Run 1	Run 2
0.25	4	4
0.5	5	5



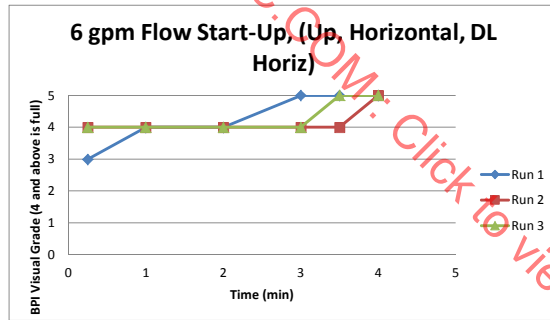
Experiment 649-651

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	5	4
0.75	5	5	5



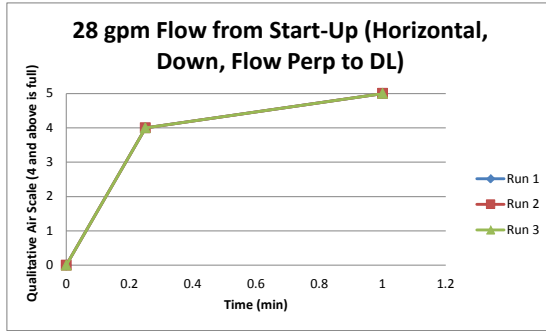
Experiment 652-654

Time	Run 1	Run 2	Run 3
0.25	3	4	4
1	4	4	4
2	4	4	4
3	5	4	4
3.5	5	4	5
4	5	5	5



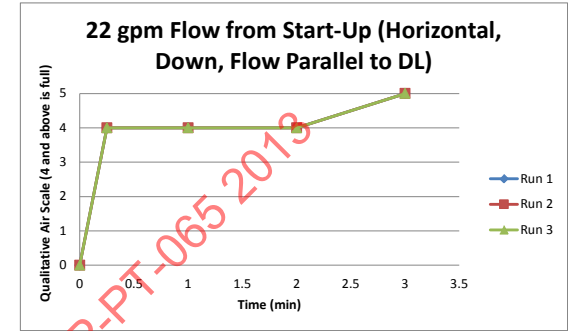
Experiment 760-762

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	5	5	5



Experiment 763-765

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5

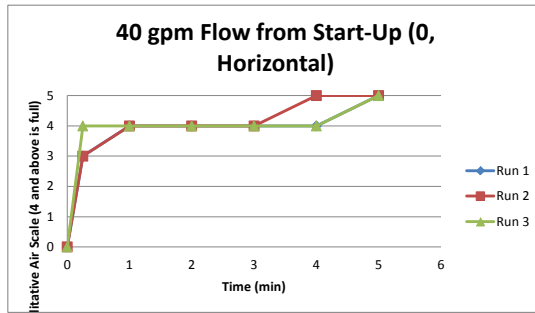


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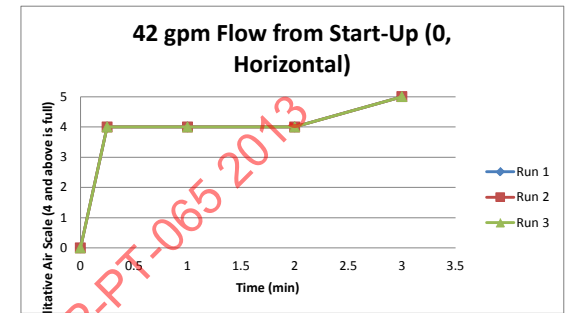
Experiment 725-727

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	5	4
5	5	5	5



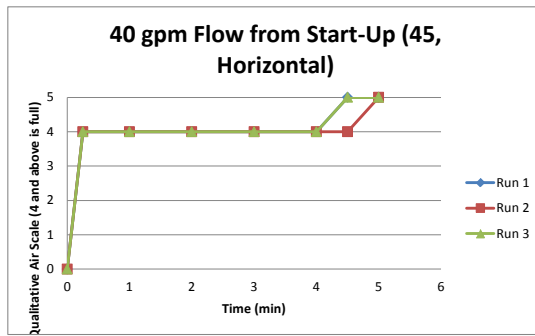
Experiment 728-730

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



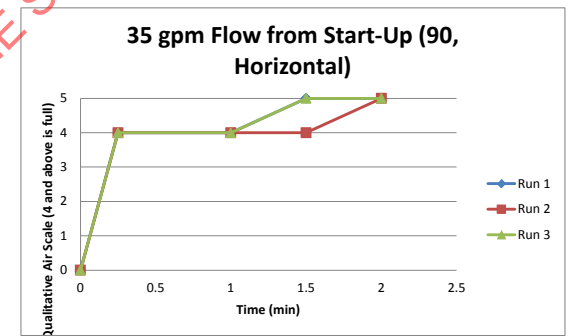
Experiment 733-735

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
4.5	5	4	5
5	5	5	5



Experiment 736-738

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
1.5	5	4	5
2	5	5	5

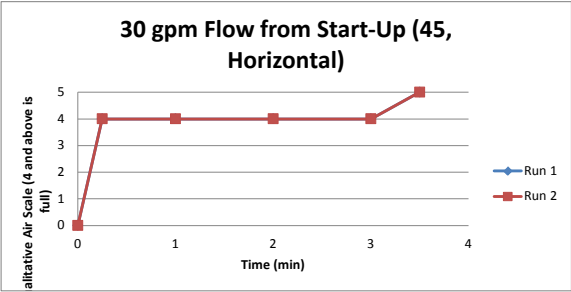


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Experiment 739-740

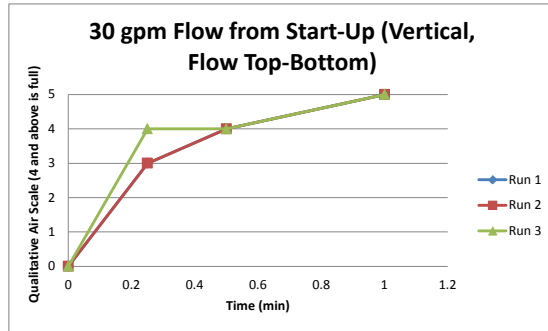
Time	Run 1	Run 2
0	0	0
0.25	4	4
1	4	4
2	4	4
3	4	4
3.5	5	5



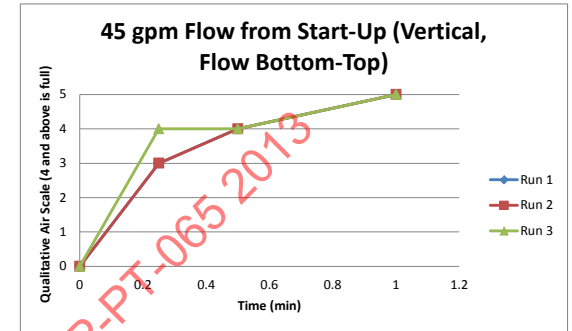
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Experiment 786-788

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	4
0.5	4	4	4
1	5	5	5

**Experiment 792-794**

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
3.5	5	4	5
4	5	5	5

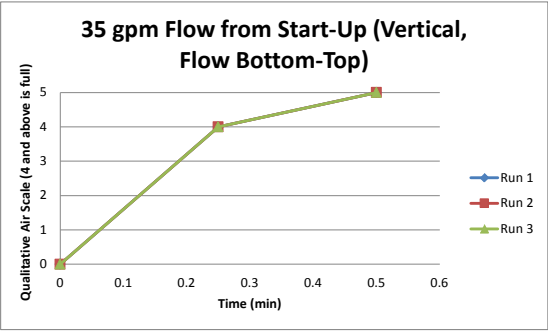


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Experiment 789-791

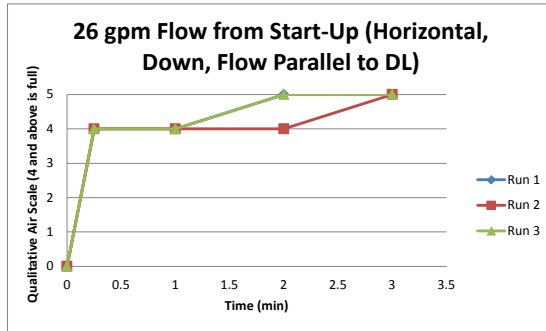
Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
0.5	5	5	5



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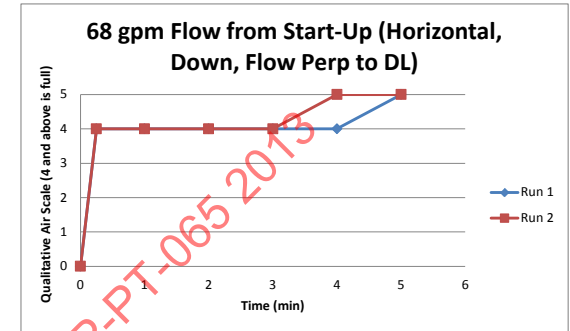
Experiment 743-745

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	5	4	5
3	5	5	5



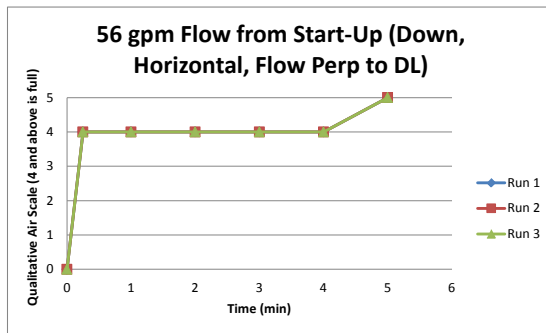
Experiment 746-747

Time	Run 1	Run 2
0	0	0
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	5
5	5	5



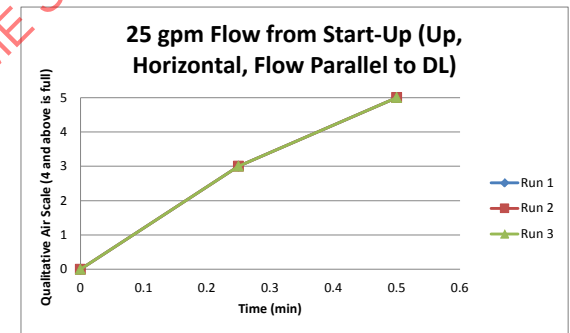
Experiment 776-778

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	5	5	5



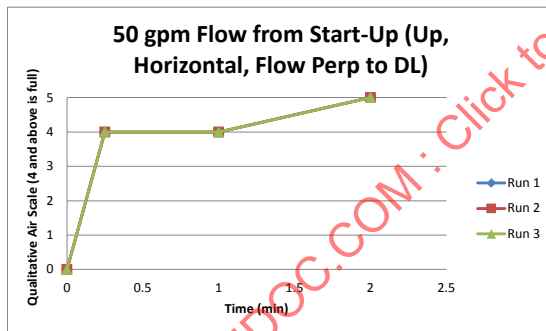
Experiment 798-800

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
0.5	5	5	5



Experiment 801-803

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	5	5	5



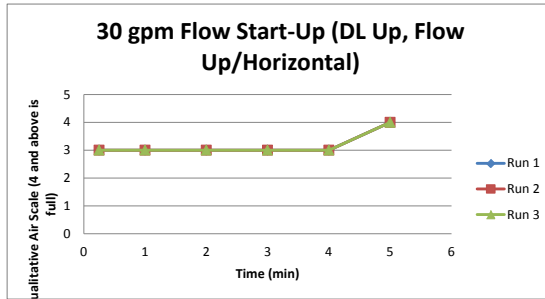
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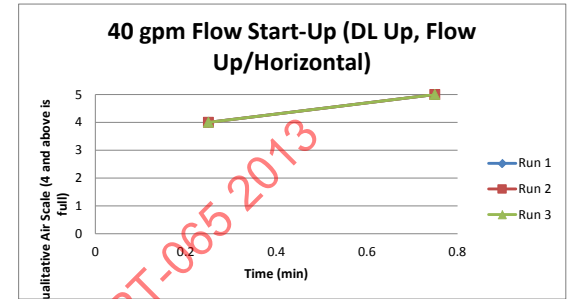
Experiment 286-288

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	4	4	4



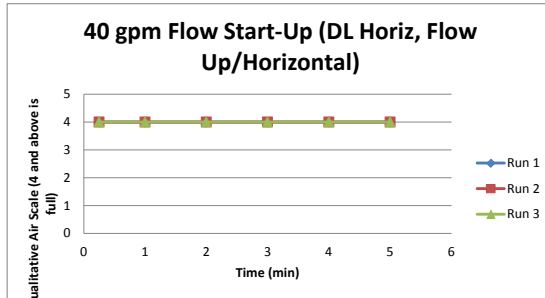
Experiment 289-291

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.75	5	5	5



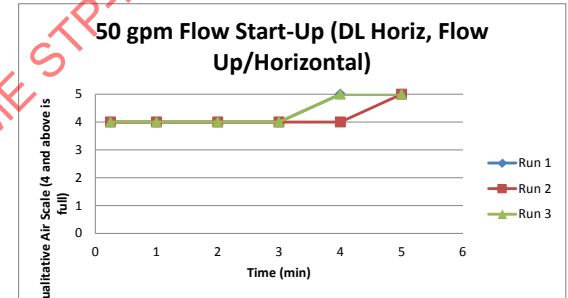
Experiment 295-297

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



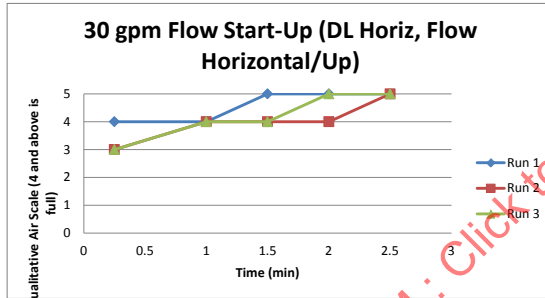
Experiment 298-300

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	4	5
5	5	5	5



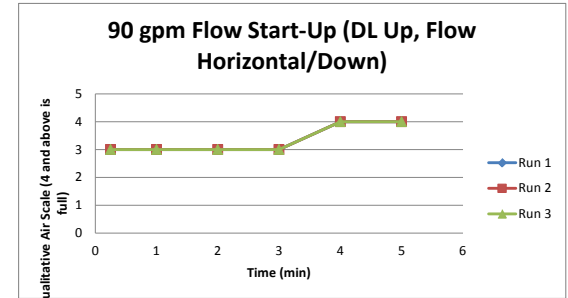
Experiment 307-309

Time	Run 1	Run 2	Run 3
0.25	4	3	3
1	4	4	4
1.5	5	4	4
2	5	4	5
2.5	5	5	5



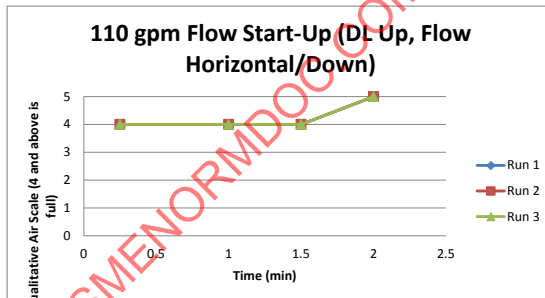
Experiment 316-318

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	4	4	4
5	4	4	4



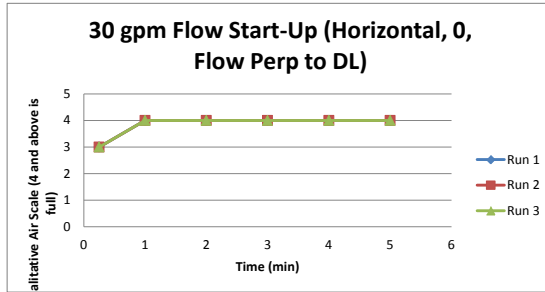
Experiment 319-321

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
1.5	4	4	4
2	5	5	5



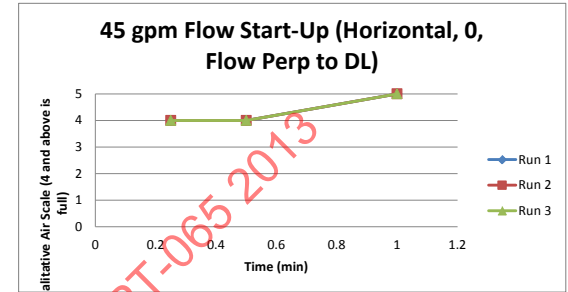
Experiment 325-327

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



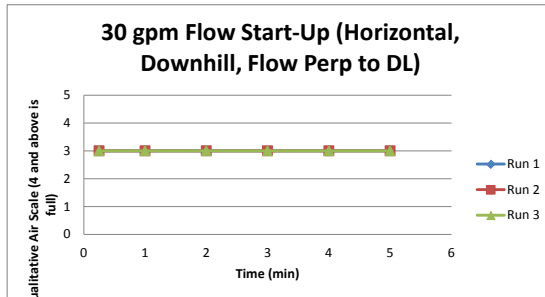
Experiment 328-330

Time	Run 1	Run 2	Run 3
0.25	4	4	4
0.5	4	4	4
1	5	5	5



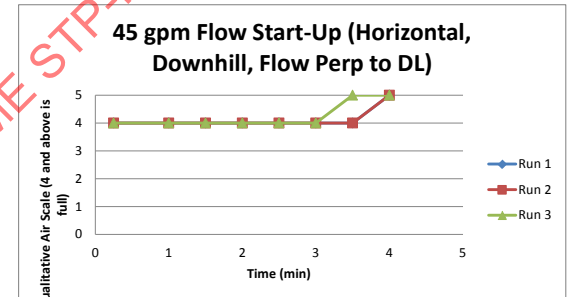
Experiment 352-354

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



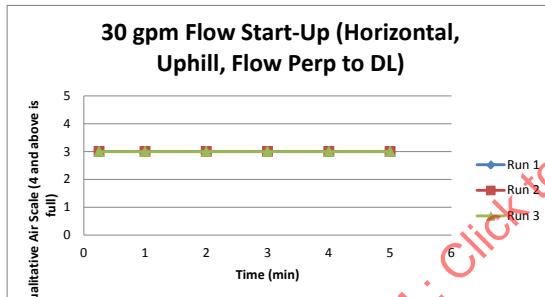
Experiment 355-357

Time	Run 1	Run 2	Run 3
0.25	4	4	4
1	4	4	4
1.5	4	4	4
2	4	4	4
2.5	4	4	4
3	4	4	4
3.5	4	4	5
4	5	5	5



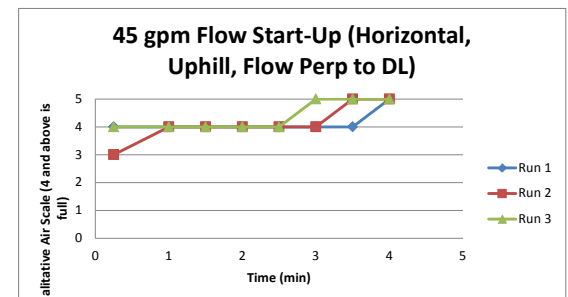
Experiment 361-363

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



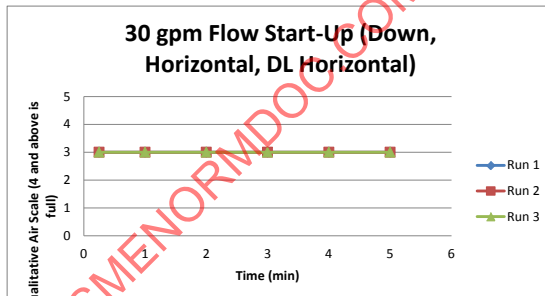
Experiment 364-366

Time	Run 1	Run 2	Run 3
0.25	4	3	4
1	4	4	4
1.5	4	4	4
2	4	4	4
2.5	4	4	4
3	4	4	5
3.5	4	5	5
4	5	5	5



Experiment 376-378

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3

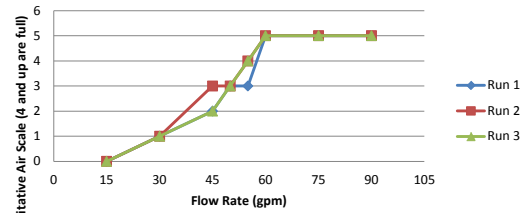


Experiment 1-3

Initial Runs

Flow Rate	Run 1	Run 2	Run 3
15	0	0	0
30	1	1	1
45	2	3	2
50	3	3	3
55	3	4	4
60	5	5	5
75	5	5	5
90	5	5	5

Initial Flow Increase Runs (0 Rotation, 0 Slope)

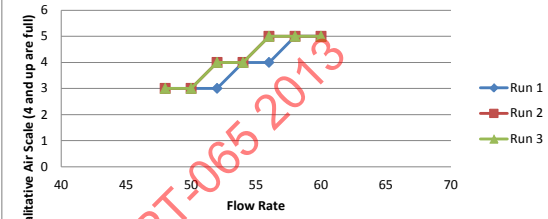


Experiment 4-6

Selected Runs

Flow Rate	Run 1	Run 2	Run 3
48	3	3	3
50	3	3	3
52	3	4	4
54	4	4	4
56	4	5	5
58	5	5	5
60	5	5	5

Selected Flow Increase Runs (0 Rotation, 0 Slope)

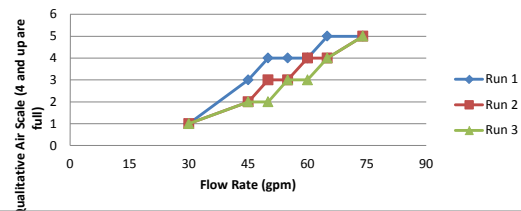


Experiment 46-48

Initial Runs

Flow Rate	Run 1	Run 2	Run 3
30	1	1	1
45	3	2	2
50	4	3	2
55	4	3	3
60	4	4	3
65	5	4	4
74	5	5	5

Initial Flow Increase Runs (45 Horizontal)

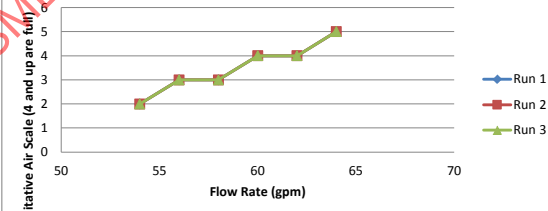


Experiment 49-51

Selected Runs

Flow Rate	Run 1	Run 2	Run 3
54	2	2	2
56	3	3	3
58	3	3	3
60	4	4	4
62	4	4	4
64	5	5	5

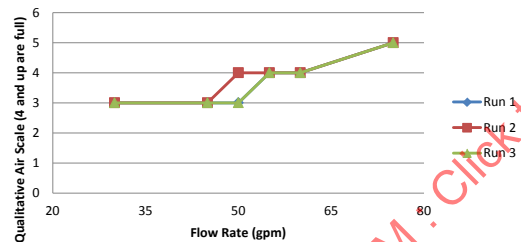
Selected Flow Increase Runs (45 Horizontal)



Experiment 67-69

Flow Rate	Run 1	Run 2	Run 3
30	3	3	3
45	3	3	3
50	3	4	3
55	4	4	4
60	4	4	4
75	5	5	5

Flow Increase Runs (90 Horizontal)

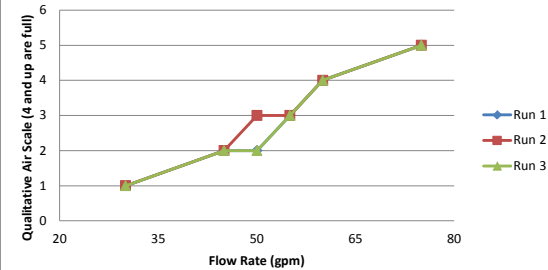


Experiment 88-90

Initial Runs

Flow Rate	Run 1	Run 2	Run 3
30	1	1	1
45	2	2	2
50	2	3	2
55	3	3	3
60	4	4	4
75	5	5	5

Initial Flow Increase Runs (0, Uphill)

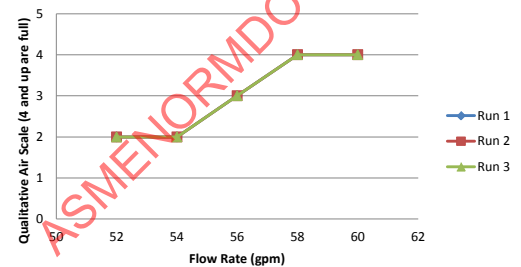


Experiment 91-93

Selected Runs

Flow Rate	Run 1	Run 2	Run 3
52	2	2	2
54	2	2	2
56	3	3	3
58	4	4	4
60	4	4	4

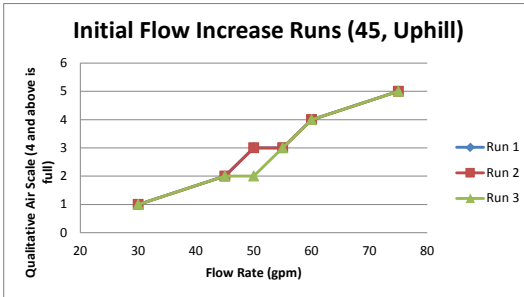
Selected Flow Increase Runs (0, Uphill)



Experiment 106-108

Initial Runs

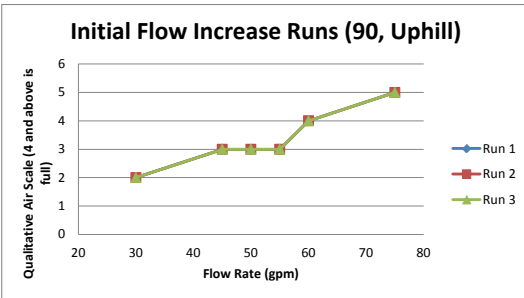
Flow Rate	Run 1	Run 2	Run 3
30	1	1	1
45	2	2	2
50	3	3	2
55	3	3	3
60	4	4	4
75	5	5	5



Experiment 124-126

Initial Runs

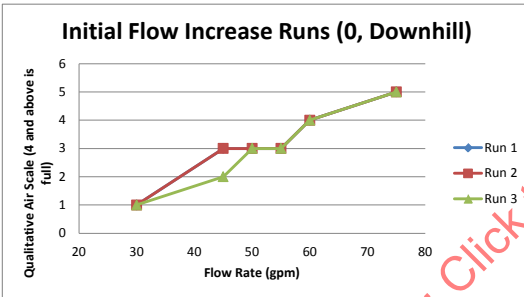
Flow Rate	Run 1	Run 2	Run 3
30	2	2	2
45	3	3	3
50	3	3	3
55	3	3	3
60	4	4	4
75	5	5	5



Experiment 142-144

Initial Runs

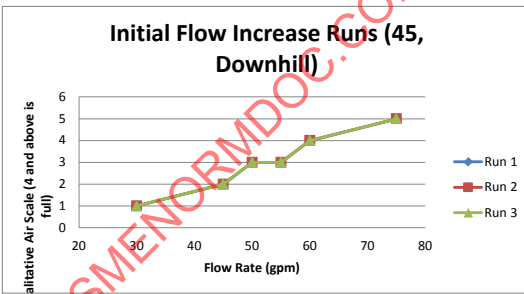
Flow Rate	Run 1	Run 2	Run 3
30	1	1	1
45	3	3	2
50	3	3	3
55	3	3	3
60	4	4	4
75	5	5	5



Experiment 160-162

Initial Runs

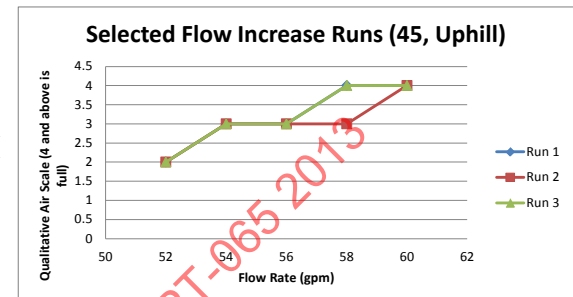
Flow Rate	Run 1	Run 2	Run 3
30	1	1	1
45	2	2	2
50	3	3	3
55	3	3	3
60	4	4	4
75	5	5	5



Experiment 109-111

Selected Runs

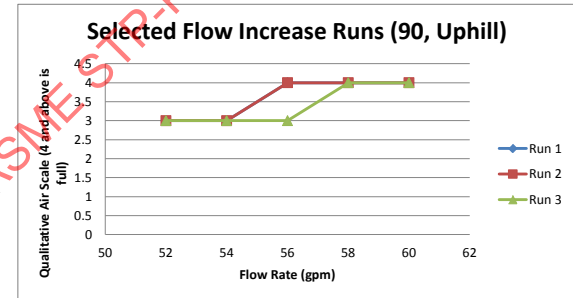
Flow Rate	Run 1	Run 2	Run 3
52	2	2	2
54	3	3	3
56	3	3	3
58	4	3	4
60	4	4	4



Experiment 127-129

Selected Runs

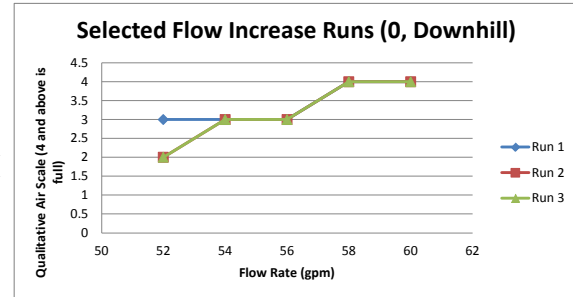
Flow Rate	Run 1	Run 2	Run 3
52	3	3	3
54	3	3	3
56	4	4	3
58	4	4	4
60	4	4	4



Experiment 145-147

Selected Runs

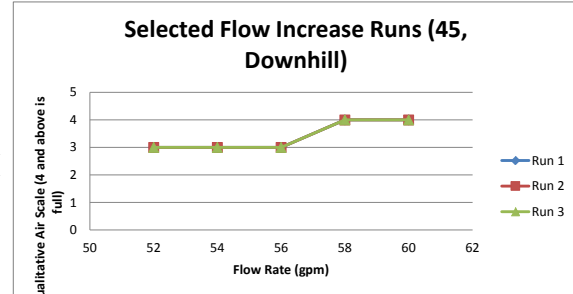
Flow Rate	Run 1	Run 2	Run 3
52	3	2	2
54	3	3	3
56	3	3	3
58	4	4	4
60	4	4	4



Experiment 163-165

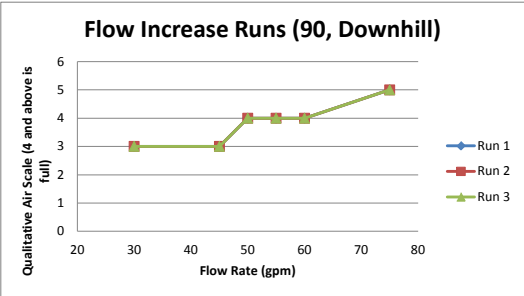
Selected Runs

Flow Rate	Run 1	Run 2	Run 3
52	3	3	3
54	3	3	3
56	3	3	3
58	4	4	4
60	4	4	4



Experiment 176-178

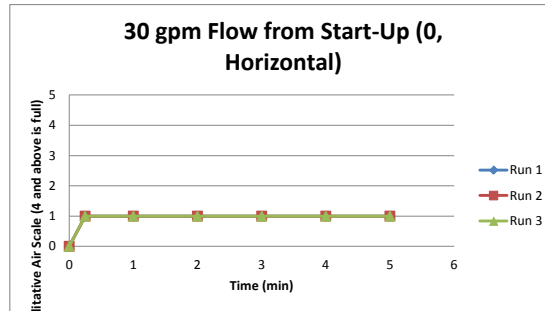
Flow Rate	Run 1	Run 2	Run 3
30	3	3	3
45	3	3	3
50	4	4	4
55	4	4	4
60	4	4	4
75	5	5	5



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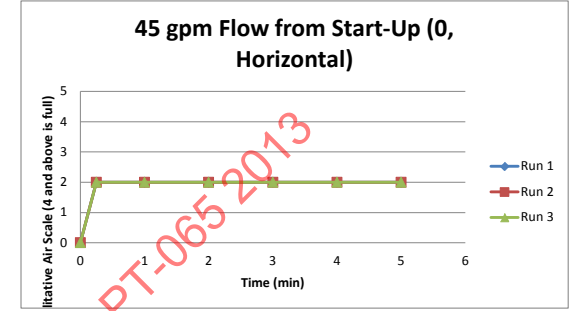
Experiment 7-9

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1



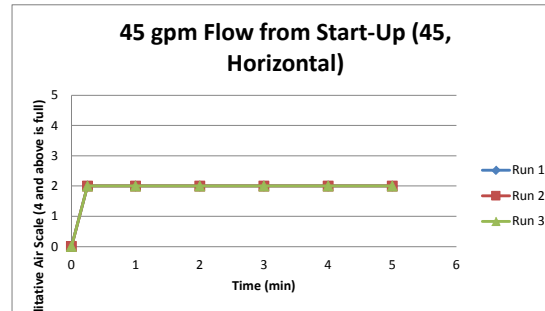
Experiment 10-12

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	2	2	2
2	2	2	2
3	2	2	2
4	2	2	2
5	2	2	2



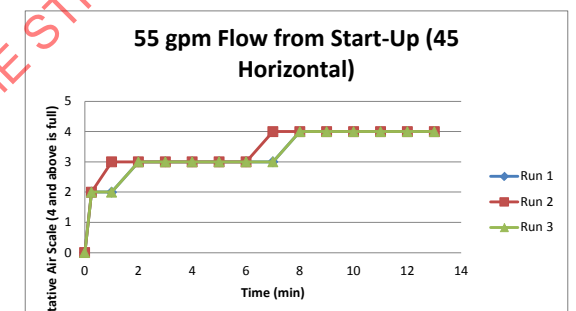
Experiment 52-54

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	2	2	2
2	2	2	2
3	2	2	2
4	2	2	2
5	2	2	2



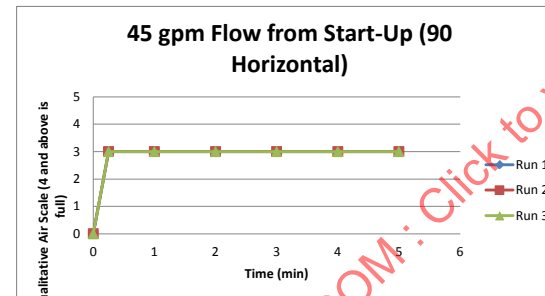
Experiment 55-57

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	2	3	2
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	4	3
8	4	4	4
9	4	4	4
10	4	4	4
11	4	4	4
12	4	4	4
13	4	4	4



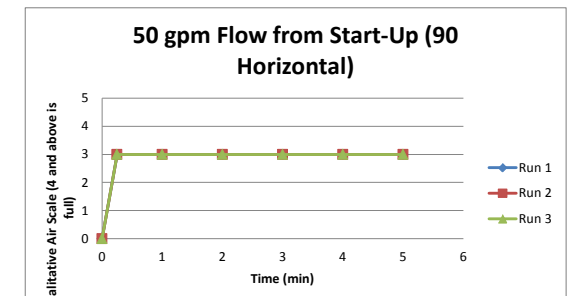
Experiment 70-72

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



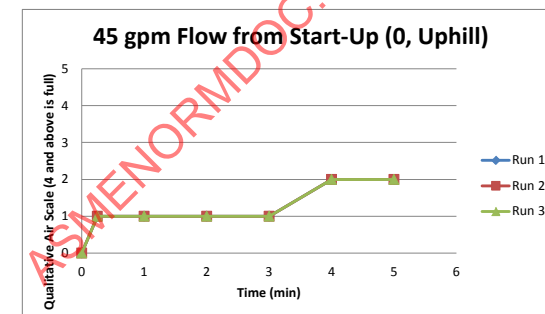
Experiment 73-75

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



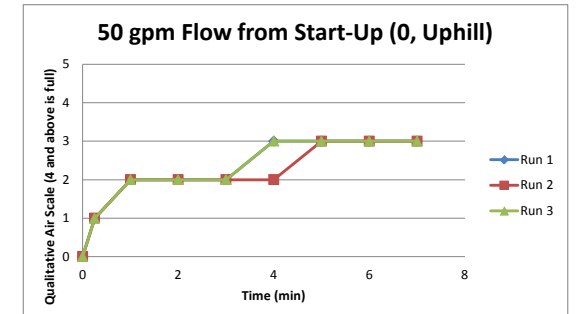
Experiment 94-96

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	1	1	1
2	1	1	1
3	1	1	1
4	2	2	2
5	2	2	2



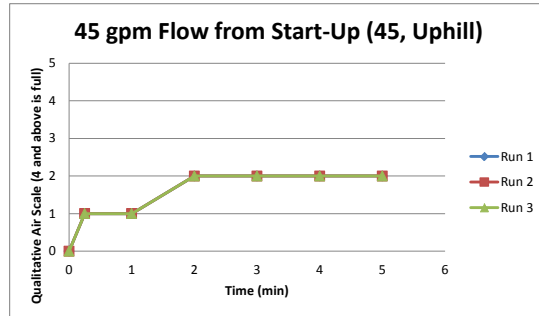
Experiment 97-99

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	2	2	2
2	2	2	2
3	2	2	2
4	3	2	3
5	3	3	3
6	3	3	3
7	3	3	3



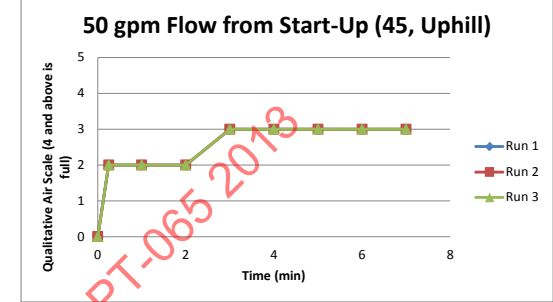
Experiment 112-114

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	1	1	1
2	2	2	2
3	2	2	2
4	2	2	2
5	2	2	2



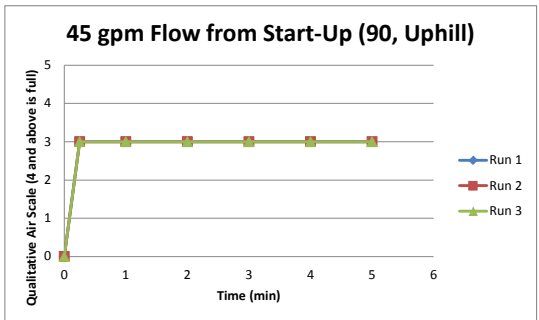
Experiment 115-117

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	2	2	2
2	2	2	2
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3



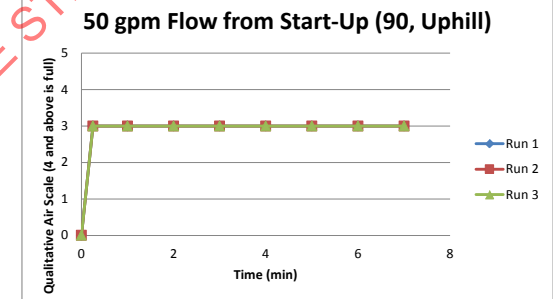
Experiment 130-132

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



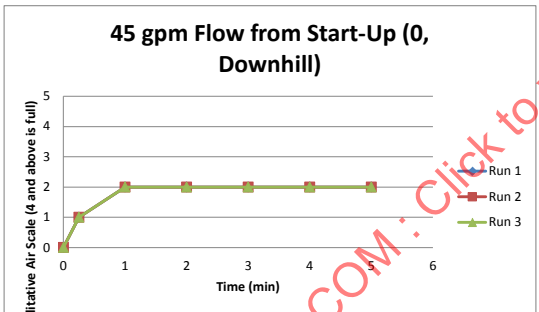
Experiment 133-135

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3



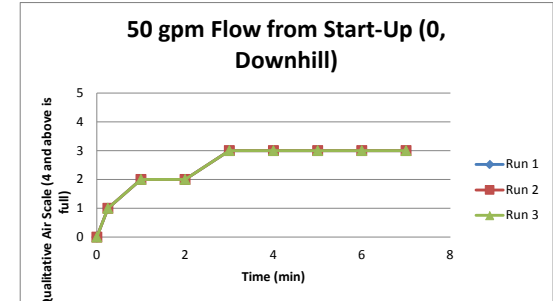
Experiment 148-150

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	2	2	2
2	2	2	2
3	2	2	2
4	2	2	2
5	2	2	2



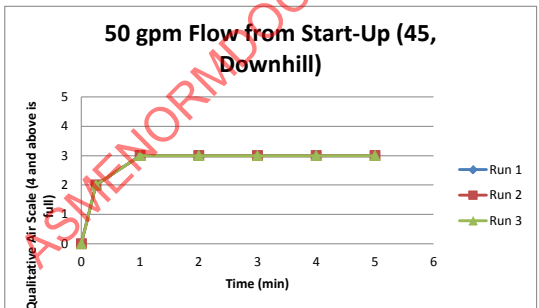
Experiment 151-153

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	2	2	2
2	2	2	2
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3



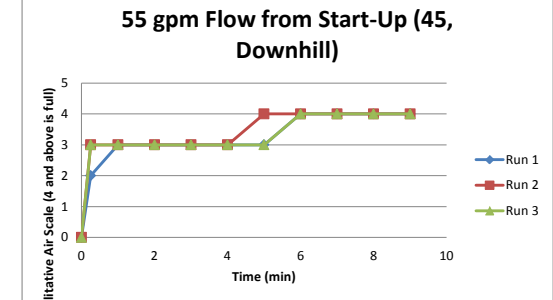
Experiment 166-168

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3



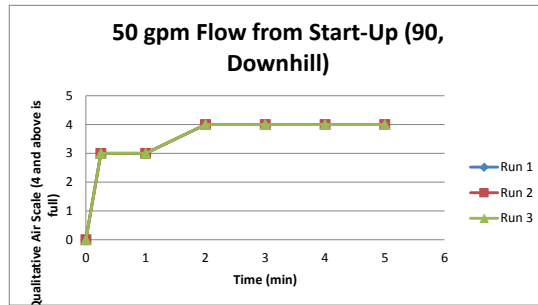
Experiment 169-171

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	3	3
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	4	3
6	4	4	4
7	4	4	4
8	4	4	4
9	4	4	4



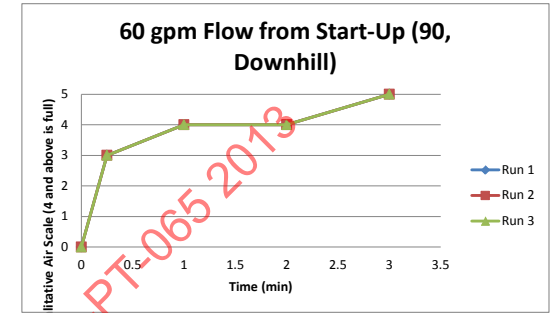
Experiment 166-168

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



Experiment 166-168

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	4	4	4
2	4	4	4
3	5	5	5

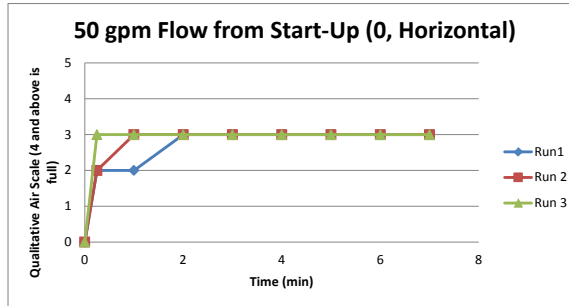


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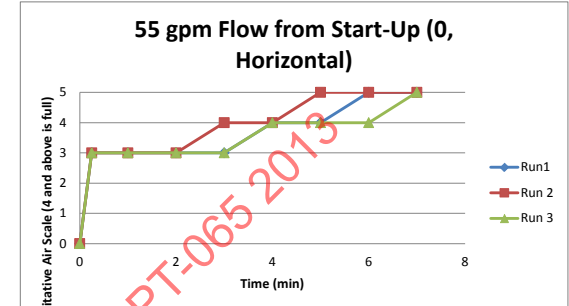
Experiment 13-15

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	2	2	3
1	2	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3



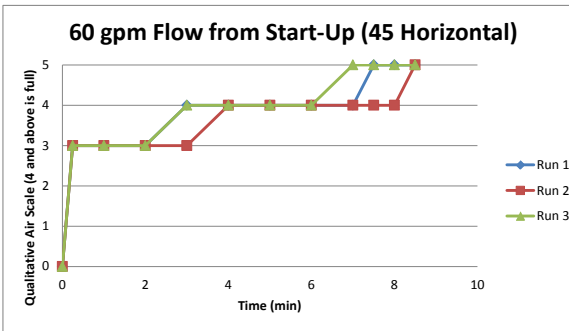
Experiment 16-18

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	3	4	3
4	4	4	4
5	4	5	4
6	5	5	4
7	5	5	5



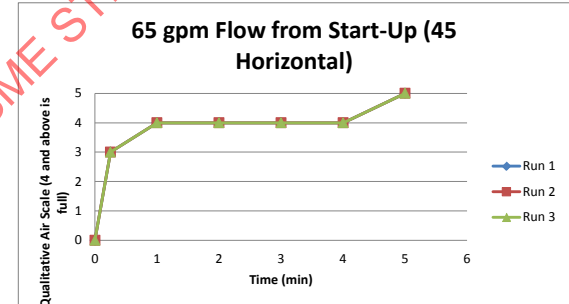
Experiment 58-60

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	4	3	4
4	4	4	4
5	4	4	4
6	4	4	4
7	4	4	5
7.5	5	4	5
8	5	4	5
8.5	5	5	5



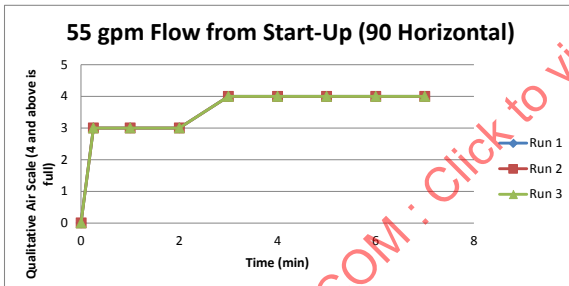
Experiment 61-63

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	5	5	5



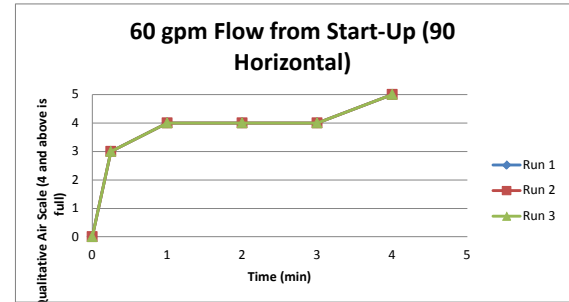
Experiment 76-78

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	3	3	3
3	4	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	4	4	4



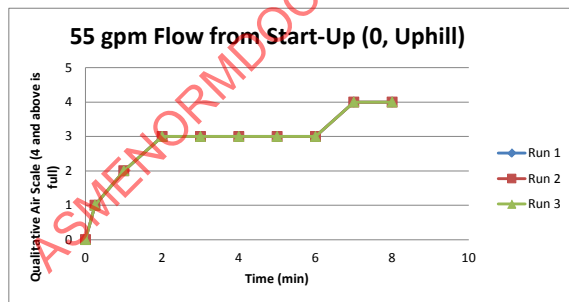
Experiment 79-81

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	4	4	4
2	4	4	4
3	4	4	4
4	5	5	5



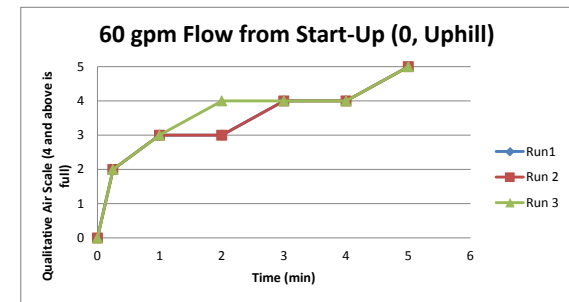
Experiment 100-102

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	2	2	2
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	4	4	4
8	4	4	4



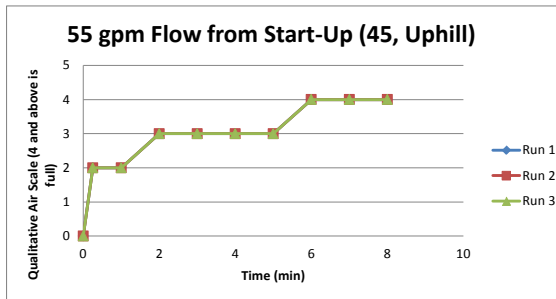
Experiment 103-105

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	3	3	3
2	3	3	4
3	4	4	4
4	4	4	4
5	5	5	5



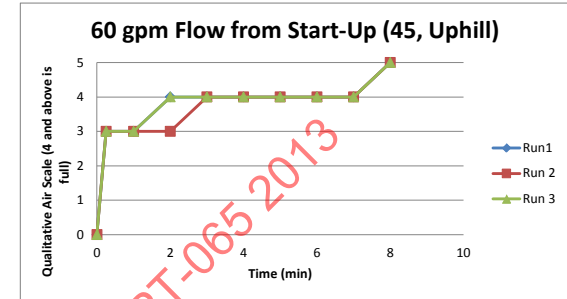
Experiment 118-120

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	2	2	2
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	4	4	4
7	4	4	4
8	4	4	4



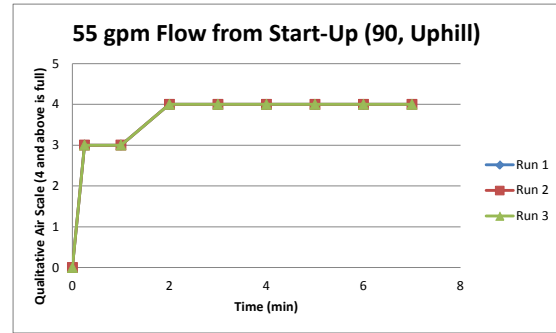
Experiment 121-123

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	3	4
3	4	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	4	4	4
8	5	5	5



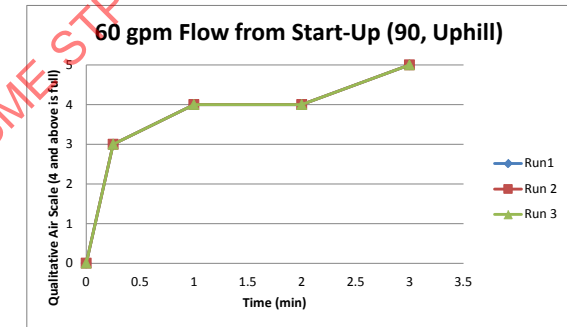
Experiment 136-138

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	4	4	4



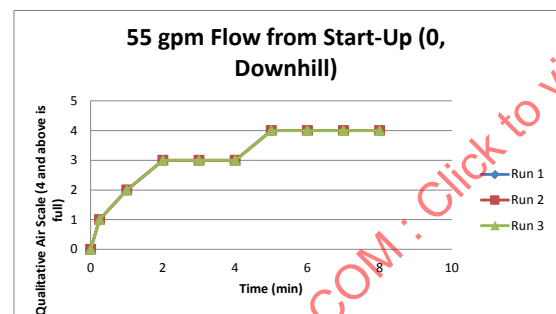
Experiment 139-141

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	4	4	4
2	4	4	4
3	5	5	5



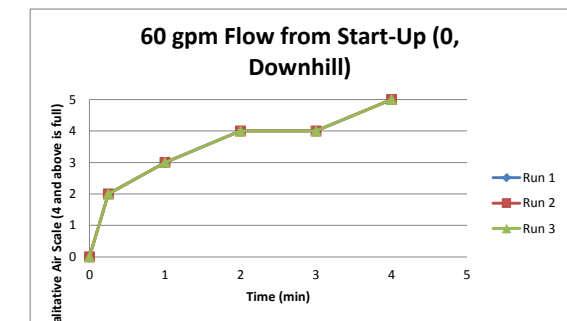
Experiment 154-156

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	1	1	1
1	2	2	2
2	3	3	3
3	3	3	3
4	3	3	3
5	4	4	4
6	4	4	4
7	4	4	4
8	4	4	4



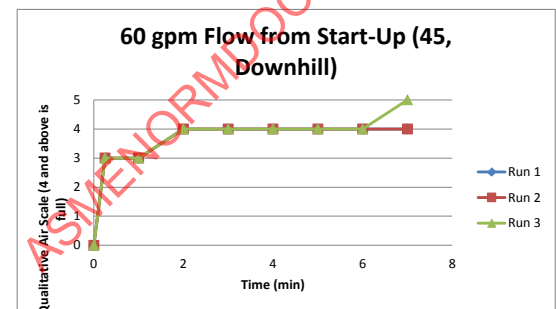
Experiment 157-159

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	3	3	3
2	4	4	4
3	4	4	4
4	5	5	5



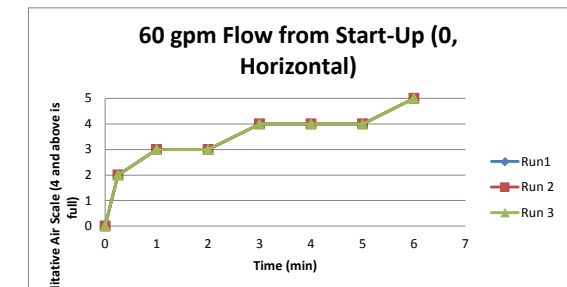
Experiment 172-174

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	4	4	5



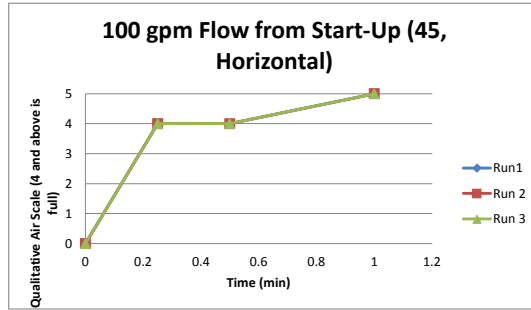
Experiment 187-189

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	2	2	2
1	3	3	3
2	3	3	3
3	4	4	4
4	4	4	4
5	4	4	4
6	5	5	5

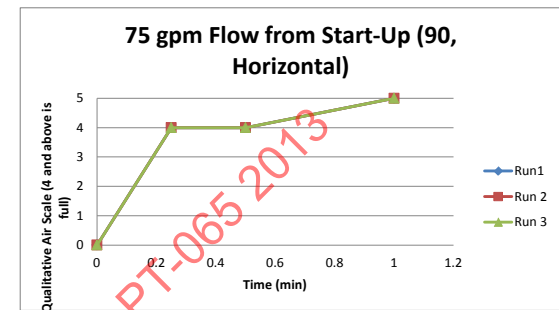


Experiment 1035-1037

Time	Run1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
0.5	4	4	4
1	5	5	5

**Experiment 1038-1040**

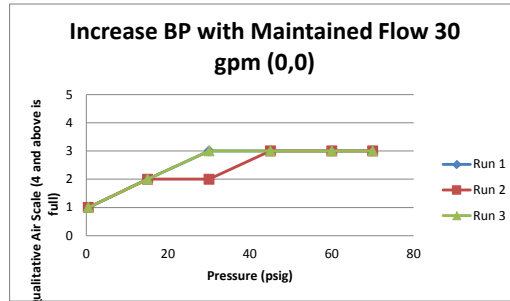
Time	Run1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
0.5	4	4	4
1	5	5	5



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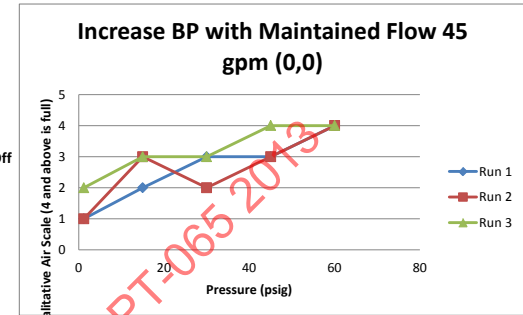
Experiment 28-30

Pressure	Run 1	Run 2	Run 3	
0.5	1	1	1	
15	2	2	2	
30	3	2	3	
45	3	3	3	
60	3	3	3	
70	3	3	3	
0	2	1	1	Pump Off



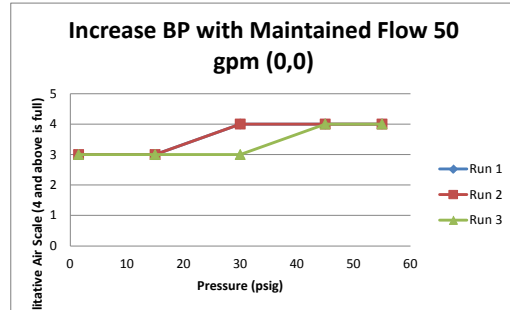
Experiment 31-33

Pressure	Run 1	Run 2	Run 3	
1.2	1	1	2	
15	2	3	3	
30	3	2	3	
45	3	3	4	
60	4	4	4	
0	3	3	3	Pump Off



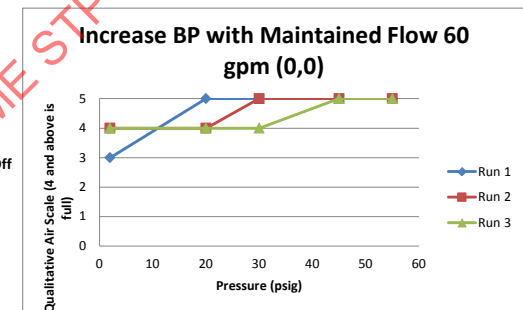
Experiment 34-36

Pressure	Run 1	Run 2	Run 3	
1.5	3	3	3	
15	3	3	3	
30	4	4	3	
45	4	4	4	
55	4	4	4	
0	4	4	3	Pump Off



Experiment 37-39

Pressure	Run 1	Run 2	Run 3	
2	3	4	4	
20	5	4	4	
30	5	5	4	
45	5	5	5	
55	5	5	5	
0	5	5	5	Pump Off

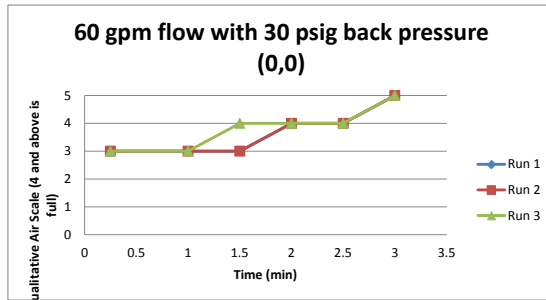


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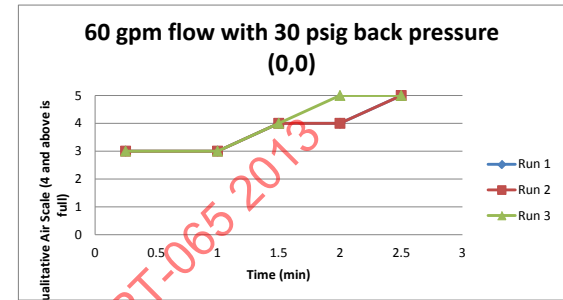
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Experiment 40-42

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
1.5	3	3	4
2	4	4	4
2.5	4	4	4
3	5	5	5

**Experiment 43-45**

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
1.5	4	4	4
2	4	4	5
2.5	5	5	5

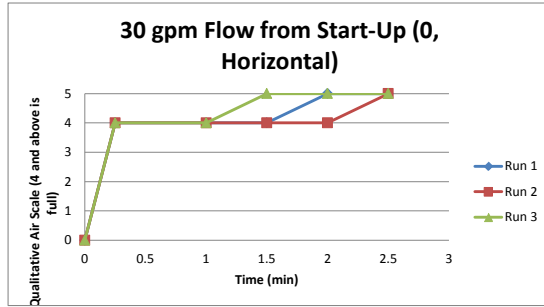


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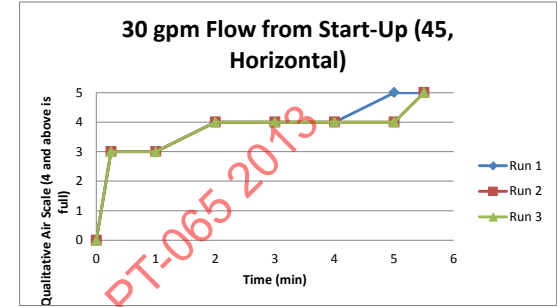
Experiment 190-192

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
1.5	4	4	5
2	5	4	5
2.5	5	5	5



Experiment 196-198

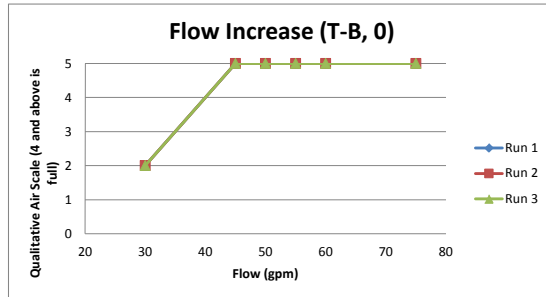
Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	5	4	4
5.5	5	5	5



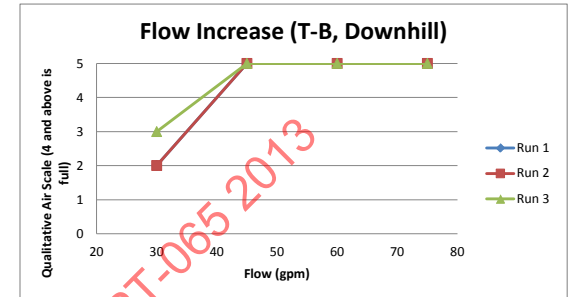
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Experiment 205-207

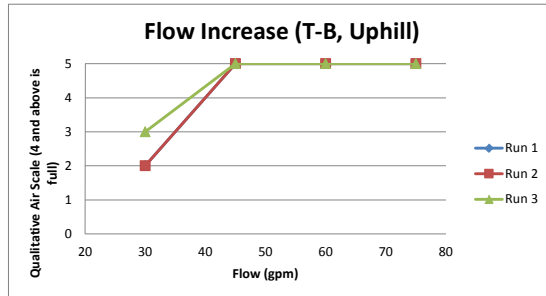
Flow	Run 1	Run 2	Run 3
30	2	2	2
45	5	5	5
50	5	5	5
55	5	5	5
60	5	5	5
75	5	5	5

**Experiment 217-219**

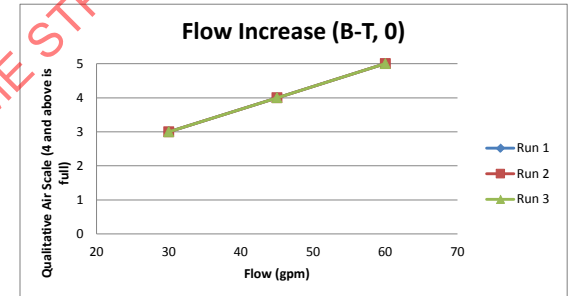
Flow	Run 1	Run 2	Run 3
30	2	2	3
45	5	5	5
60	5	5	5
75	5	5	5

**Experiment 229-231**

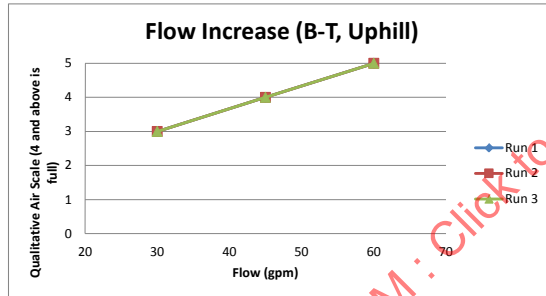
Flow	Run 1	Run 2	Run 3
30	2	2	3
45	5	5	5
60	5	5	5
75	5	5	5

**Experiment 256-258**

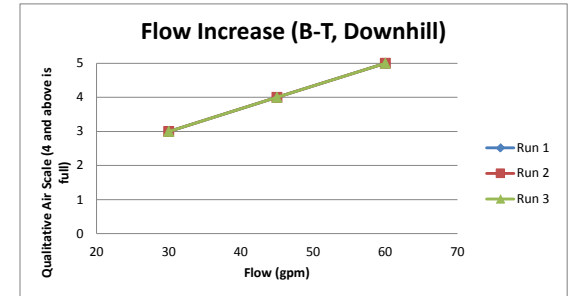
Flow	Run 1	Run 2	Run 3
30	3	3	3
45	4	4	4
60	5	5	5

**Experiment 265-267**

Flow	Run 1	Run 2	Run 3
30	3	3	3
45	4	4	4
60	5	5	5

**Experiment 2674-276**

Flow	Run 1	Run 2	Run 3
30	3	3	3
45	4	4	4
60	5	5	5



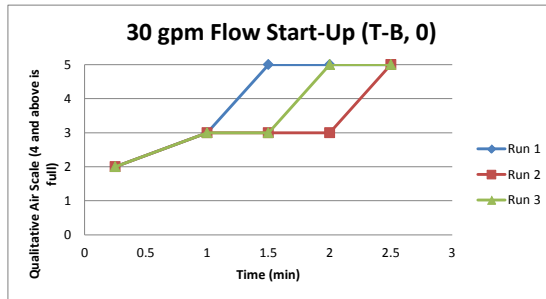
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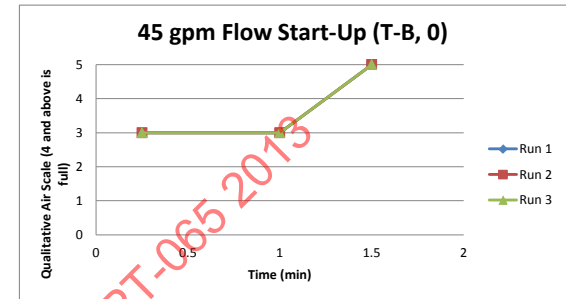
Experiment 208-210

Time	Run 1	Run 2	Run 3
0.25	2	2	2
1	3	3	3
1.5	5	3	3
2	5	3	5
2.5	5	5	5



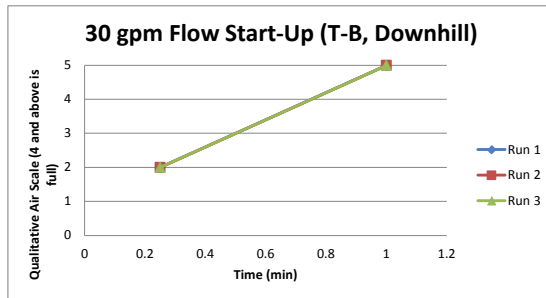
Experiment 211-213

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
1.5	5	5	5



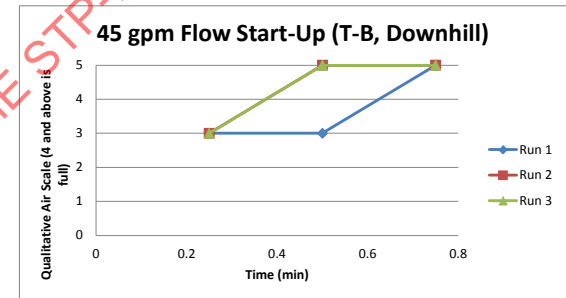
Experiment 220-222

Time	Run 1	Run 2	Run 3
0.25	2	2	2
1	5	5	5



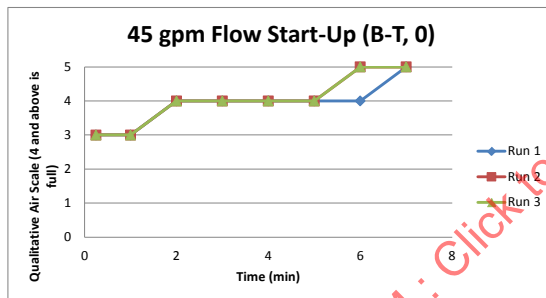
Experiment 223-225

Time	Run 1	Run 2	Run 3
0.25	3	3	3
0.5	3	5	5
0.75	5	5	5



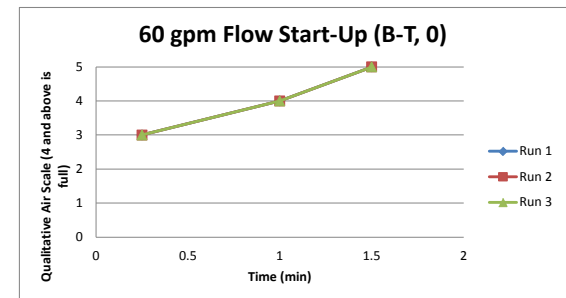
Experiment 259-261

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
6	4	5	5
7	5	5	5



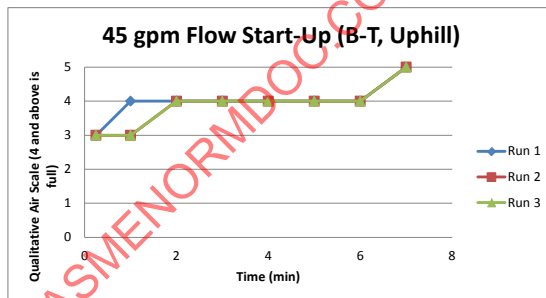
Experiment 262-264

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
1.5	5	5	5



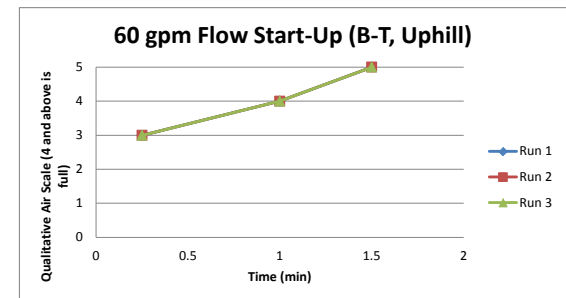
Experiment 268-270

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	5	5	5



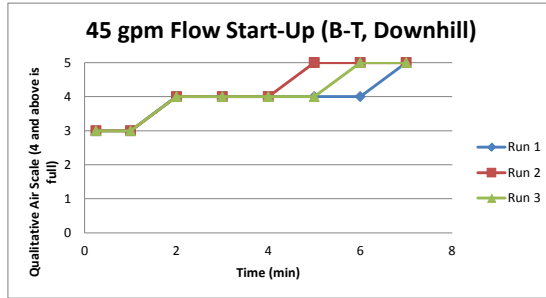
Experiment 271-273

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
1.5	5	5	5



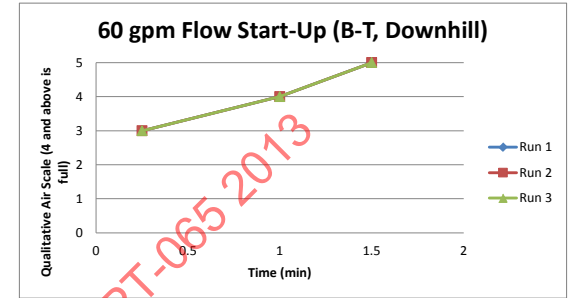
Experiment 277-279

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
2	4	4	4
3	4	4	4
4	4	4	4
5	4	5	4
6	4	5	5
7	5	5	5



Experiment 280-282

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
1.5	5	5	5

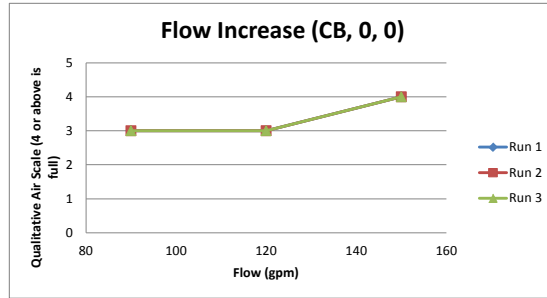


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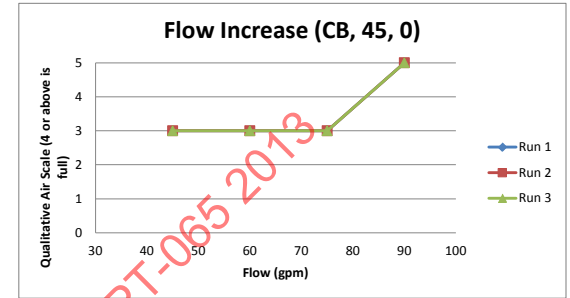
Experiment 235-237

Flow	Run 1	Run 2	Run 3
90	3	3	3
120	3	3	3
150	4	4	4



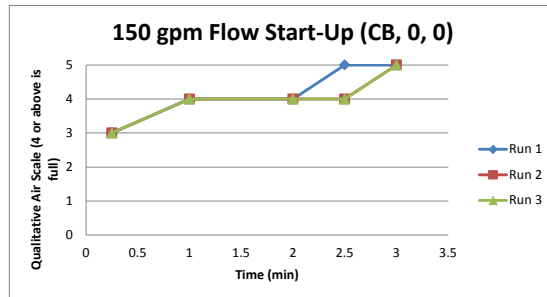
Experiment 241-243

Flow	Run 1	Run 2	Run 3
45	3	3	3
60	3	3	3
75	3	3	3
90	5	5	5



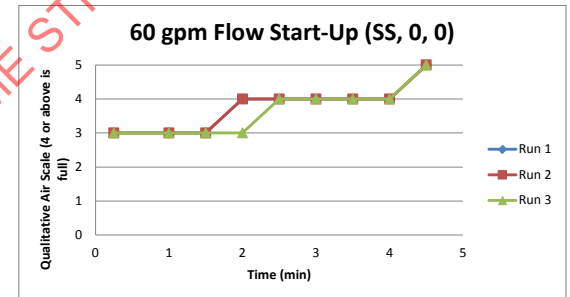
Experiment 238-240

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	4	4	4
2	4	4	4
2.5	5	4	4
3	5	5	5



Experiment 247-249

Time	Run 1	Run 2	Run 3
0.25	3	3	3
1	3	3	3
1.5	3	3	3
2	4	4	3
2.5	4	4	4
3	4	4	4
3.5	4	4	4
4	4	4	4
4.5	5	5	5

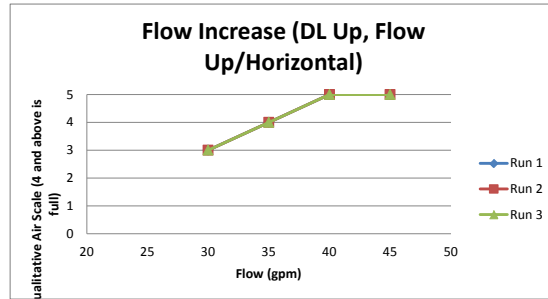


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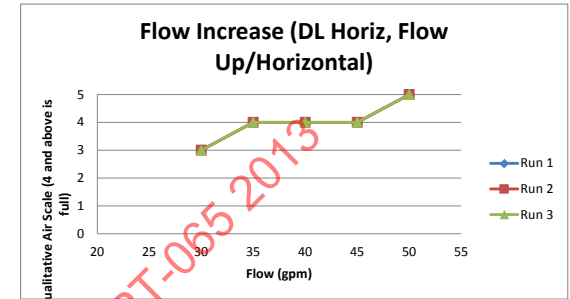
Experiment 283-285

Flow	Run 1	Run 2	Run 3
30	3	3	3
35	4	4	4
40	5	5	5
45	5	5	5



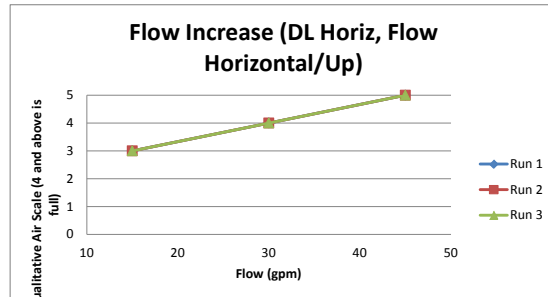
Experiment 292-294

Flow	Run 1	Run 2	Run 3
30	3	3	3
35	4	4	4
40	4	4	4
45	4	4	4
50	5	5	5



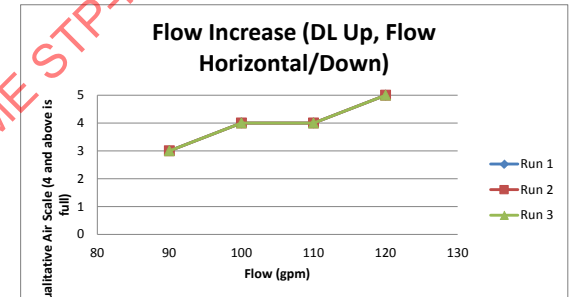
Experiment 301-303

Flow	Run 1	Run 2	Run 3
15	3	3	3
30	4	4	4
45	5	5	5



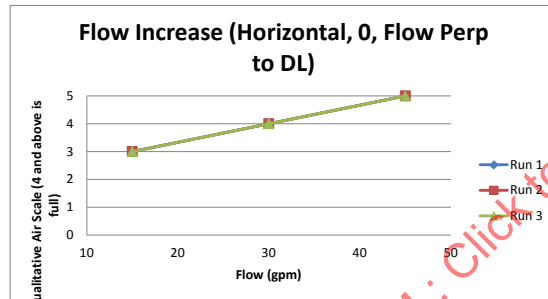
Experiment 313-315

Flow	Run 1	Run 2	Run 3
90	3	3	3
100	4	4	4
110	4	4	4
120	5	5	5



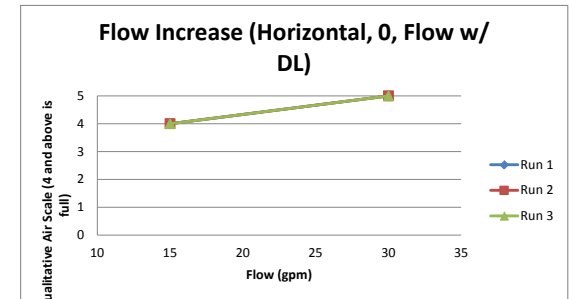
Experiment 322-324

Flow	Run 1	Run 2	Run 3
15	3	3	3
30	4	4	4
45	5	5	5



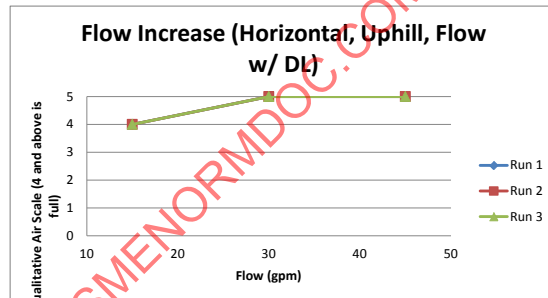
Experiment 331-333

Flow	Run 1	Run 2	Run 3
15	4	4	4
30	5	5	5



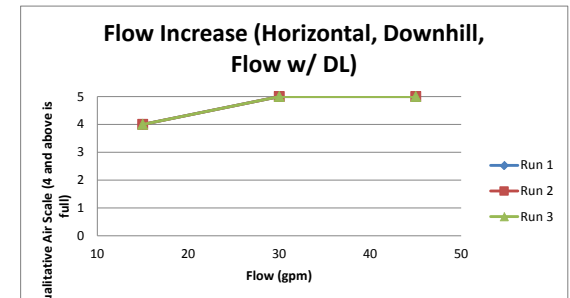
Experiment 337-339

Flow	Run 1	Run 2	Run 3
15	4	4	4
30	5	5	5
45	5	5	5



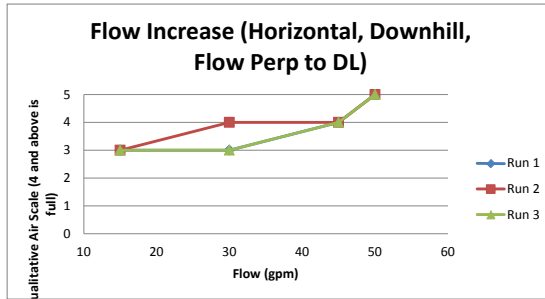
Experiment 343-345

Flow	Run 1	Run 2	Run 3
15	4	4	4
30	5	5	5
45	5	5	5

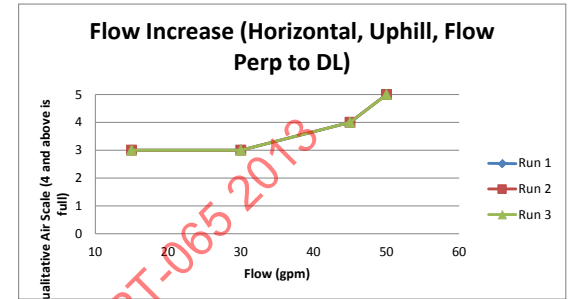


Experiment 349-351

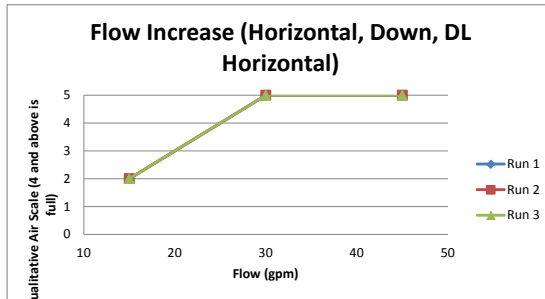
Flow	Run 1	Run 2	Run 3
15	3	3	3
30	3	4	3
45	4	4	4
50	5	5	5

**Experiment 358-360**

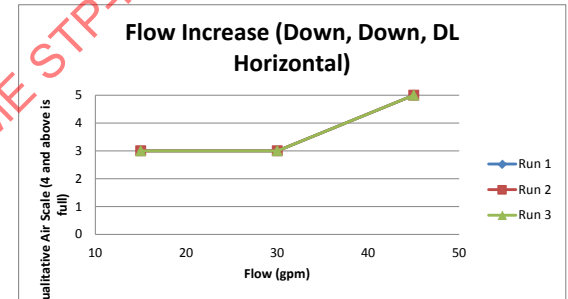
Flow	Run 1	Run 2	Run 3
15	3	3	3
30	3	3	3
45	4	4	4
50	5	5	5

**Experiment 367-369**

Flow	Run 1	Run 2	Run 3
15	2	2	2
30	5	5	5
45	5	5	5

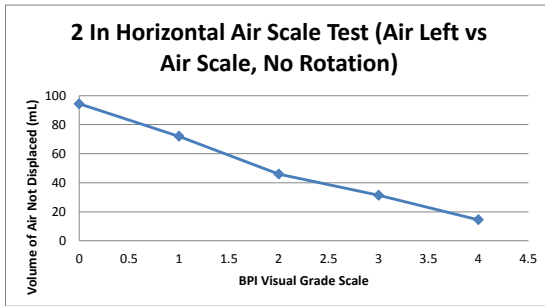
**Experiment 373-375**

Flow	Run 1	Run 2	Run 3
15	3	3	3
30	3	3	3
45	5	5	5

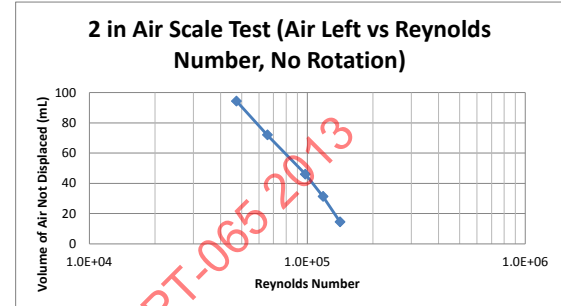


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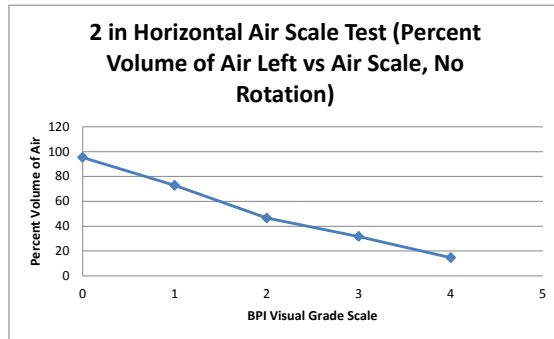
Air Scale	Volume of Air Left (mL)
0	94.33 ± 1.53
1	72.00 ± 2.65
2	46.00 ± 2.00
3	31.33 ± 2.31
4	14.50 ± 4.80



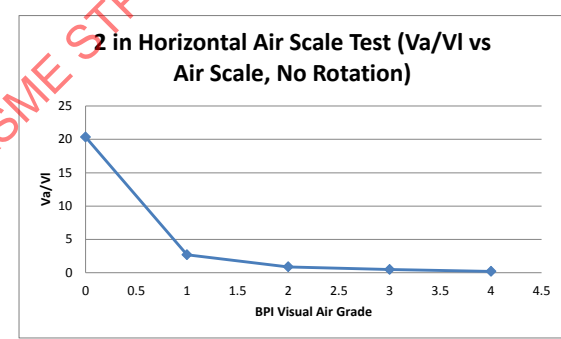
Reynolds Number	Volume of Air Left (mL)
4.7310E+04	94.33 ± 1.53
6.5628E+04	72.00 ± 2.65
9.7905E+04	46.00 ± 2.00
1.1818E+05	31.33 ± 2.31
1.4141E+05	14.50 ± 4.80



Air Scale	Percent Volume of Air
0	95.32
1	72.75
2	46.48
3	31.66
4	14.65



Air Scale	Va/VI
0	20.35
1	2.67
2	0.87
3	0.46
4	0.17

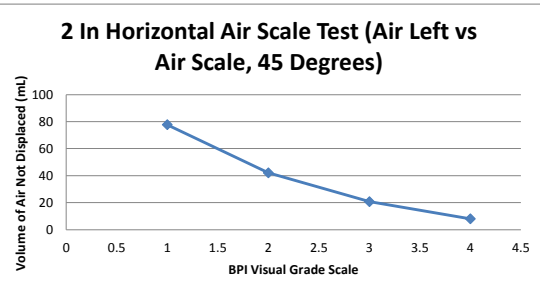


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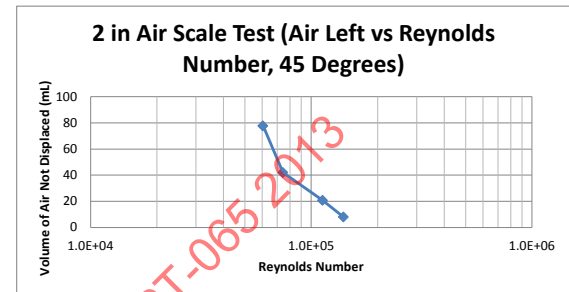
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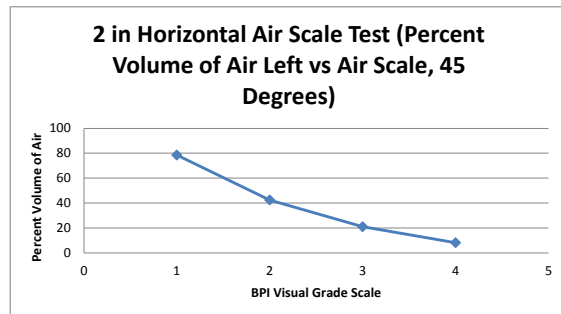
Air Scale	Volume of Air Left (mL)
1	77.67 ± 2.52
2	42.00 ± 3.61
3	20.67 ± 1.53
4	8.00 ± 3.00



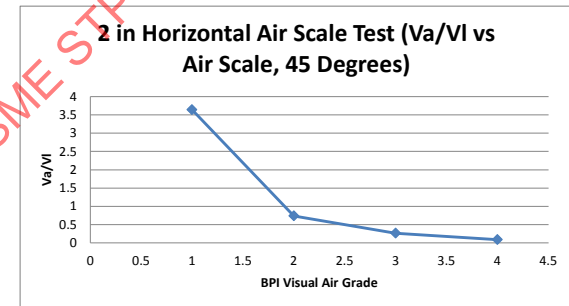
Reynolds Number	Volume of Air Left (mL)
6.0420E+04	77.67 ± 2.52
7.4425E+04	42.00 ± 3.61
1.1250E+05	20.67 ± 1.53
1.3996E+05	8.00 ± 3.00



Air Scale	Percent Volume of Air
1	78.47
2	42.44
3	20.88
4	8.08



Air Scale	Va/VI
1	3.65
2	0.74
3	0.26
4	0.09



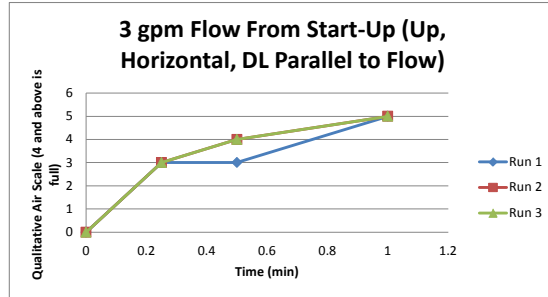
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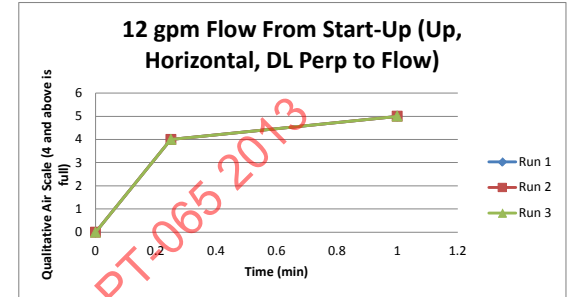
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Experiment 832-834

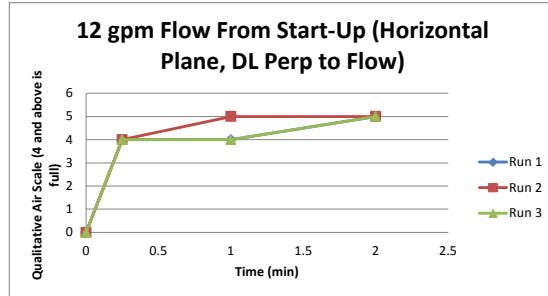
Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
0.5	3	4	4
1	5	5	5

**Experiment 836-838**

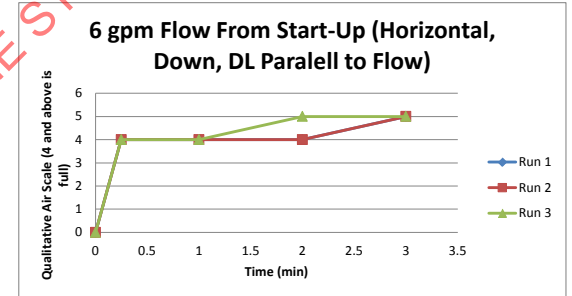
Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	5	5	5

**Experiment 876-878**

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	5	4
2	5	5	5

**Experiment 931-933**

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	5
3	5	5	5

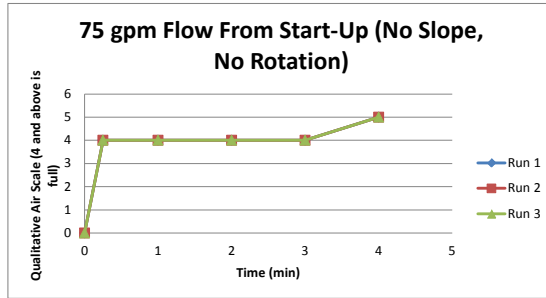


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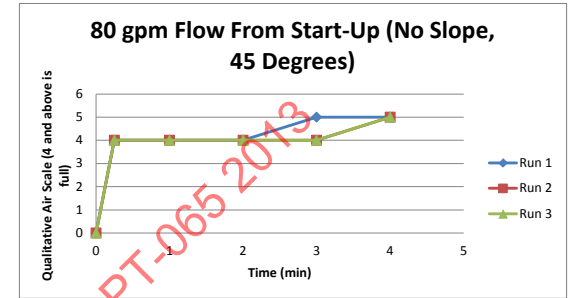
Experiment 901-903

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	5	5



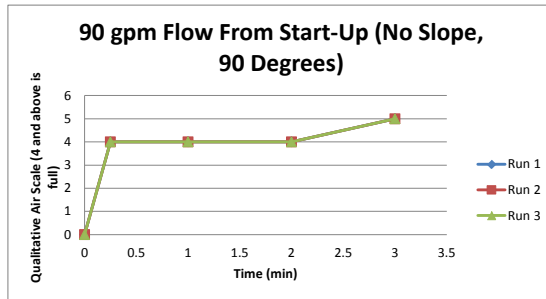
Experiment 908-910

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	4	4
4	5	5	5



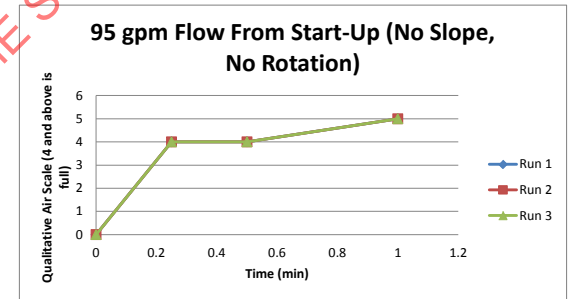
Experiment 915-917

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



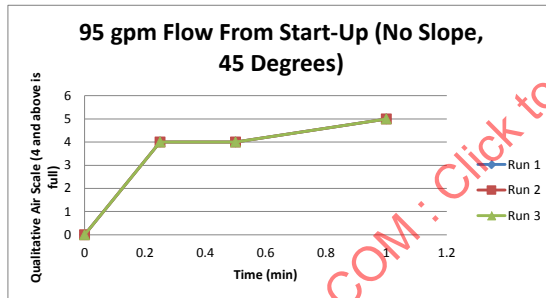
Experiment 1051-1053

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
0.5	4	4	4
1	5	5	5



Experiment 1048-1050

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
0.5	4	4	4
1	5	5	5



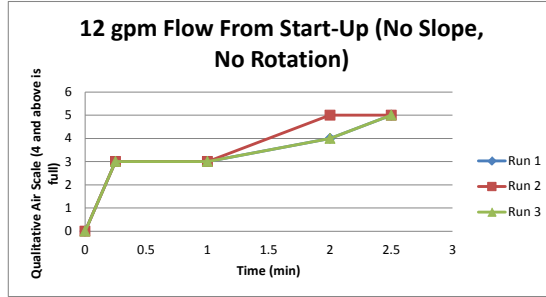
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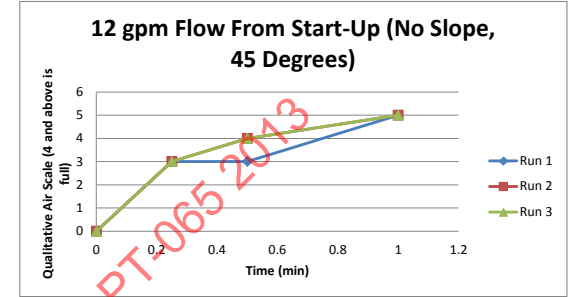
Experiment 852-854

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	3	3	3
2	4	5	4
2.5	5	5	5



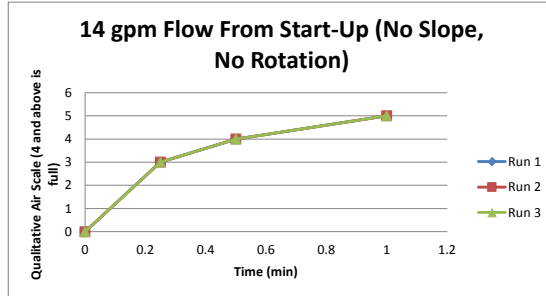
Experiment 855-857

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
0.5	3	4	4
1	5	5	5



Experiment 1054-1056

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
0.5	4	4	4
1	5	5	5



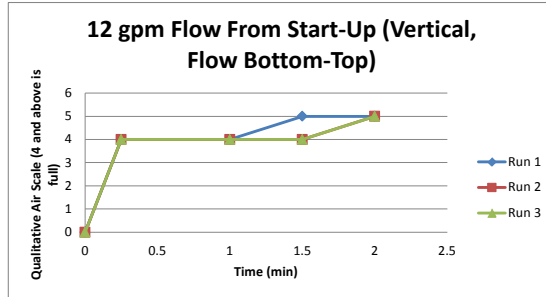
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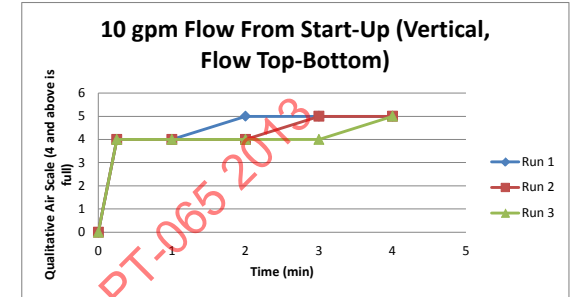
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Experiment 840-842

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
1.5	5	4	4
2	5	5	5

**Experiment 936-938**

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	5	4	4
3	5	5	4
4	5	5	5

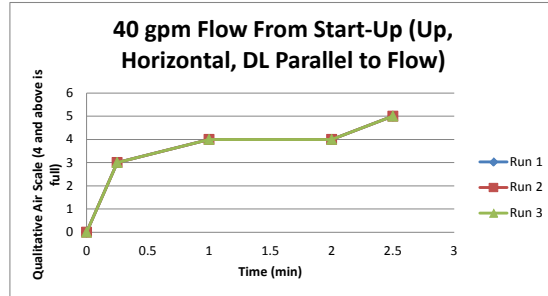


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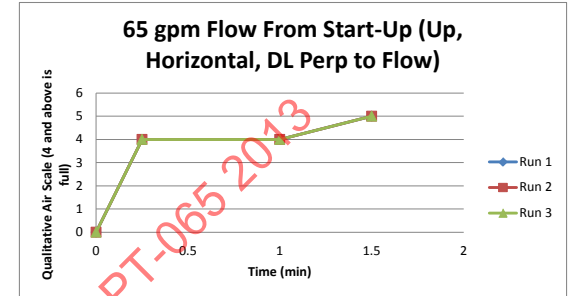
Experiment 820-822

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	3	3	3
1	4	4	4
2	4	4	4
2.5	5	5	5



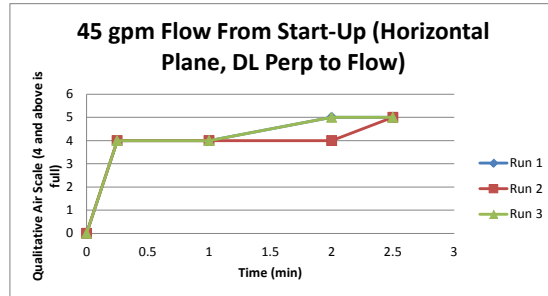
Experiment 829-831

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
1.5	5	5	5



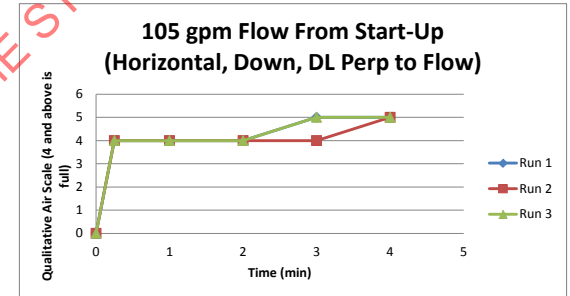
Experiment 868-870

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	5	4	4
2.5	5	5	5



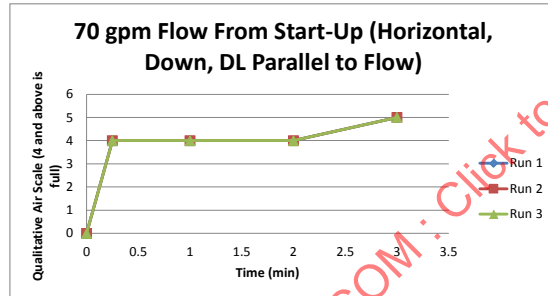
Experiment 921-923

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	4	5
4	5	5	5



Experiment 928-930

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5



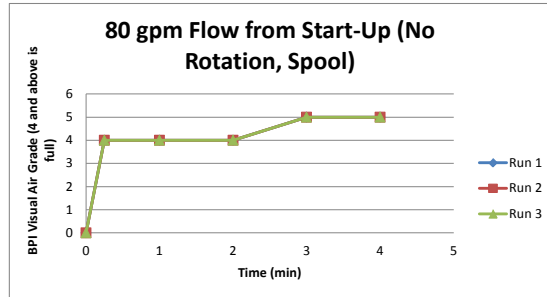
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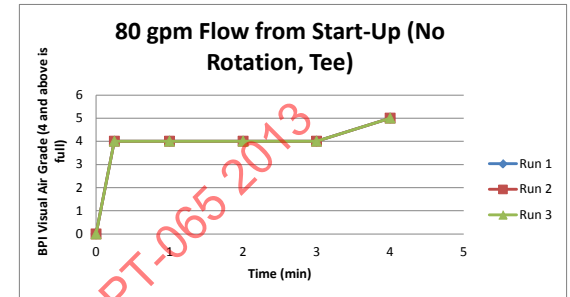
Experiment 984-986

Time	Spool		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5
4	5	5	5



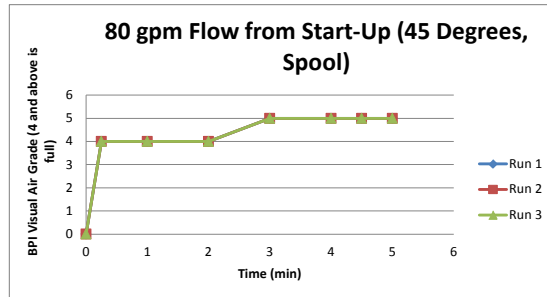
Experiment 984-986

Time	Tee		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	5	5	5



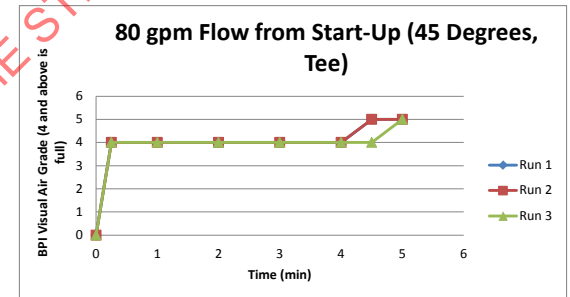
Experiment 987-989

Time	Spool		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5
4	5	5	5
4.5	5	5	5
5	5	5	5



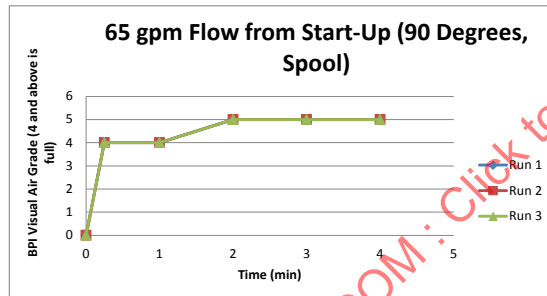
Experiment 987-989

Time	Tee		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
4.5	5	5	4
5	5	5	5



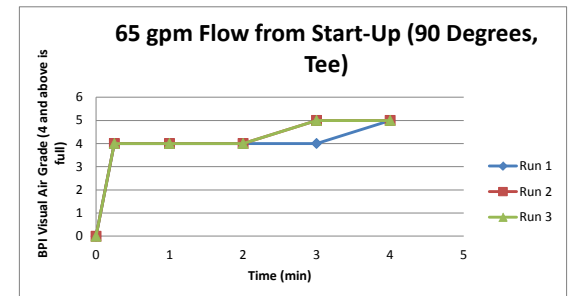
Experiment 1000-1002

Time	Spool		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	5	5	5
3	5	5	5
4	5	5	5



Experiment 1000-1002

Time	Tee		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	5	5
4	5	5	5



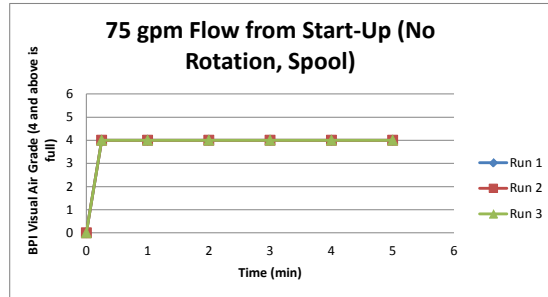
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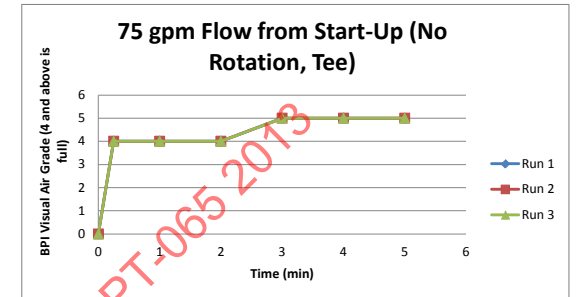
Experiment 948-950

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



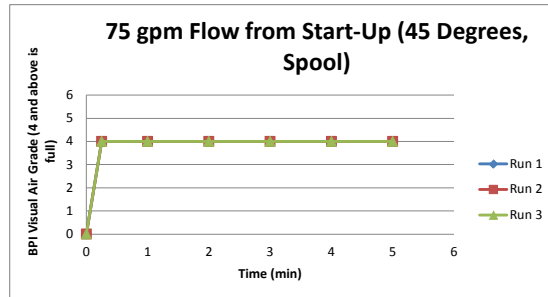
Experiment 948-950

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	5	5	5
4	5	5	5
5	5	5	5



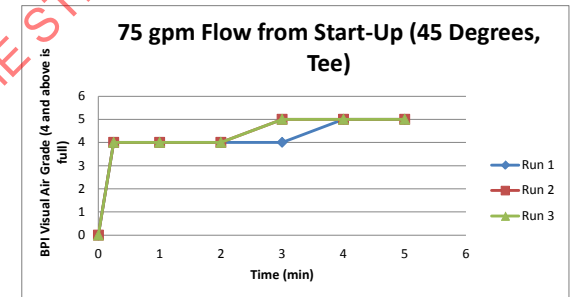
Experiment 960-962

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



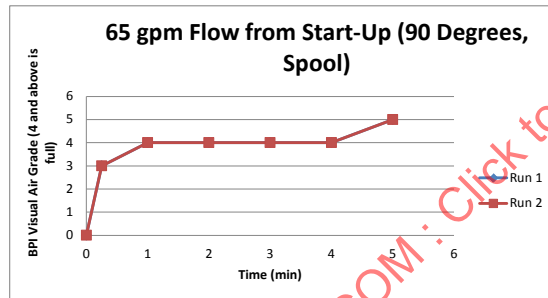
Experiment 960-962

Time	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	5	5
4	5	5	5
5	5	5	5



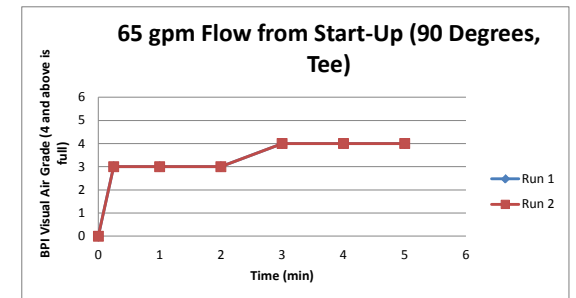
Experiment 973-974

Time	Run 1	Run 2
0	0	0
0.25	3	3
1	4	4
2	4	4
3	4	4
4	4	4
5	5	5



Experiment 973-974

Time	Run 1	Run 2
0	0	0
0.25	3	3
1	3	3
2	3	3
3	4	4
4	4	4
5	4	4



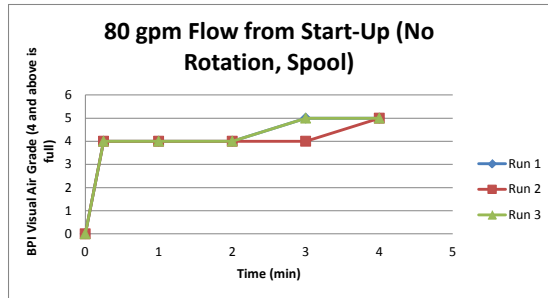
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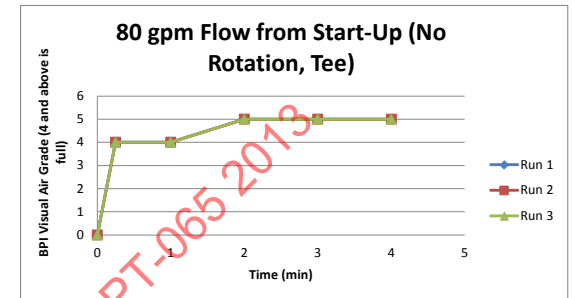
Experiment 951-953

Time	Spool			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
3	5	4	5	5
4	5	5	5	5



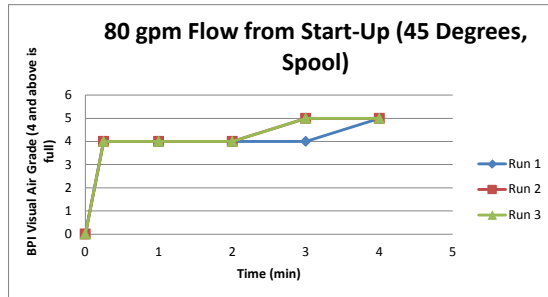
Experiment 951-953

Time	Tee			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	4	4	4	4
1	4	4	4	4
2	5	5	5	5
3	5	5	5	5
4	5	5	5	5



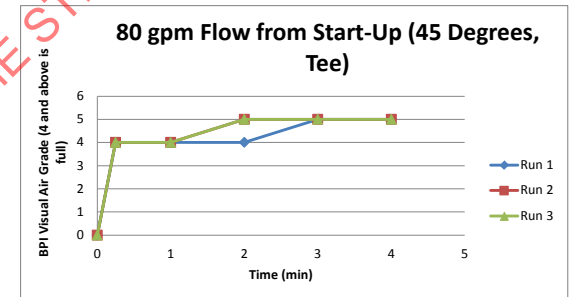
Experiment 963-965

Time	Spool			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	4	4	4	4
1	4	4	4	4
2	4	4	4	4
3	4	5	5	5
4	5	5	5	5



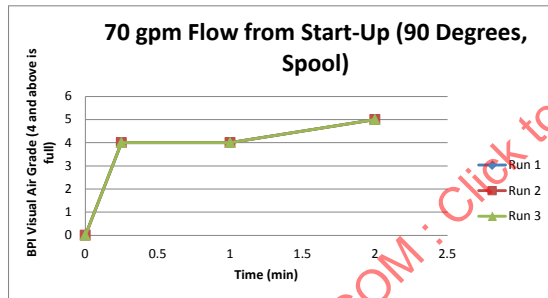
Experiment 963-965

Time	Tee			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	4	4	4	4
1	4	4	4	4
2	4	5	5	5
3	5	5	5	5
4	5	5	5	5



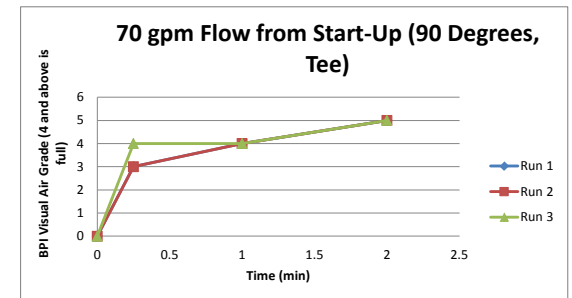
Experiment 975-977

Time	Spool			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	4	4	4	4
1	4	4	4	4
2	5	5	5	5



Experiment 975-977

Time	Tee			
	Run 1	Run 2	Run 3	
0	0	0	0	0
0.25	3	3	3	4
1	4	4	4	4
2	5	5	5	5



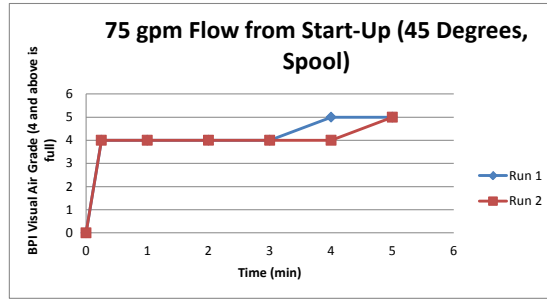
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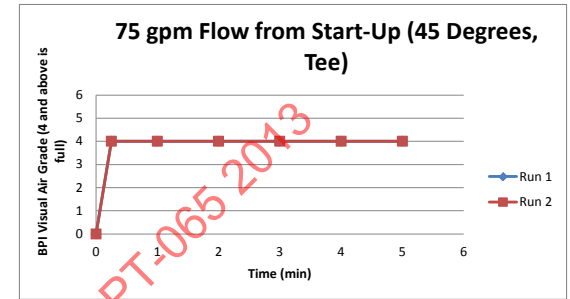
Experiment 990-991

Time	Spool	
	Run 1	Run 2
0	0	0
0.25	4	4
1	4	4
2	4	4
3	4	4
4	5	4
5	5	5



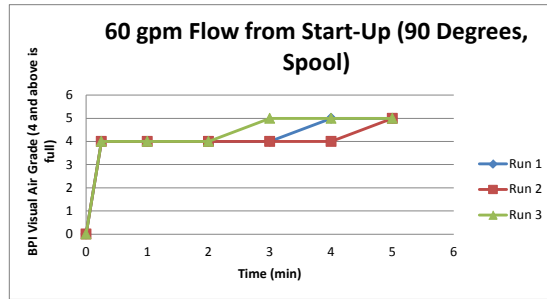
Experiment 990-991

Time	Tee	
	Run 1	Run 2
0	0	0
0.25	4	4
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4



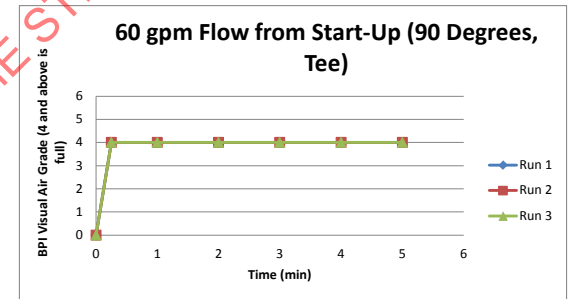
Experiment 997-999

Time	Spool		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	5
4	5	4	5
5	5	5	5



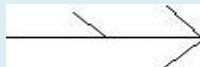
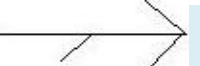
Experiment 997-999

Time	Tee		
	Run 1	Run 2	Run 3
0	0	0	0
0.25	4	4	4
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4



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Flow Rate (gpm)		Velocity (ft/s)				
60		9.8805				
Tube	Rotation (degrees)	Slope (1/8" by 12")	Orientation	Time to Clear (s)	Reynolds Number	
2" T Horizontal	0	0		360		
2" T Horizontal	45	0		460		
2" T Horizontal	90	0		240		
2" T Horizontal	135	0		1		
2" T Horizontal	180	0		1		
2" T Horizontal	0	Uphill		300		
2" T Horizontal	45	Uphill		480		
2" T Horizontal	90	Uphill		180		
2" T Horizontal	0	Downhill		240		
2" T Horizontal	45	Downhill		420		
2" T Horizontal	90	Downhill		180		

APPENDIX H: LITERATURE

The following literatures are supplements in the development of this document:

- Dead-end Considerations based on Literature and own work, *Bo Boye Busk Jensen*
- Testing to Determine Flow rates Required to Flood Piping, *Jeff J. Gaerke P.E*
- Characteristics of flow field and water concentration in a horizontal Deadleg, *M.A. Habib*
- On the Development of Deadleg Criterion, *M.A. Habib*

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Dead-end considerations based on literature and own work.

Bo Boye Busk Jensen, 2010

On the topic of understanding the hygienically design issues around the so-called “dead-end” geometry, that can appear in any process line or piece of equipment, some work has already been done. This document tries to collect the most important results from these.

- Grasshoff work
- EHEDG movies
- CFD work by Jensen
- Experimental work by Jensen

The general rules on L/d found in different guidelines and standards are:

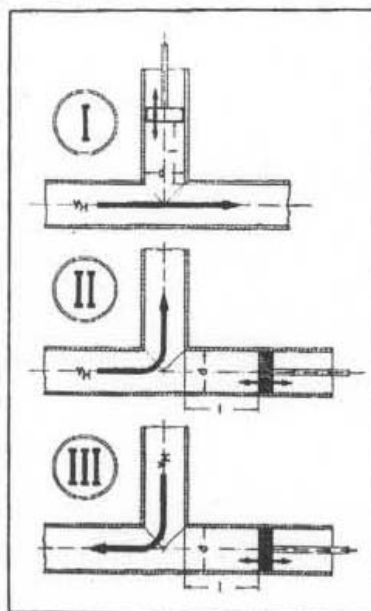
- ASME BPE: $L/d < 2:1$
- 3-A: $L/d < 2:1$ (T-613-00 – not yet published)
- EHEDG: $L/d < 1:1$ (Guideline no.: 10)
- Japan: $L/D < 1.5:1$ (Sei presentation at ASME BPE 2011 – Philly)

Grasshoff

Has published a number of papers that uses data from experimental work that he did – but the one where the data was established is this one:

- 1980: Untersuchungen zum Strömungsverhalten von Flüssigkeiten in zylindrischen Toträumen von Rohrleitungssystemen, in Kieler Milchwirtschaftliche forschungsbereich

The three different configurations Grasshoff deals with – in German: “Strömungsaufall”



The piping in the test section was made from $\varnothing 50$ plexiglass to allow flow visualisation. Upstream the test section a 2 m straight pipe was present to allow a fully developed flow before the test section. The length of the dead-end was adjusted by a moveable plunger. L is the distance from where the dead-end pipe is attached to the main pipe (see figure above) and d is the diameter of the dead-end pipe.

The flow inside the pipe varied between 1 and 5 m/s giving Reynolds numbers between 45,000-224,000 at 16°C and 90,000-452,000 at 50°C

The tests that Grasshoff performed on these configurations was:

- Flow visualization using VESTYPOR $\varnothing 0.5$ mm particles with a density of 1000 kg/m^3
- Flow quantification using flow visualization
- Fluid exchange investigating the replacement of a conducting liquid with a non-conducting liquid.

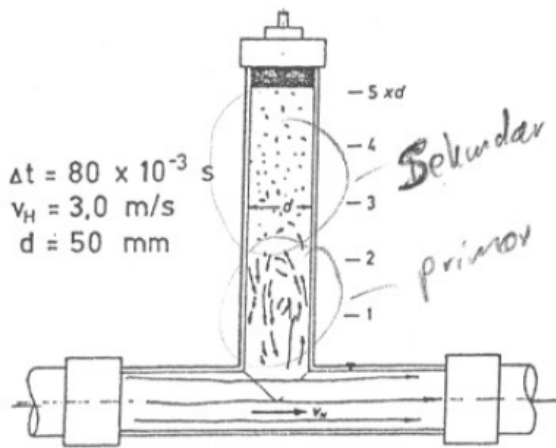
Flow Visualization:

Flow was visualized inside the three different configurations by a camera with a long exposure.

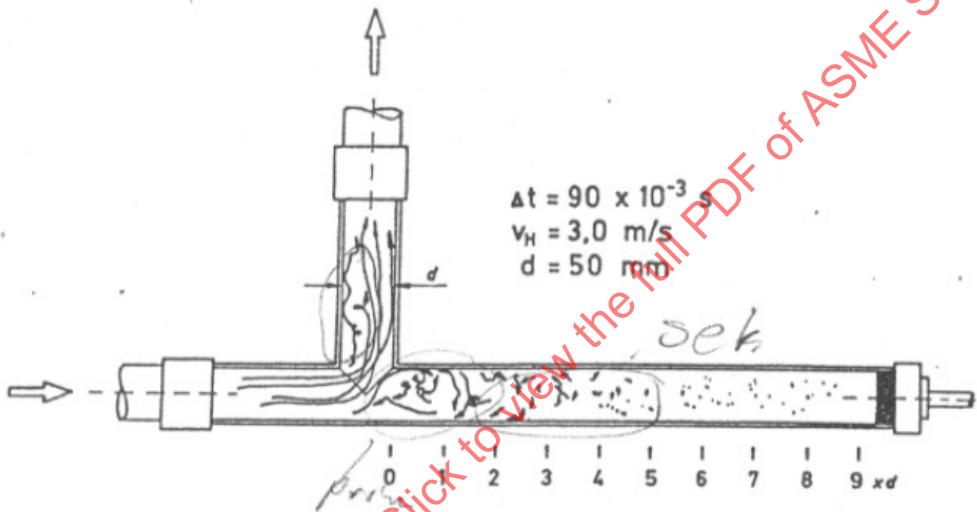
The pictures show that for all three configurations there is a primary and a secondary recirculation zone in the dead-end. The locations of these two zones are approximately:

- Case 1: $L/D = 2$ (little or no action in secondary)
- Case 2: $L/D = 2-3$ (more intense secondary up to 5)
- Case 3: $L/D = 2$ (little or no action in secondary)

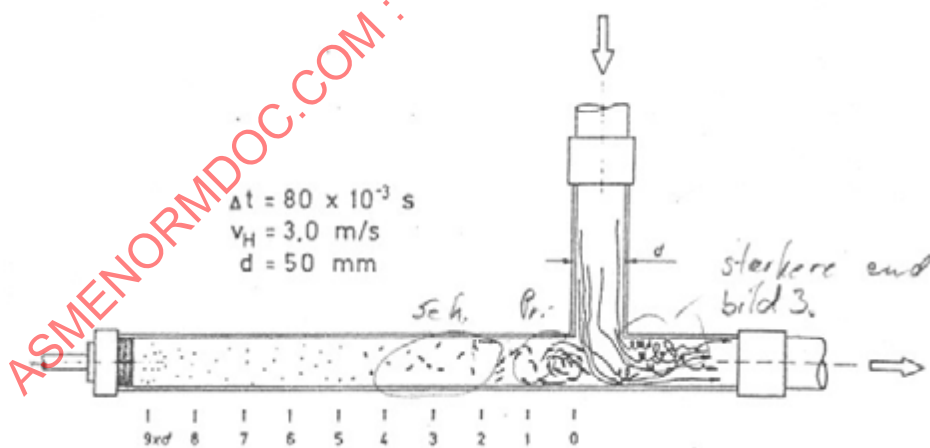
The visualization shown here from Grasshoff is done at a high Reynolds number. So one would ask what would happen if the velocity was reduced or increased. As the Reynolds number from 1 m/s up to 5 m/s in all cases are above 30,000 then the theory tells that the flow pattern will be the same regardless of Reynolds number and thereby velocity. Of course the intensity (velocity of the primary and secondary recirculations zones) depends on the velocity in the main flow, but the positions and sizes of the recirculations zones does not change. The higher the velocity the more exchange between main flow and primary and secondary recirculation will take place is shown later.



Case 1



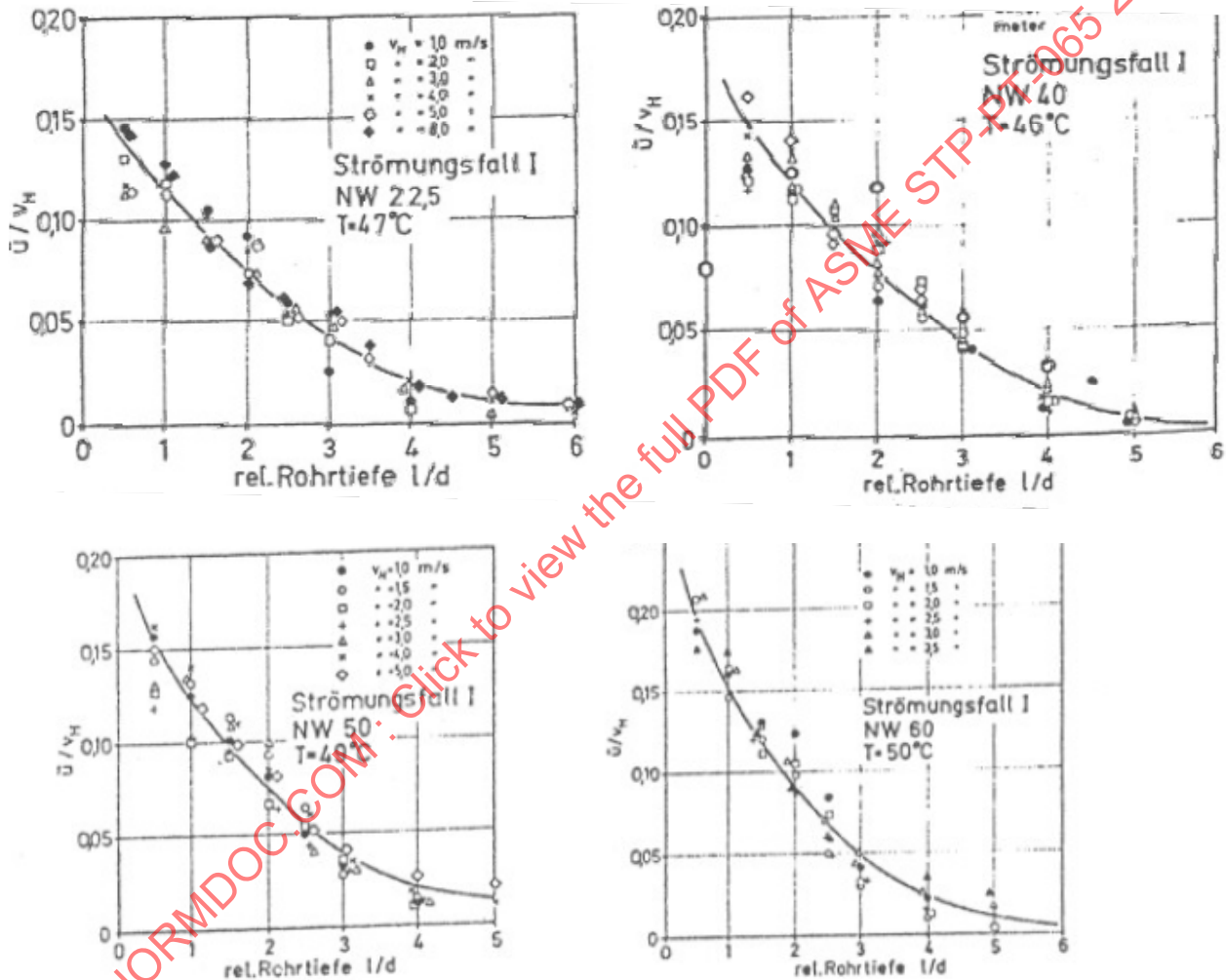
Case 2



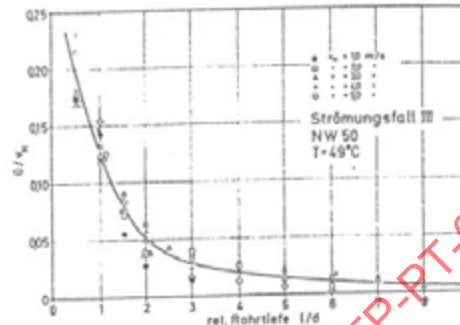
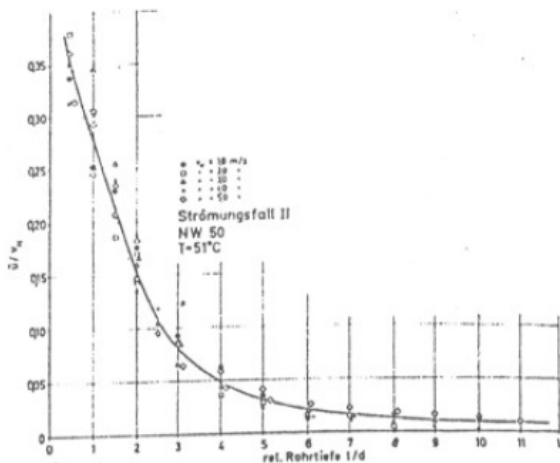
Case 3

Velocity in dead-end

The flow velocity in the dead-end as a function of velocity was also provided by Grasshoff. For Case 1 the measurements were done for $\varnothing 22.5$, $\varnothing 40$, $\varnothing 50$ and $\varnothing 60$. The graphs below show that the pipe diameter has no influence on the velocity in the dead-end. For all 4 pipe sizes the velocity at $L/d = 1$ is below 0.125 (1/8) of that in the main pipe. This means that the wall shear stress in this area is a MAXIMUM of 0.025 of the wall shear stress found in the main pipe. In many areas this is probably much lower due to local variations in flow velocity in the primary recirculation zone. Going further into the dead-end only makes this worse. This is the same for Case 3 configuration.



For Case 2 configuration of dead-end the average velocity in the dead-end is below 0.275 of that in the main pipe at $l/d > 1$.



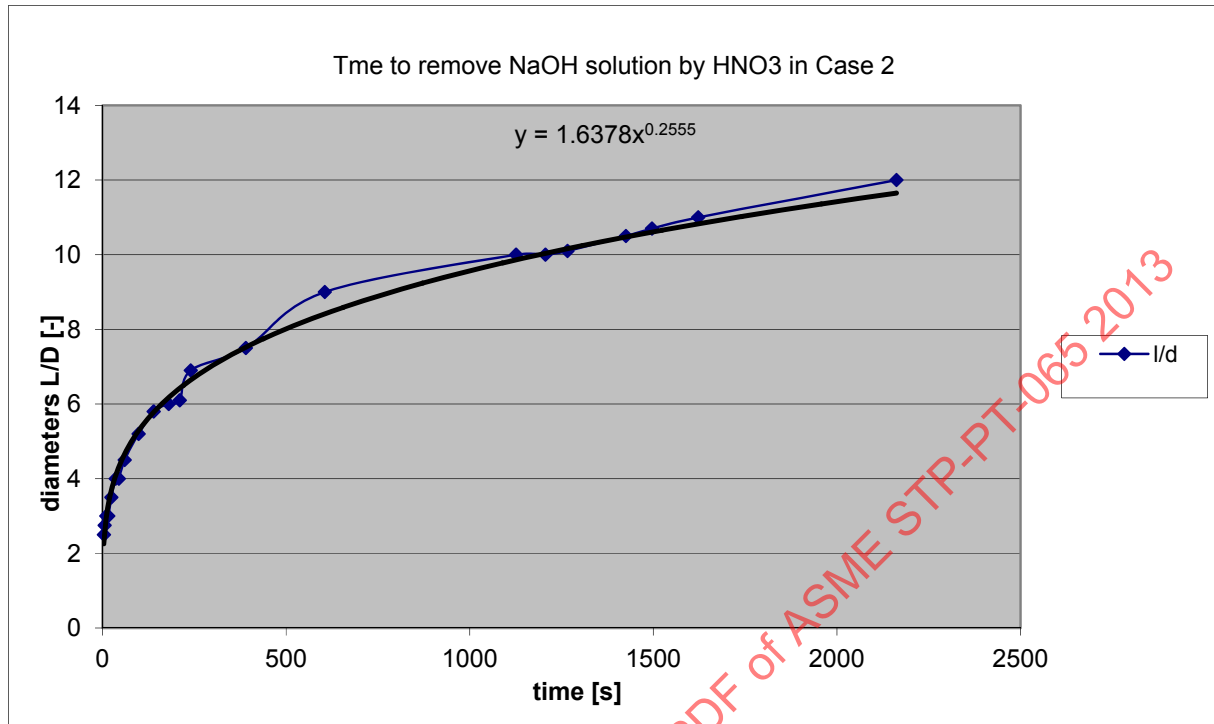
This means that the mechanical (wall shear stress) cleaning effect of the flow is very low in the primary recirculation that stretches up to L/d of approx. 2 for all 3 cases. This, in combination with the lower mass and heat transfer in the recirculation zones, decreases the cleaning rate.

Fluid exchange in dead-end

Grasshoff uses a 0.1-n-NaOH solution with added Phenolphthalein. The Phenolphthalein is added to colour the fluid. The pipe system is filled with this liquid. Then the pipe system is cleaned pumping through a HNO_3 solution. This both flush out the NaOH solution and neutralizes the NaOH solution so that the Phenolphthalein changes colour from a red to a colourless solution. The exchange of fluid is measured by conductive changes in the system.

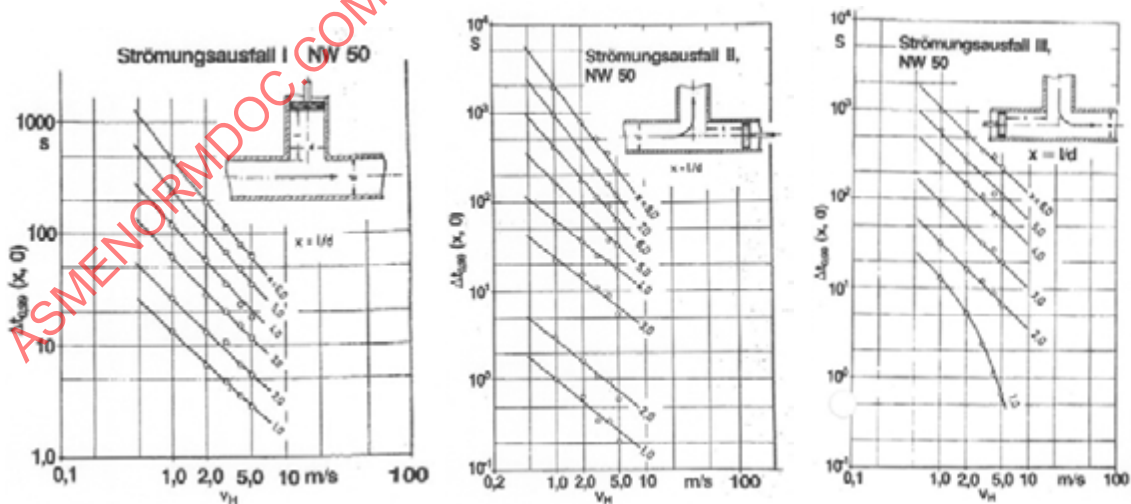
In the papers there are pictures taken of the colour shift length (L/d) as a function of time. Plotting these as a function of time it can be seen how the time for fluid exchange increases slowly from L/d 2.5 to around 6, from where any further exchanges takes longer time.

- Fluid exchange in a NW50 V_{pipe} = 2,6 – case II



The data for the conductivity measurement for showing the time it takes to changes the conductivity to 99% of the original shows:

- Case 1: worse than flow against. No jump in the time for fluid exchange between L/d's.
- Case 2: Up to L/d < 2 gives the fastest exchange of the tree. But going to L/d = 3 makes a large difference in fluid exchange time (at 1.5 m/s going from L/d = 2 to L/d = 3 the fluid exchange time increases with a factor of 10). Above 2 it actually becomes just as bad as Case 1.
- Case 3: This only works well at high velocity (approx. 5 m/s) at L/d = 1. Below that the fluid exchange is very poor.



The fluid exchange or the velocity (wall shear stress) cannot be looked upon solely to evaluate the cleaning effect. This is a combination of fluid exchange and wall shear stress.

The primary recirculation zone in the dead-ends extents around $1\frac{1}{2}$ - $2 \cdot D$ into the dead-end for the best configuration (Case 2).

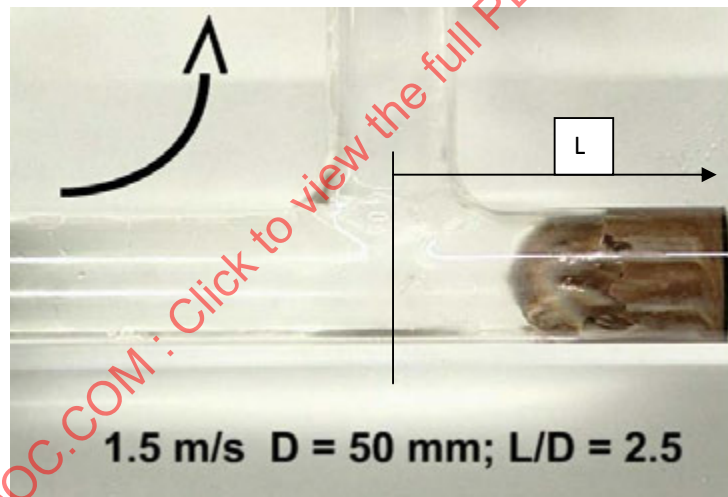
Case II could have L/d one larger than that of Case I and III as cleaning is better in case II

EHEDG movies

As part of EHEDG educational toolbox for teaching courses in hygienic design the EHEDG has produced a DVD that contains movies that shows:

- How chocolate is removed from a dead-end at different velocities and dead-end length. The diameter is $\varnothing 50$ and $\varnothing 75$ and the geometry is made from glass.
- How spherical balls are flushed out of the dead-end at different velocities and dead-end length.

L/D is measured from the center line of the main pipe to the end of the dead-end. This means that the L/D used in this section is 0.5 larger compared to the L/D used in the previous section (and the one normally used by ASME BPE, 3-A and EHEDG).



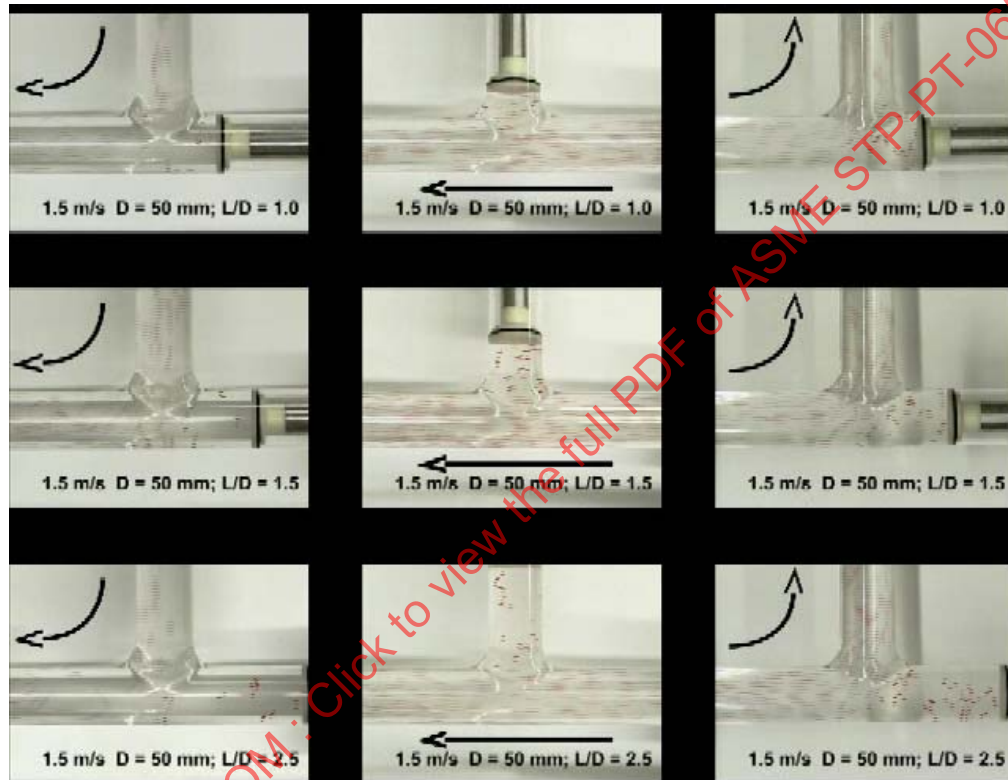
From EHEDG training video (Courtesy of EHEDG) – for INTERNAL ASME BPE USE ONLY.

Overview of configurations investigated with chocolate cleaning:

L/D	velocity	Diameter	Case	Removed	Cleaning time [s]	Comment
1	1.5	50	2	Chocolate (Nutella)	8	
1.5	1.5	50	2	Chocolate (Nutella)	49	Takes long time to remove the soil in the corner at the end of the dead-end. Most is cleaned out in

						30 s
2.5	1.5	50	2	Chocolate (Nutella)	>300	Last 0.5D is not cleaned after 300s.

For the experiments with small spheres (red) a number of combinations of experiments has been performed. The velocity range tested is 0.3 m/s to 1.5 m/s and the dead-end length is between 0.5 and 2.5 L/D at two different pipe diameters.



From EHEDG training video (Courtesy of EHEDG) – for INTERNAL ASME BPE USE ONLY.

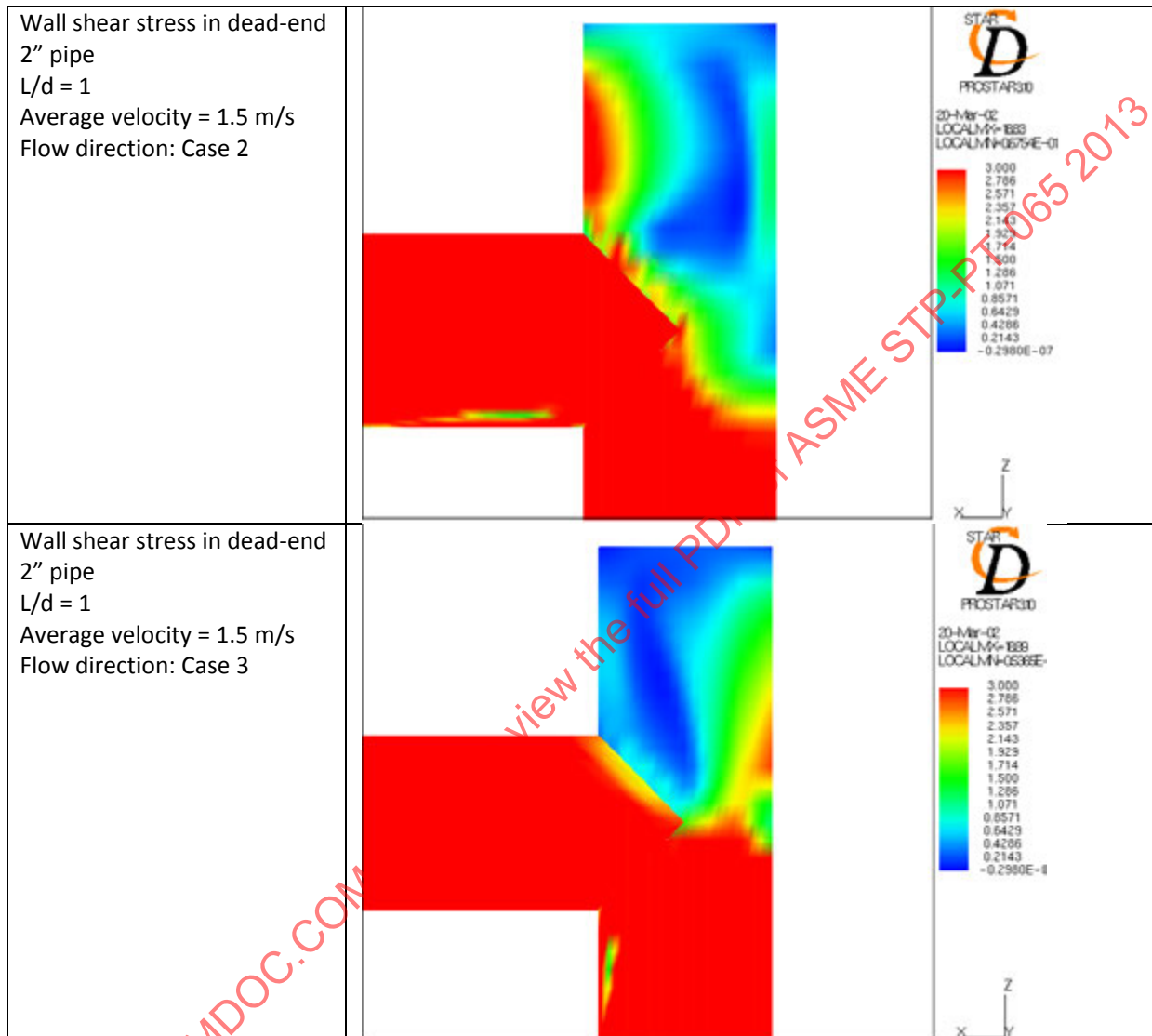
Observations:

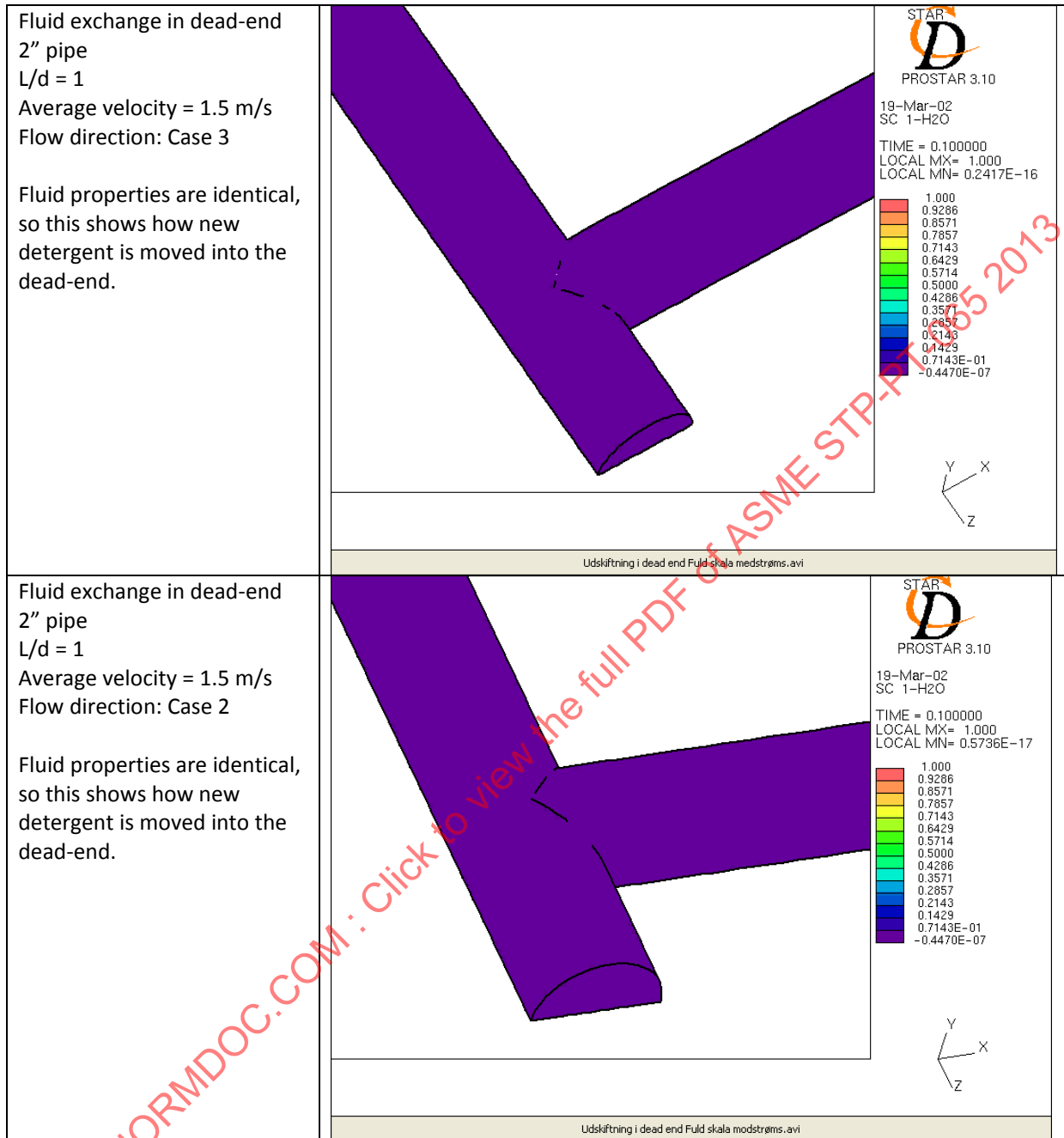
- For Case 1 and 3 there is a primary and a secondary recirculation zone when L/D is 2.5. This is not the case for Case 2.
- For L/D = 1.5 there is only a primary recirculation zone in all cases.
- Difficult to see if there is a difference between $\varnothing 50$ and $\varnothing 75$

Similar movies have been made på by APV. I think it is called "Clean around the bend". I have a copy of this on VHS tape.

CFD work by Jensen

As part of my work at the Univeristy I did some numerical work on different dead-ends design and configurations. Below is show some of the results achieved in these CFD studies





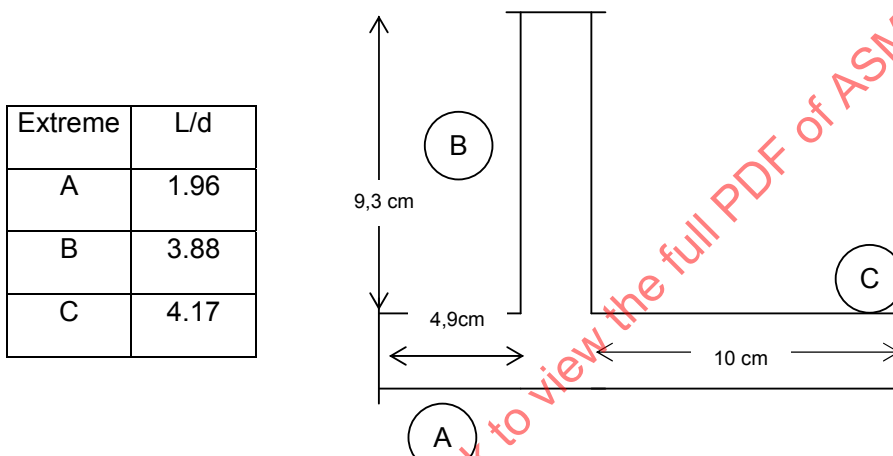
Also we did some work looking at what happens to the flow field and wall shear stress inside an dead-end when pulsating the inlet flow. The work was done on a $\varnothing 50$ mm pipe dead-end case 1 system with L/d of 1. Experimental work was done by smearing mustard onto the surfaces in the dead-end and the cleaning was monitored visually as a function of time. This shows that cleaning in the dead-end takes longest time in the corner where the dead-end wall and end cap meets and also in an area on both sides of the dead-end wall. This area can be predicted slow to clean from the CFD predictions of the wall shear stress distribution on the dead-end walls (see movies in PPT file – “flow in dead-end.ppt”).

Experiemental work by Jensen

As part of my work at the University I did some experimental work on flows in dead-ends. Below is show some of the results.

As student of mine did a lot of experiements, but I must admit that the work was never finally concluded upon. The most interesting test performed compared to that of Grasshoff, was the insertion of a flow diverter to force flow into dead-end.

Plexiglas dead-end, and depending on the pipe connections, different dead-end lengths can be obtained (see table).



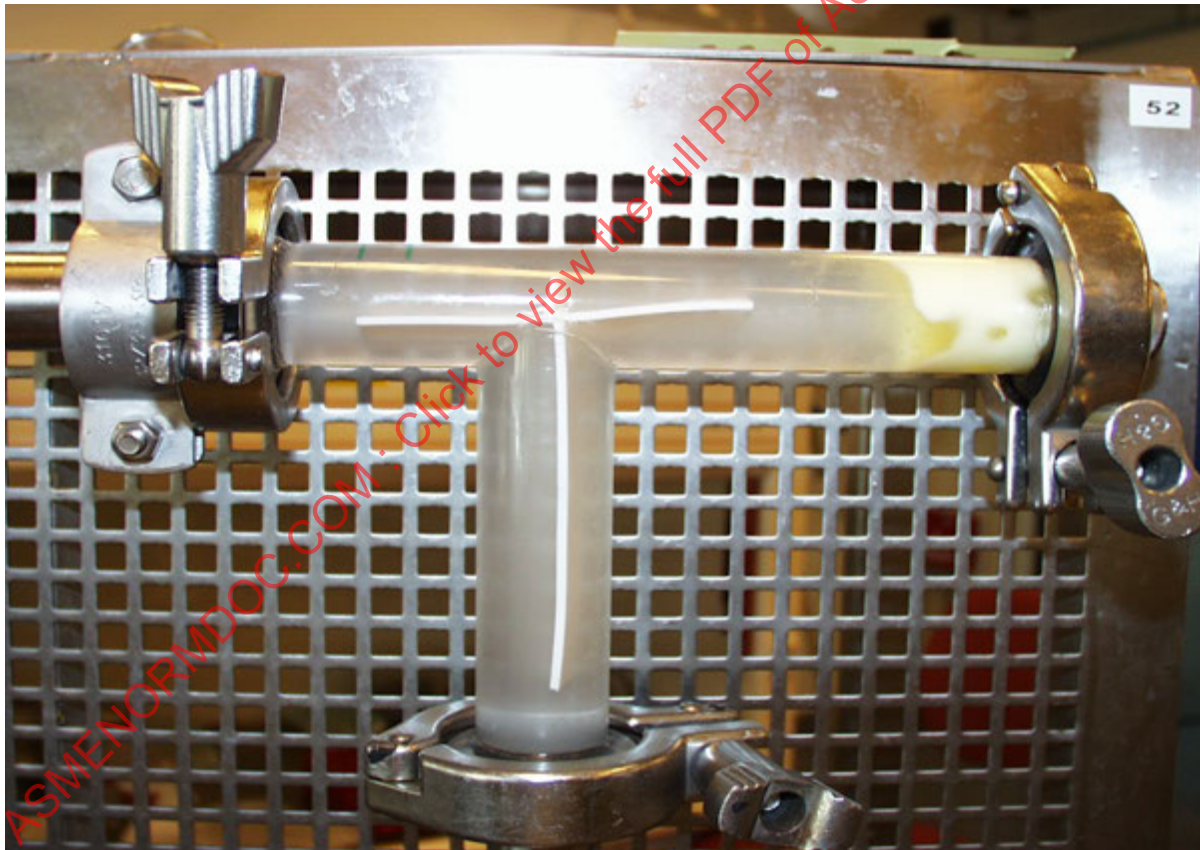
The dead-end was filled with salt and then cleaned out using cold water. The flow rate of 1500 l/h corresponds to 1 m/s.

Results for a dead-end system without flow diverter:

Date	Product	Flow (l/h)	Flow diverter	Flow case	Dead end	Removal time (min)	Observations
24/04/01	Salt	1500	N	2	A	1:31	Salt forming aggregates
24/04/01	Salt	1500	N	2	A	1:25	Salt in powder
24/04/01	Salt	1500	N	2	A		Not recorded
24/04/01	Salt	1500	N	3	A	10	Still something left
24/04/01	Salt	1500	N	3	A	-	
24/04/01	Salt	1500	N	2	C	7:45	Still something left

03/05/01	Salt	1500	N	2	C	18	Still something left
03/05/01	Salt	1500	N	3	C	30	Still something left
31/05/01	Salt	1500	Y	3	A	-	Dead end not completely filled. Not useful.
31/05/01	Salt	1500	Y	3	A	3 sec.	Instantaneously removed
31/05/01	Salt	1500	Y	3	C	32 sec	(see (1))

This shows a large difference in the cleaning time for an $L/d = 2$ if the flow is case 2 or case 3. Also a large increase in removal time is seen going to the large $L/d = 4.2$. Also it shows that there is a potential of inserting a flow diverter into the flow. This is only possibility if this flow diverter can be mounted and constructed in a hygienically designed way.



Except from the salt removal trails there was several other experiments comparing with and without flow diverter using other products as well. The results of these are collected in the table below.

Date	Product	Flow (l/h)	Flow diverter	Flow direction	Dead end	Removal time (min)	Temp (°C)		Observations
							Init	final	
19/06/01	butter	1500	N	L	Long (C)	10	58	69	Air-oil bubble
19/06/01	butter	1500	Y	L	Long (C)	1	71	70	Air-oil bubble
19/06/01	butter	1500	Y	R	Long (C)	1:10	54	56	
19/06/01	butter	1500	N	R	Long (C)	3	56,6		Air-oil bubble

Date	Product	Flow (l/h)	Flow diverter	Flow direction	Dead end	Removal time	Temp (°C)		Observations
							Init	final	
20/06/01	mustard	1500	N	R	Long (C)	3 min 6 min empty Q = 2200	59,5	70	Stop removing Still the same No effect Some more cleaning
20/06/01	mustard	1500	Y	R	Long (C)	16 sec	53	70	Completely cleaned
20/06/01	mustard	1500	Y	L	Long (C)	1:30 min 2:30 min (Q = 2200)	54	56	Almost all out More removed Something left
20/06/01	mustard	1500	N	L	Long (C)	5 min 7 min (Q = 2200) 12 min	55,1		Only L/2 removed More removal No more removal

Testing to Determine Flowrates Required to Flood Piping

06 June 2011

Jeff J. Gaerke P.E.

Abstract

This report documents the results of a study to determine the flowrates required to flood¹ piping ranging from 0.5 to 4 inches in diameter with water. Flooding flowrates were determined for piping installed in both a horizontal and vertical orientation. The impact that outlet type, pipe slope, pump type, water temperature, and back pressure had on the flooding flowrate was evaluated. Data was also collected on liquid heights in horizontal piping at different points along the length of the piping for flowrates less than the flooding flowrate. Empirical equations, based on the inside diameter of the piping, were generated from the test results and can be used to determine the flooding flowrate of piping under a variety of installation conditions and outlet types.

Keywords

Flooding flowrate, liquid height, CIP

¹ Note: the definition of “flood” is dependent upon the pipe orientation. This is defined later in this document.

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1. INTRODUCTION

A study was performed to determine the flowrates required to flood piping ranging from 0.5 to 4 inches in diameter with water. Flooding flowrates were determined for piping installed in a horizontal, downward sloped, and vertical orientation. The impact that water temperature, pipe slope, pump type, and back pressure had on the flooding flowrate was evaluated. Data was also collected on liquid heights in horizontal piping at different points along the length of the piping for flowrates less than the flooding flowrate.

2. THE TEST SETUP

This section contains a description of the pumping skid and piping configuration used to perform the testing.

2.1. DESCRIPTION OF CIRCULATING PUMPING SKID AND COMPONENTS USED FOR TESTING

A schematic of the testing arrangement follows as Figure 1 and a picture of the test arrangement follows as Figure 2:

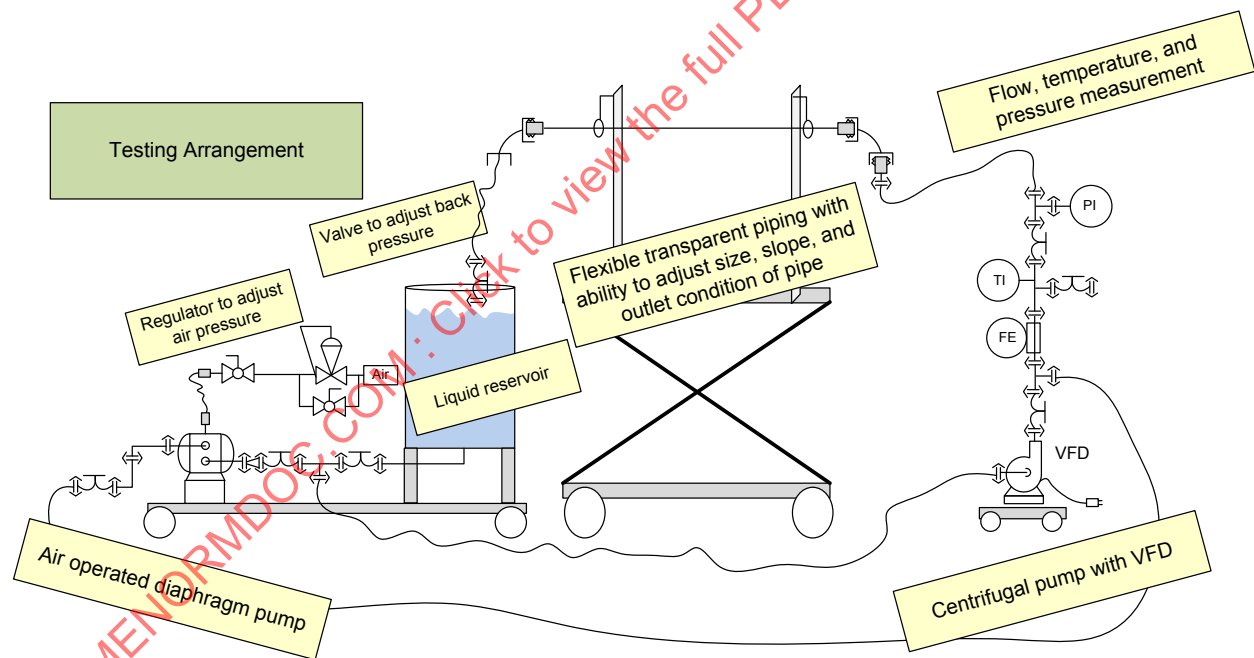


Figure 1 - Schematic of testing arrangement

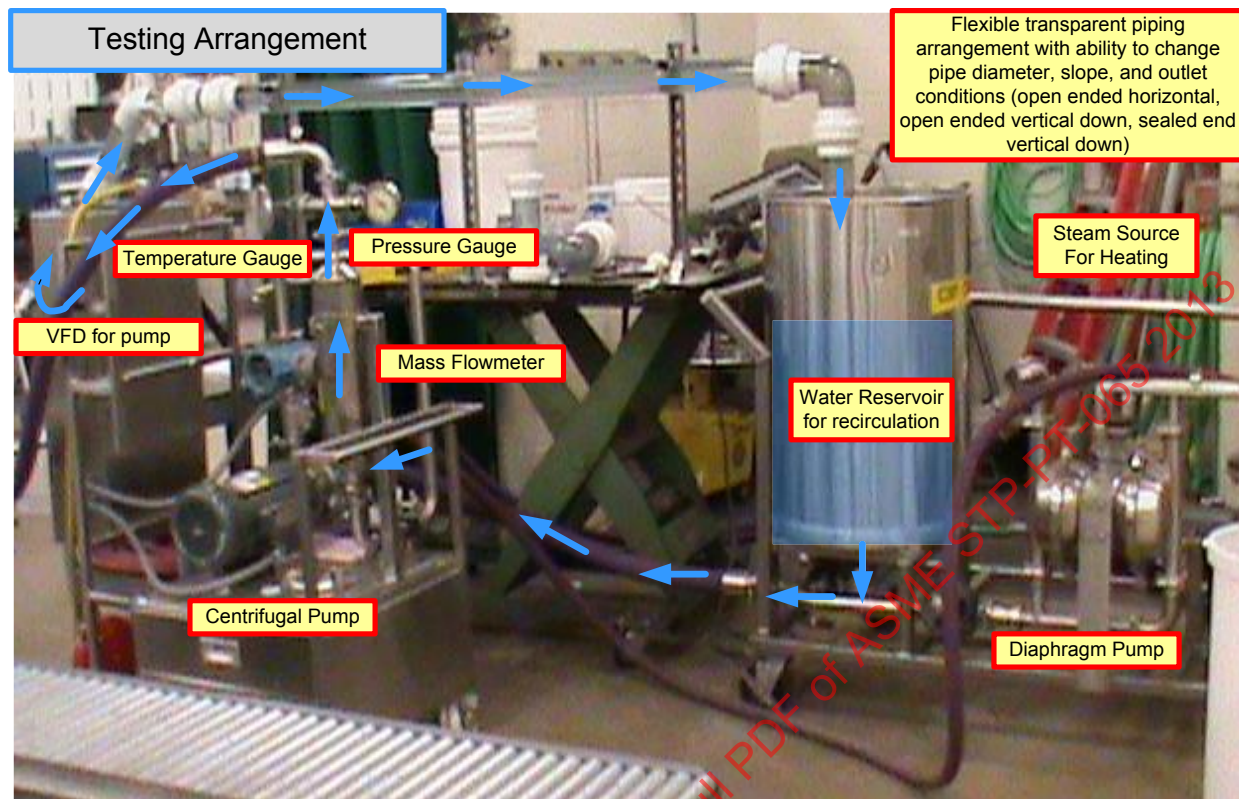


Figure 2 - Picture of test setup

2.1.1. General flow path

A quantity of water added to a 200 L drum serves as the liquid reservoir. Water that flows out of the bottom of this drum is directed to a pump which provides the driving force to move the liquid at the desired flowrate through a mass flowmeter, a temperature gauge, and a pressure gauge. Flexhoses are used to direct the fluid to the inlet of the transparent pipe being evaluated. Water flows through the transparent piping and is directed back to the liquid reservoir where it is recirculated.

2.1.2. Listing of major components used in testing skid

- Waukesha Cherry Burrell centrifugal pump, model 220 66LV – serial #3185020
 - Note: this centrifugal pump is equipped with a variable frequency drive (VFD) used to control the speed of the motor. The VFD is programmed with a “soft start” feature to ramp up the speed from being off to the desired speed setpoint over approximately 5 seconds.
- Murzan air operated diaphragm pump –model # P150SL, serial #9401 1865.
- Micromotion mass flowmeter – model # T100T6738CAUEZZZZ, serial #907723, calibration date = 9/13/10.
- Ashcroft pressure gauge, 0-160 psig, calibration date = 9/13/10.
- Ashcroft temperature gauge, 0-200° C, calibration date = 9/13/10.

2.1.3. Selection of piping components used for testing

Hygienic pharmaceutical process piping is typically fabricated from stainless steel tubing rather than piping. One difference between tubing and piping is the inside diameter (ID) dimension. The nominal size for tubing refers to the outside diameter (OD) dimension. As an example, 2" 16 gauge tubing has an outside diameter of 2" and a wall thickness of 0.065", which results in an inside diameter of 1.87". The transparent PVC piping and components used for testing were available as schedule 40 or schedule 80 piping (not available in tubing ID dimensions). The schedule of the piping refers to the wall thickness (schedule 80 piping and components have a greater wall thickness than schedule 40 components). The outside diameter of schedule 40 and 80 piping is the same, but it is not the same as the nominal pipe size. As an example, 2" piping has an OD of 2.375" and the ID is dependent upon the schedule of the piping purchased. For nominal 2" piping, the ID is 2.07" for schedule 40 components and 1.94" for schedule 80 components. When selecting the clear PVC piping for this testing, the piping schedule that resulted in an ID as close as possible to that of commonly used tubing sizes was chosen. The piping and unions used in the testing were available in both schedule 40 and schedule 80, but the 90° elbows were only available as schedule 40. In some cases this resulted in schedule 40 clear PVC 90° elbows being connected to schedule 80 clear PVC pipe. In this document, when an inside diameter is listed, it refers to the ID of the *piping* used in the testing unless otherwise noted. Table 1 lists the pipe schedule and dimensions of the PVC piping components purchased for the testing.

Component	Nominal Size		Piping Schedule	Wall Thickness		Outside Diameter		Inside Diameter	
	(Inch)	(mm)		(Inch)	(mm)	(Inch)	(mm)	(Inch)	(mm)
Elbow 90 deg	4	101.6	40	0.24	6.02	4.50	114.30	4.03	102.26
Pipe	4	101.6	40	0.24	6.02	4.50	114.30	4.03	102.26
Union	4	101.6	40	0.24	6.02	4.50	114.30	4.03	102.26
Elbow 90 deg	3	76.2	40	0.22	5.49	3.50	88.90	3.07	77.93
Pipe	3	76.2	40	0.22	5.49	3.50	88.90	3.07	77.93
Union	3	76.2	40	0.22	5.49	3.50	88.90	3.07	77.93
Elbow 90 deg	2	50.8	40	0.15	3.91	2.38	60.33	2.07	52.50
Pipe	2	50.8	80	0.22	5.54	2.38	60.33	1.94	49.25
Union	2	50.8	80	0.22	5.54	2.38	60.33	1.94	49.25
Elbow 90 deg	1.5	38.1	40	0.15	3.68	1.90	48.26	1.61	40.89
Pipe	1.5	38.1	80	0.20	5.08	1.90	48.26	1.50	38.10
Union	1.5	38.1	80	0.20	5.08	1.90	48.26	1.50	38.10
Elbow 90 deg	1	25.4	40	0.13	3.38	1.32	33.40	1.05	26.64
Pipe	1	25.4	80	0.18	4.55	1.32	33.40	0.96	24.31
Union	1	25.4	80	0.18	4.55	1.32	33.40	0.96	24.31
Elbow 90 deg	0.75	19.1	40	0.11	2.87	1.05	26.67	0.82	20.93
Pipe	0.75	19.1	80	0.15	3.91	1.05	26.67	0.74	18.85
Union	0.75	19.1	80	0.15	3.91	1.05	26.67	0.74	18.85
Elbow 90 deg	0.375	9.5	40	0.09	2.31	0.68	17.15	0.49	12.52
Pipe	0.375	9.5	80	0.13	3.20	0.68	17.15	0.42	10.74
Union	0.375	9.5	80	0.13	3.20	0.68	17.15	0.42	10.74

Table 1 – Pipe schedule and dimensions of components tested.

2.1.4. Data collected

Visual observations, and where applicable liquid heights, were recorded on the water passing through the transparent piping. Flowrate, temperature, and pressure data were recorded where applicable. All observations, measurement data collected, and calibration information on the instruments used are documented in Laboratory Notebook number 18960 pages 1-78. “Unique test numbers” listed throughout this document refer to individual tests documented in the laboratory notebook.

2.1.5. Variables evaluated

The flexible test setup allowed for the evaluation of the following variables associated with pipe flooding flowrates.

Pipe diameter

Several pipe sizes were evaluated. Nominal pipe diameters ranged from 3/8" to 4".

Distance from outlet of the 6 foot horizontal spool piece

Liquid heights within the piping were taken at different distances from the outlet of the 6 foot horizontal spool piece.

Pipe outlet condition

Three different pipe outlet conditions were tested as follows:

- “Open end horizontal outlet” – is defined as nothing added to outlet of horizontal 6 foot spool piece of piping. Water freefalls from outlet of horizontal piping.
- “Open end vertical outlet” – is defined as a 90° elbow is connected to the outlet of the horizontal 6 foot spool piece, and a 12 inch spool piece is connected to the 90° elbow directed downward. A 6 inch air gap is maintained between the outlet of the vertical spool piece and the liquid level in the drum.
- “Sealed end vertical outlet” – is defined as a 90° elbow is connected to the outlet of the horizontal 6 foot spool piece, and a 24 inch spool piece is connected to the 90° elbow directed downward. The end of the 24 inch spool piece is submersed 6 inches in the water in the drum, sealing the outlet.

Pipe slope

0% (no slope or horizontal), 5% upward, and 5% downward slope were evaluated on a 6 foot spool piece of transparent piping mounted horizontally. The piping was also evaluated in the vertical orientation. The outlet piping was evaluated when installed vertically straight up and down, and at angles of 30°, 45°, and 60° as measured from the horizontal (0° being horizontal).

Water temperature

Several temperatures were evaluated: ambient temperature (approximately 20°C) and hotter temperatures at 60-70°C.

Pump type

Two different pumps were evaluated: a centrifugal pump which provides a consistent flow (without pulsations) and an air operated diaphragm pump which delivers pulsating flow.

Backpressure

The impact that increasing the backpressure has on the flooding flowrate was evaluated. Testing was performed with essentially zero backpressure and with 30 psig backpressure.

2.2. TEST PLAN

Due to the large number of variables to be tested, a small number of tests were performed on each pipe size, and then more extensive testing was performed on the 2" piping. It is assumed that the observations from the additional testing using the 2" piping also apply to the other piping sizes.

2.2.1. Testing performed on all pipe sizes evaluated

This section contains descriptions of the tests performed on each pipe size tested.

Determination of liquid height versus distance from pipe outlet

Liquid was supplied from the pumping skid to the transparent PVC pipe via flexhose. In connecting to the PVC pipe, the flexhose always came from a lower elevation, and the pipe size always transitioned gradually via reducers from the flexhose to the PVC pipe. The PVC piping was configured to include a 6 foot horizontal spool piece of transparent piping installed flat (0% slope – determined by a calibrated digital level) with an open end horizontal outlet (see Figure 3).

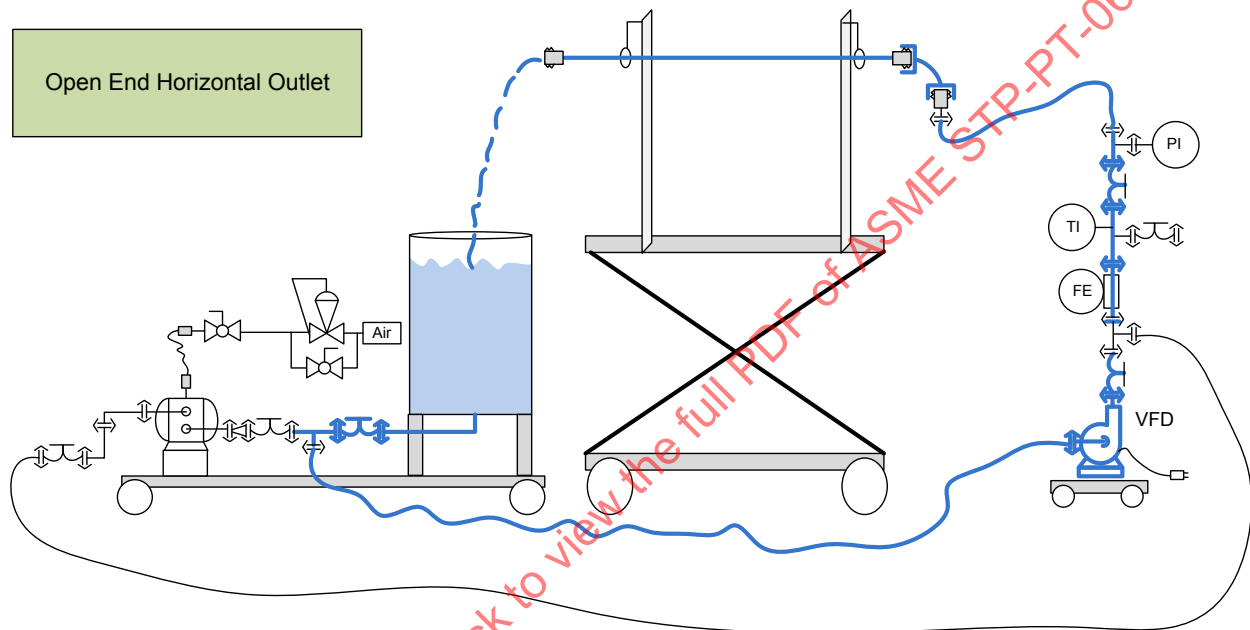


Figure 3 – Schematic of open end horizontal outlet

This testing was performed using the centrifugal pump. The flowrate of the water supplied to the PVC pipe was controlled by adjusting the speed of the pump via the VFD. This testing was performed using ambient temperature water. Liquid heights within the piping were measured at three distances from the outlet of the horizontal spool piece: 6 inches from the outlet, 36 inches from the outlet, and 66 inches from the outlet (see Figure 4).

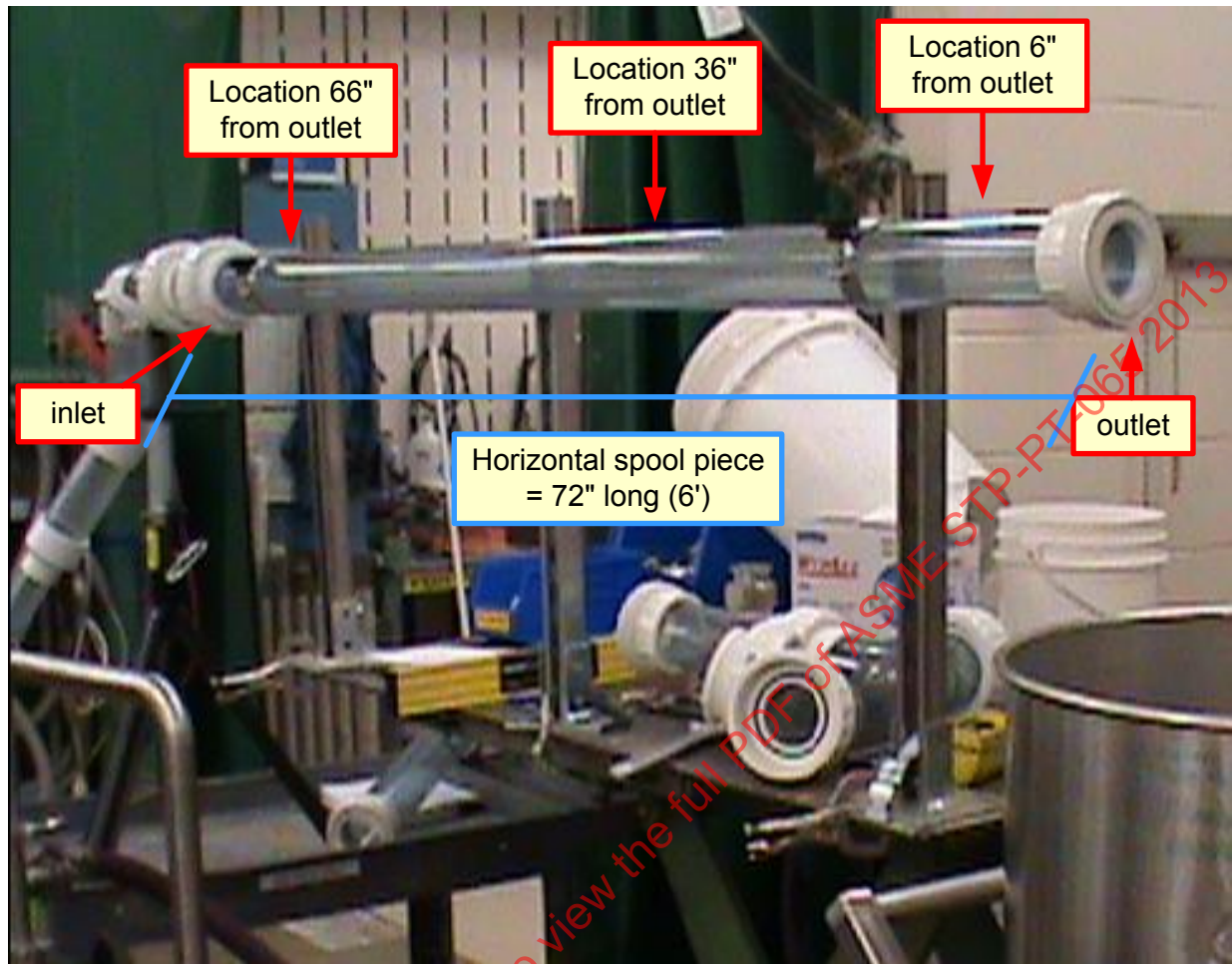


Figure 4 – Picture showing three locations where liquid height measurements were taken

Liquid height measurements were measured using a modified small square fitted with a bubble level and a ruler that measured in millimeters (see Figure 5).



Figure 5 – Picture of modified level used to measure liquid heights

To take height measurements, the square was placed at the required distance from the pipe outlet on the outside bottom of the transparent pipe, the square was leveled, and the liquid height measurement was recorded. The actual liquid height was later determined by subtracting the

wall thickness of the piping from the recorded liquid height. In some cases ripples were observed in the piping (see Figure 6).



Figure 6 – Picture of ripple

If a ripple occurred at the measurement location, the height of the liquid formed by the ripple was recorded (in some cases a peak and in other cases a valley).

Determination of flooding flowrate of 6 foot horizontal pipe open on end

Using the same setup described for determining the liquid heights at various distances from the pipe outlet, the flowrate required to flood a 6 foot open ended horizontal pipe was determined. The horizontal pipe was defined as “flooded” when all of the air was displaced from the pipe to a point no more than 6 inches from the outlet of the horizontal pipe within 60 seconds of starting the pump.

Note: the starting point was always a completely empty pipe with the pump off. Several different flowrates were quickly tested to determine the flowrate that would first flood the piping within the 60 second time period. Testing was then generally performed in triplicate, and results were recorded at this pump speed/flowrate.

Determination of flooding flowrate of 6 foot horizontal pipe with 12 inch vertical pipe open on end

The setup for this testing was similar to that described in determining the flooding flowrate of a 6 foot open ended horizontal pipe. The only differences are that a 90° clear PVC elbow was added to the horizontal 6 foot spool piece and a 12 inch spool piece was connected to the 90° elbow directed straight downward. A 6 inch air gap was maintained between the outlet of the vertical spool piece and the liquid level in the drum (see Figure 7).

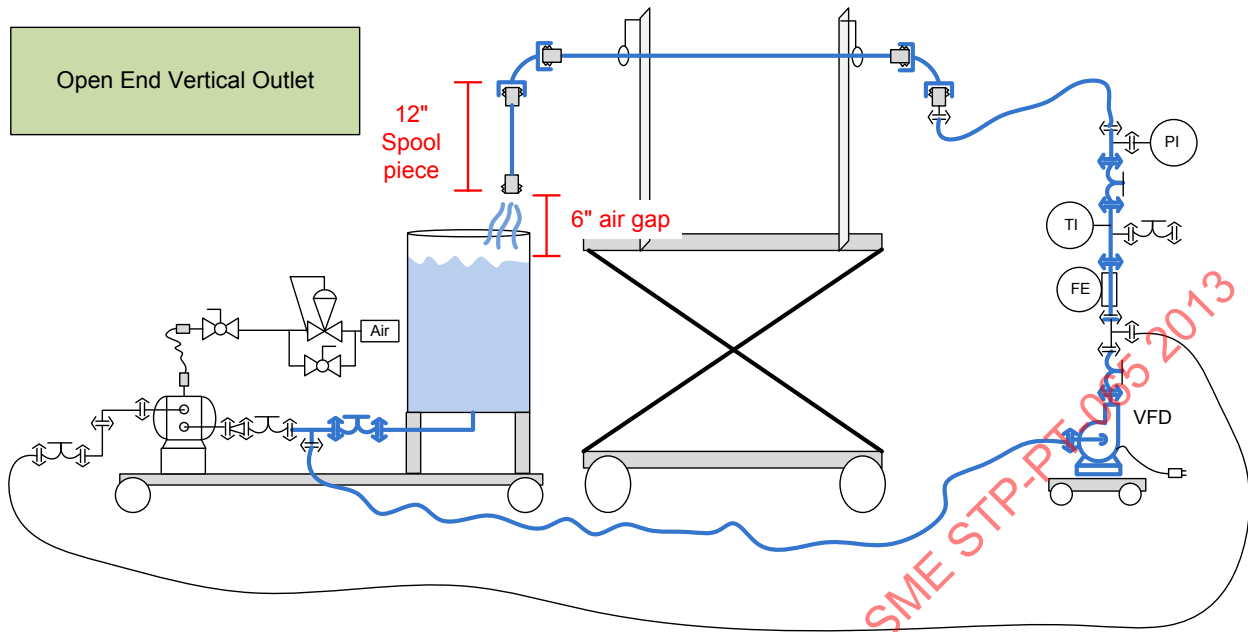


Figure 7 - Schematic of open end vertical outlet

The vertical pipe was defined as “flooded” when all of the air was displaced from the horizontal pipe, the 90° clear PVC elbow, and the vertical pipe (no air remained in the piping system).

Note: the starting point was always a completely empty pipe with the pump off. Several different flowrates were quickly tested to determine the flowrate that would first flood the piping within the 60 second time period. Testing was then generally performed in triplicate, and results were recorded at this pump speed/flowrate.

Determination of flooding flowrate of 6 foot horizontal pipe with 24 inch vertical pipe sealed on end

The setup for this testing was similar to that described in determining the flooding flowrate of a 12 inch open end vertical pipe. The only differences are that instead of using a 12 inch spool piece with a 6 inch air gap, a 24 inch spool piece was used and the end of the spool piece was submersed 6 inches in the water, sealing the end of the spool piece (see Figure 8).

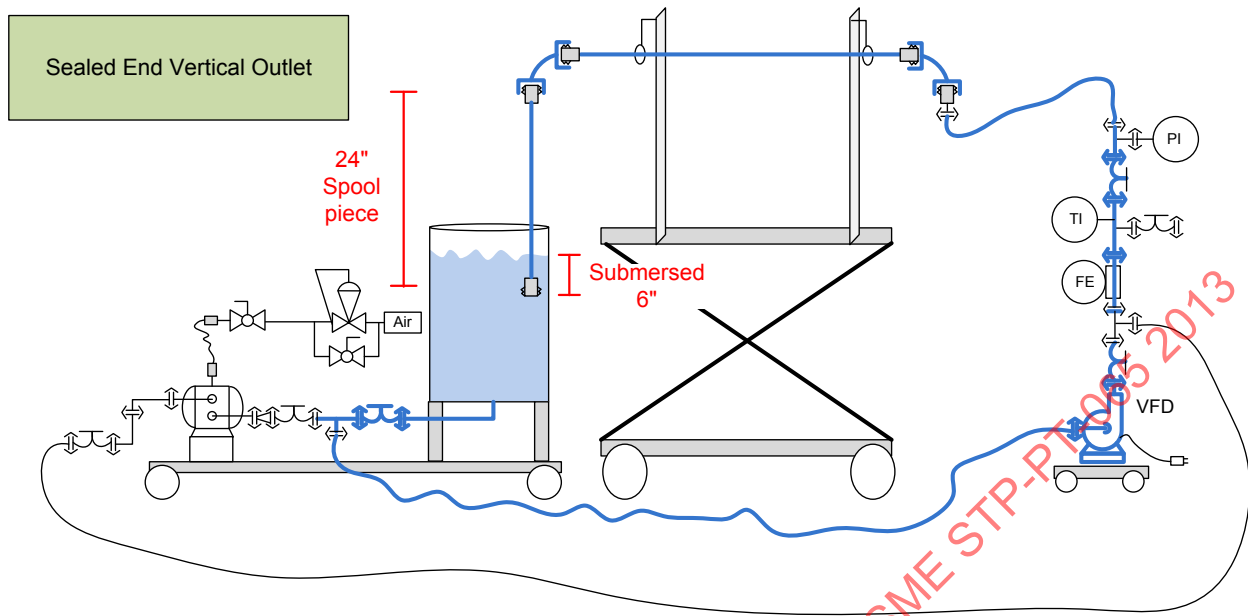


Figure 8 - Schematic of vertical pipe with sealed outlet

The vertical pipe was defined as “flooded” when all of the air was displaced from the horizontal pipe, the 90° clear PVC elbow, and the vertical pipe (no air remaining in the piping system).

Note: the starting point was always a completely empty pipe with the pump off. Several different flowrates were quickly tested to determine the flowrate that would first flood the piping within the 60 second time period. Testing was then generally performed in triplicate, and results were recorded at this pump speed/flowrate.

2.2.2. Additional testing performed only on 2" piping

Additional testing was performed on the 2" transparent piping as follows:

Pipe slope

In addition to testing with the 6 foot horizontal spool piece being installed completely horizontal (0% slope), testing was performed with all three pipe outlet conditions previously described with both a 5% upward and 5% downward slope on the 6 foot spool piece of transparent piping mounted in a horizontal plane.

The vertical piping was evaluated when installed straight up and down and at angles of 30°, 45°, and 60° as measured from the horizontal (0° being horizontal).

Water temperature

In addition to testing with ambient temperature water, testing was also performed with 60° C and 70° C water with all three outlet types previously described. The reservoir of water was heated by direct injecting steam into the drum of water while circulating.

Note: although this testing was only initially planned to be performed at 60° C with 2" piping, additional testing was performed on piping ranging in diameter from 3/8" to 4" at an elevated temperature of approximately 70° C. 70° C is a common temperature used in clean-in-place

(CIP) applications for cleaning piping, and this additional testing was performed to better understand the flowrates required to flood piping under typical CIP conditions.

Pump type

In addition to testing with a centrifugal pump, additional testing was performed using an air operated diaphragm pump. The purpose of this test was to determine the impact that the pulsating flow delivered by the diaphragm pump had on both the height of liquid in the pipe and the flooding flowrate as compared to that obtained from the consistent flow supplied by the centrifugal pump.

Backpressure

The impact that increasing the backpressure had on the flooding flowrate was also evaluated. Testing was performed with essentially zero backpressure and with 30 psig backpressure.

3. RESULTS AND DISCUSSION OF TESTING

3.1. RESULTS OF DETERMINATION OF LIQUID HEIGHT VERSUS DISTANCE FROM PIPE OUTLET

Table 2 lists the liquid height measurement within the pipe taken at three different distances from the outlet of the 6 foot horizontal pipe for different pipe sizes at various flowrates. The liquid height was measured from the outside bottom of the transparent pipe. The wall thickness of the piping was then subtracted from the measured values to determine the actual height of liquid inside the piping. These values were used in the liquid height graphs.

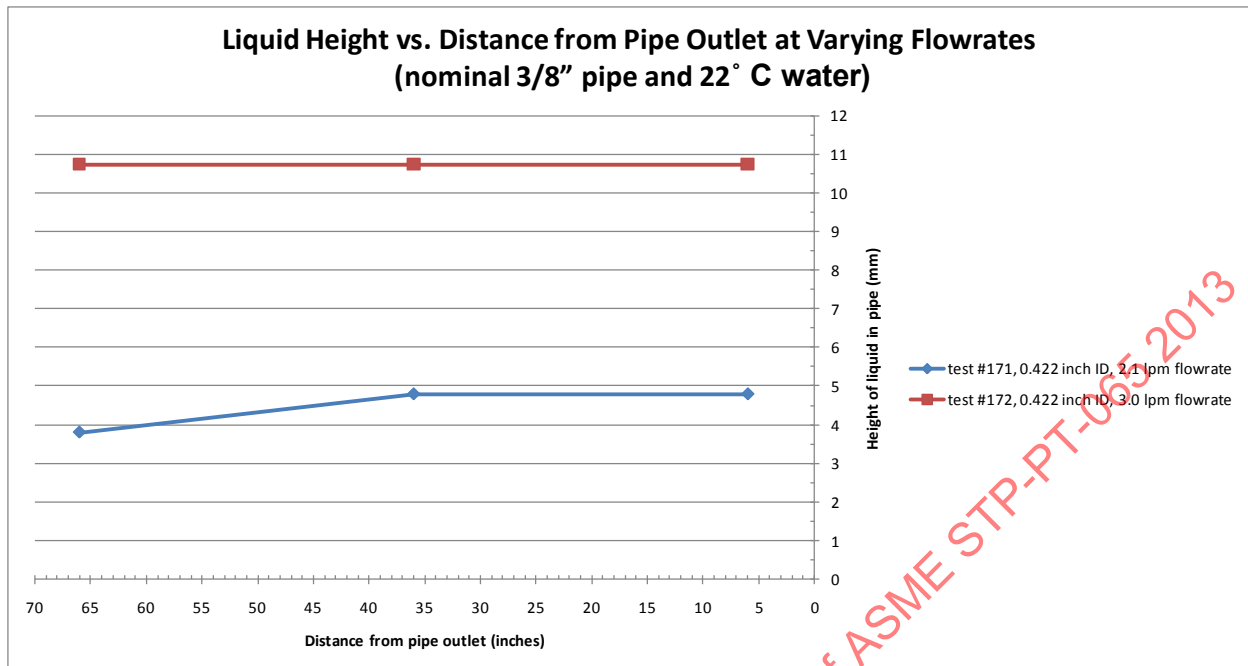
Graphs 1-6 indicate the liquid height versus location from the pipe outlet at different flowrates. These graphs were completed for nominal pipe diameters of 3/8", 3/4", 1", 1.5", 2" and 3". The values plotted are the liquid heights from the inside bottom of the pipe.

Data was also collected on 4" piping, but towards the end of testing, it was determined that the horizontal piping support had slipped and was no longer completely flat. Instead of a 0% slope, the piping was sloped 0.3% downward towards the outlet. Because of this the 4" liquid height data is not presented in this report.

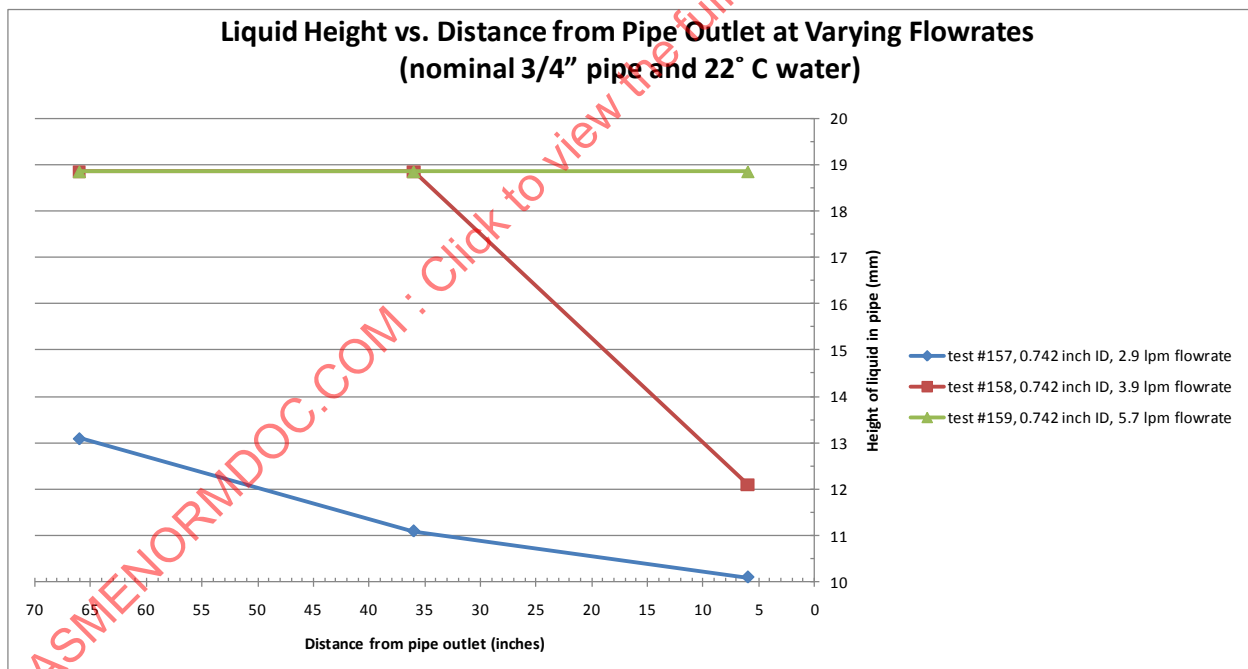
It should also be noted that the 3/8" and 3/4" transparent piping was not as rigid as the larger sizes tested. Because of this, it was difficult to install the 6 foot spool piece of piping completely flat. Additional supports were added, but it was still difficult to install the 6 foot length of piping without any bows/local low points in it. The presence of slight bows in the piping may have impacted the liquid heights measured in the 3/8" and 3/4" piping.

Unique # for Test Result	Nominal Pipe Size (in)	Pipe Schedule	Pipe ID (mm)	Pipe Wall Thickness (mm)	Water Temp (°C)	Flowrate (lpm)	Height from Outside Bottom of Pipe (mm)			Height from Inside Bottom of Pipe (mm)			Height from Outside Bottom of Pipe when Flooded (mm)
							66" from Outlet	36" from Outlet	6" from Outlet	66" from Outlet	36" from Outlet	6" from Outlet	
171	0.38	80	10.74	3.20	22	2.1	7	8	8	4	5	5	14
172	0.38	80	10.74	3.20	22	3.0	14	14	14	11	11	11	14
157	0.75	80	18.85	3.91	22	2.9	17	15	14	13	11	10	23
158	0.75	80	18.85	3.91	22	3.9	23	23	16	19	19	12	23
159	0.75	80	18.85	3.91	22	5.7	23	23	23	19	19	19	23
107	1.00	80	26.64	3.38	23	2.9	25	23	18	22	20	15	30
108	1.00	80	26.64	3.38	23	4.1	29	27	21	26	24	18	30
109	1.00	80	26.64	3.38	23	4.6	30	30	23	27	27	20	30
110	1.00	80	26.64	3.38	23	5.3	30	30	30	27	27	27	30
77	1.50	80	38.10	5.08	22	8.4	34	29	24	29	24	19	43
78	1.50	80	38.10	5.08	22	13.2	40	35	29	35	30	24	43
79	1.50	80	38.10	5.08	22	15.2	43	38	31	38	33	26	43
80	1.50	80	38.10	5.08	22	19.6	43	43	34	38	38	29	43
81	1.50	80	38.10	5.08	22	24.2	43	43	43	38	38	38	43
20	2.00	80	49.25	5.54	26	16.2	38	35	30	32	29	24	55
21	2.00	80	49.25	5.54	26	22.8	43	40	33	37	34	27	55
22	2.00	80	49.25	5.54	26	28.7	49	44	38	43	38	32	55
23	2.00	80	49.25	5.54	26	32.2	53	47	39	47	41	33	55
24	2.00	80	49.25	5.54	26	36.6	55	52	42	49	46	36	55
25	2.00	80	49.25	5.54	26	40.4	55	55	43	49	49	37	55
26	2.00	80	49.25	5.54	26	43.9	55	55	55	49	49	49	55
54	3.00	40	77.93	5.49	24	10.6	28	26	22	23	21	17	83
55	3.00	40	77.93	5.49	24	21.4	38	35	30	33	30	25	83
56	3.00	40	77.93	5.49	24	35.6	46	42	36	41	37	31	83
57	3.00	40	77.93	5.49	24	48.6	53	49	42	48	44	37	83
58	3.00	40	77.93	5.49	24	67.6	62	58	49	57	53	44	83
59	3.00	40	77.93	5.49	24	79.1	66	62	52	61	57	47	83
60	3.00	40	77.93	5.49	24	92.3	70	66	55	65	61	50	83
61	3.00	40	77.93	5.49	24	107.1	76	72	59	71	67	54	83
62	3.00	40	77.93	5.49	24	116.2	79	74	62	74	69	57	83
63	3.00	40	77.93	5.49	24	123.6	81	77	64	76	72	59	83
64	3.00	40	77.93	5.49	24	128.4	83	79	65	78	74	60	83
65	3.00	40	77.93	5.49	24	140.6	83	83	70	78	78	65	83
67	3.00	40	77.93	5.49	24	151.2	83	83	83	78	78	78	83

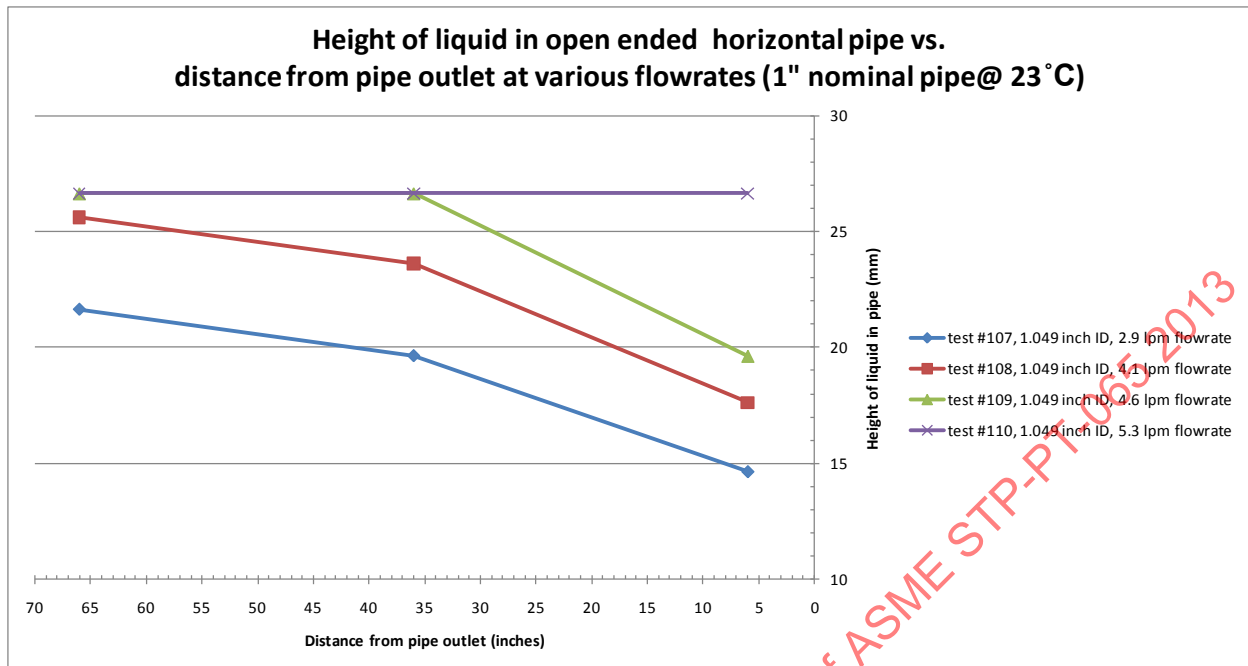
Table 2 – Liquid height test results at different locations from pipe outlet for various pipe diameters



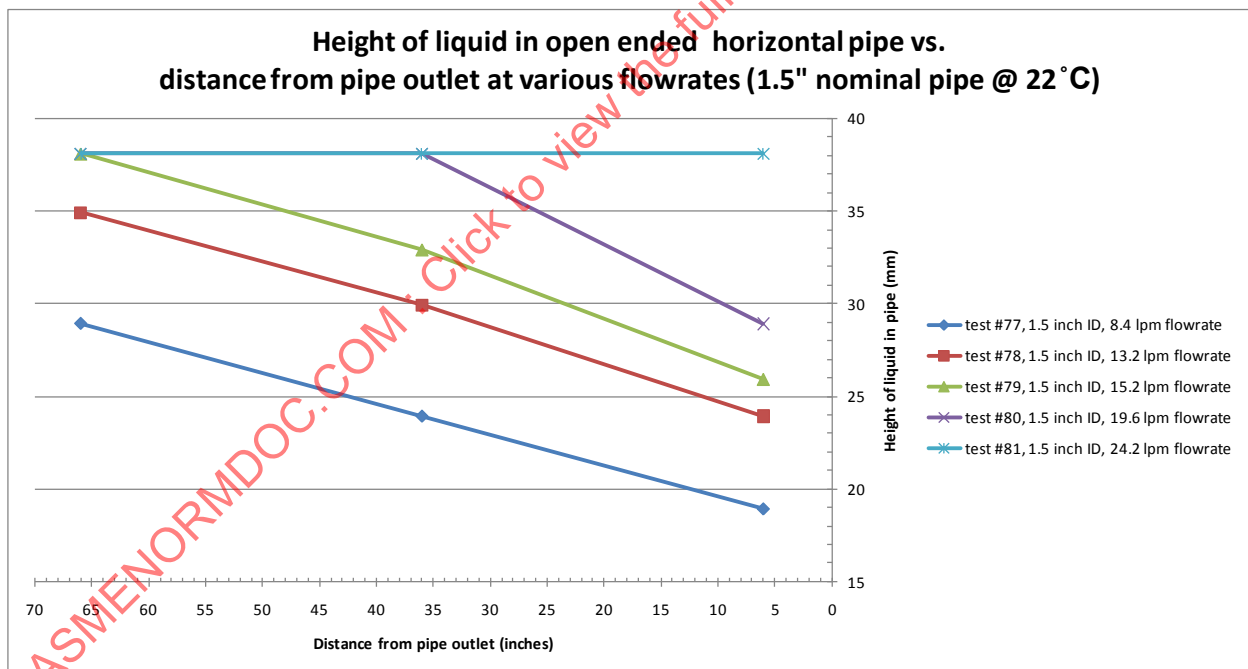
Graph 1 - Liquid height at different distances from pipe outlet for nominal 3/8" piping at various flowrates.



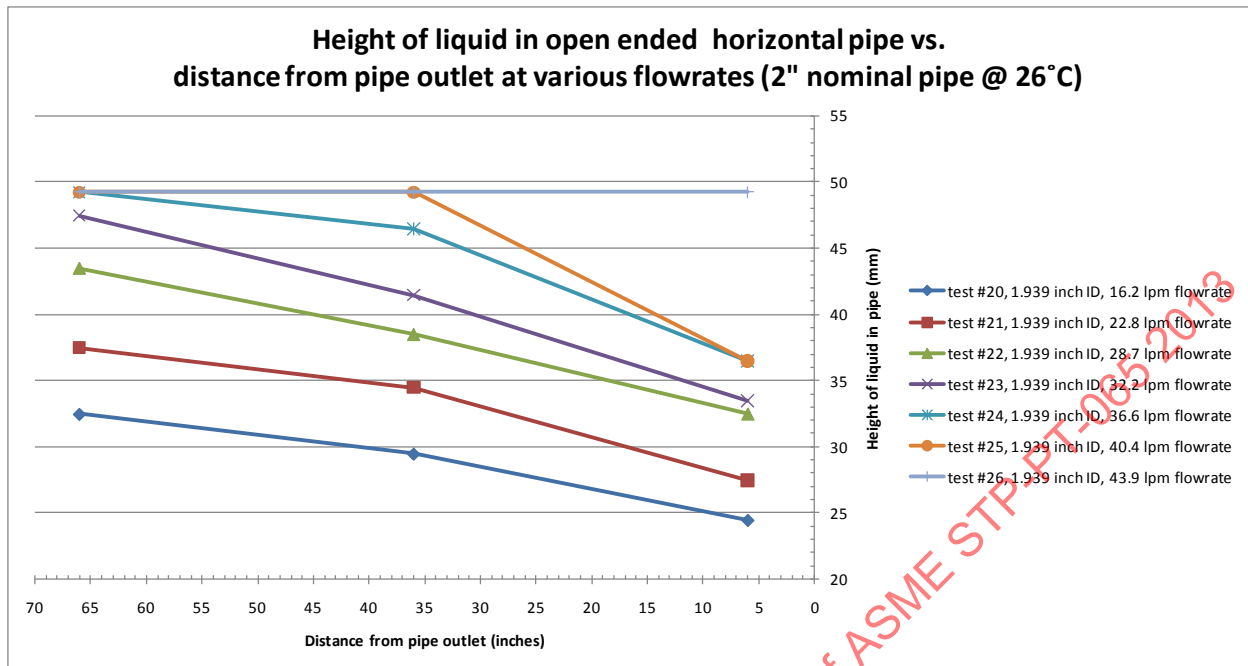
Graph 2 - Liquid height at different distances from pipe outlet for nominal 3/4" piping at various flowrates.



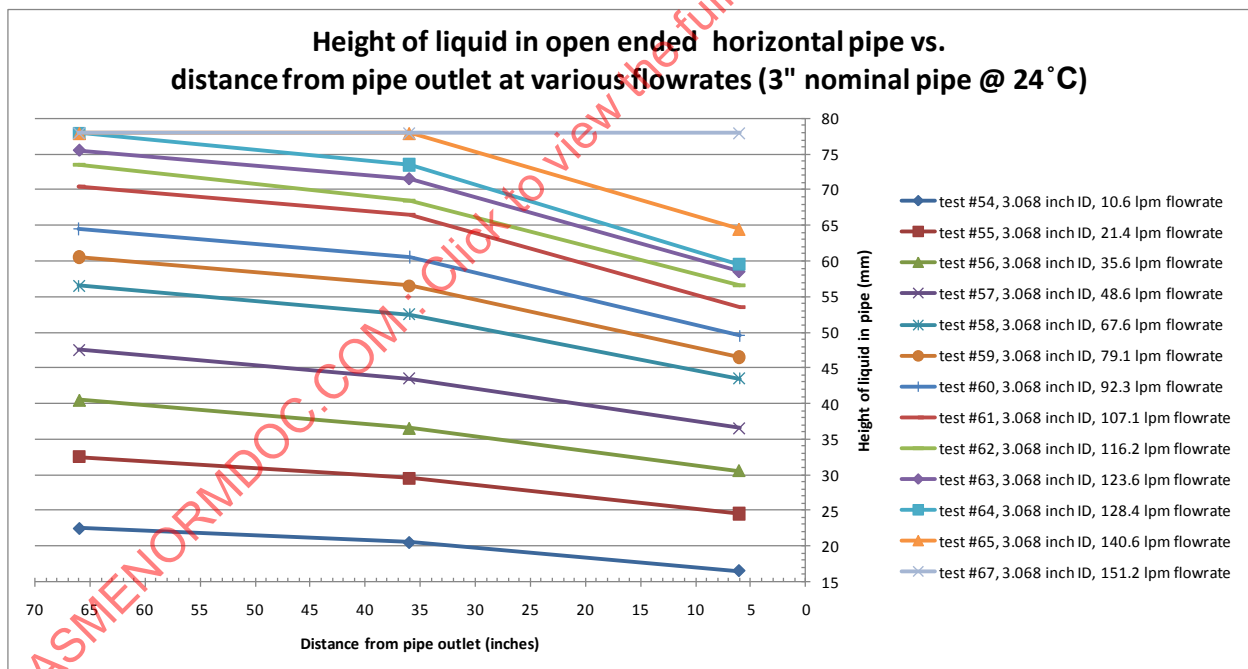
Graph 3 - Liquid height at different distances from pipe outlet for nominal 1" piping at various flowrates.



Graph 4 - Liquid height at different distances from pipe outlet for nominal 1.5" piping at various flowrates



Graph 5 - Liquid height at different distances from pipe outlet for nominal 2" piping at various flowrates.



Graph 6 - Liquid height at different distances from pipe outlet for nominal 3" piping at various flowrates.

3.2. DISCUSSION OF DETERMINATION OF LIQUID HEIGHT VERSUS DISTANCE FROM PIPE OUTLET

3.2.1. Discussion of liquid height versus flowrate

As the flowrate of liquid through the pipe increased, the height of liquid at the three locations measured also increased.

3.2.2. Discussion of liquid height versus distance from the pipe outlet

The height of the liquid at a given flowrate generally decreased as the distance from the pipe outlet decreased.

Note: this was not observed on the 3/8" testing. It is expected that this is due to the presence of a local low spot in the piping which impacted the liquid heights.

Within the 6 foot horizontal spool piece, the liquid height was generally lowest at the pipe outlet and highest at the location furthest from the outlet. Although measurements were only taken at 3 locations, a general trend observed from the liquid height versus distance from the pipe outlet graphs is that the slope of the line flattens as the distance from the pipe outlet increases.

3.3. RESULTS OF DETERMINATION OF FLOWRATE REQUIRED TO FLOOD A 6 FOOT HORIZONTAL PIPE OPEN ON END

Testing was performed with piping that ranged from 3/8" – 4" nominal pipe diameter. Data from this testing is included in Table 3.

Unique #'ers for Test Result	Nominal Pipe Size (inch)	Pipe Schedule	Pipe ID (inch)	Pipe ID (mm)	Water Temp (°C)	Flowrate Required to Flood Horizontal Piping (lpm)	Comment
172-174	0.38	80	0.42	10.74	22	3.0	Flowrate required to flood pipe may have been impacted by local low points due to sagging of the horizontal pipe.
159-161	0.75	80	0.74	18.85	22	5.7	
112-114	1.00	80	0.96	24.31	23	6.0	
81-83	1.50	80	1.50	38.10	22	24.2	
26	2.00	80	1.94	49.25	26	43.9	
187-189	3.00	40	3.07	77.93	23	158.0	
143-145	4.00	40	4.03	102.26	28	370.0	

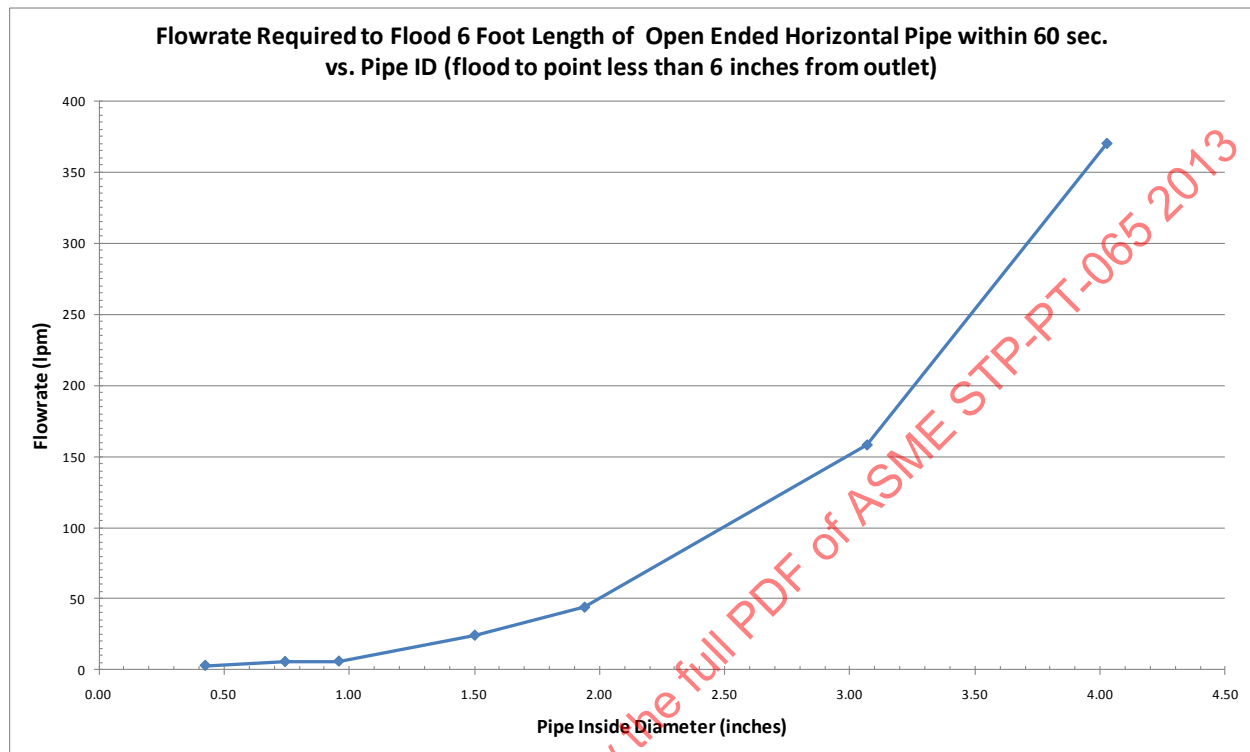
Table 3 - Test results of flowrate required to flood horizontal piping open on end

It was difficult to maintain 3/8" and 3/4" transparent piping completely horizontal due to the flexibility of this piping. Minor sagging in the piping between supports may have impacted the flowrates required to flood the piping.

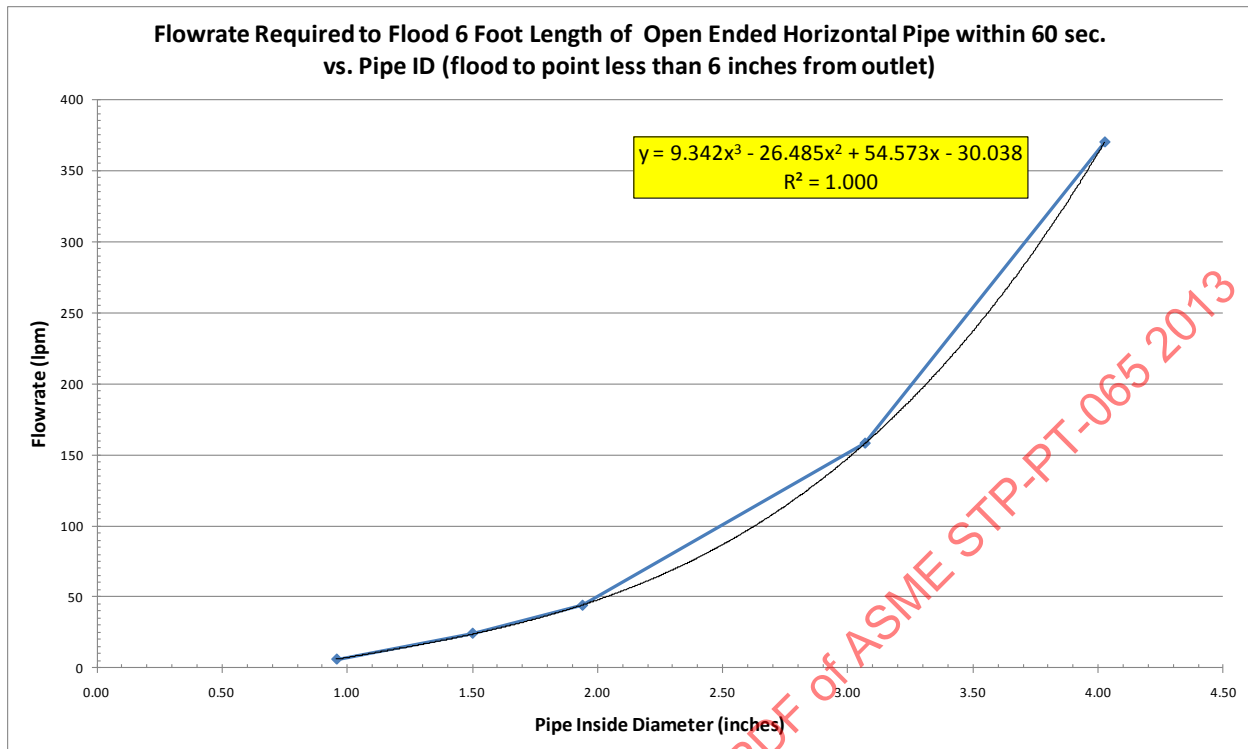
Graph 7 is a plot of the flowrate required to flood the piping with diameters ranging from a nominal 3/8" to 4".

Graph 8 is a similar plot, but the 3/8" and 3/4" data has been excluded (due to the challenges with maintaining the smaller diameter pipe completely horizontal without local low spots). A third order polynomial trend line has been added to this plot (third order polynomial chosen because

third order provided the best fit for the data). The listed R^2 value for the trendline indicates that the trendline is a good fit of the data.



Graph 7 – Flowrate required to flood horizontal piping open on end versus pipe ID



Graph 8 - Flowrate required to flood horizontal piping open on end versus pipe ID with trendline

3.4. DISCUSSION OF DETERMINATION OF FLOWRATE REQUIRED TO FLOOD A 6 FOOT HORIZONTAL PIPE OPEN ON END

Generally the horizontal piping would first flood at the point furthest from the outlet. Once the piping became flooded (liquid sealed) at a point in the piping, the portion of the piping that was liquid sealed would then slowly move towards the outlet - length of horizontal pipe is becoming more and more flooded over time - up to a point. If the flowrate wasn't high enough, only a portion of the pipe would be flooded (eg. first 36 inches). The variable frequency drive on the centrifugal pump allowed for fine adjustment of the water flowrate. In adjusting the water flowrate up and down, one could control the amount of the horizontal pipe that was flooded. As stated previously, the horizontal pipe was defined as "flooded" when all of the air was displaced from the pipe to a point no more than 6 inches from the outlet of the horizontal pipe within 60 seconds of starting the pump. As indicated in Figure 9, the height of liquid in the horizontal pipe drops off just prior to the outlet. This was particularly noticeable in the larger piping sizes tested (eg. nominal 3 and 4" piping). To completely flood the entire length of the piping (100% liquid filled at the point where the water was discharged from the pipe) required much higher flowrates and determining the flowrate at which the outlet was flooded was very subjective/difficult. Defining "flooding" as the point where all of the air was displaced from the pipe to a point no more than 6 inches from the outlet of the horizontal pipe removed this subjectivity.



Figure 9 – Picture indicating how liquid height drops off close to outlet of horizontal pipe

The equation of the trendline from Graph 8 can be used to estimate the flowrate required to flood a horizontal pipe within the range of inside diameters of approximately 1-4 inches. This is listed as Equation 1.

Equation 1

Legend

- Horizontal Pipe Flooding Flowrate = flowrate required to flood a horizontal pipe (lpm)
- x = pipe inside diameter (inches)

The graphs of liquid height versus distance from the pipe outlet indicate that the liquid height increases as the distance from the pipe outlet increases. The data suggests that the liquid height would be greater at locations further from the outlet in the longer pipe which would cause the pipe to become liquid sealed at somewhat reduced flowrates compared to the flowrate determined from the testing performed on the 6 foot spool piece. Once the pipe becomes sealed, the sealed flow then travels towards the pipe outlet. The speed at which the sealed flow travels towards the pipe outlet is dependent upon the flowrate. In defining the “flooding flowrate” as the flowrate required to completely flood 5.5 foot of horizontal piping within 60 seconds, the minimum velocity at which the sealed flow travels is at least 5.5 ft/min. The time required to move the sealed flow down the line to the outlet should be considered when determining the time required to completely flood a horizontal line. Based on the data, one would expect that a horizontal pipe longer than the 6 foot spool piece evaluated in this testing would also flood at the listed flooding flowrate but it might take longer than 60 seconds for the pipe to be flooded to a point 6 inches from the outlet.

3.5. RESULTS OF DETERMINATION OF FLOWRATE REQUIRED TO FLOOD A 6 FOOT HORIZONTAL PIPE WITH A ONE FOOT OPEN ENDED VERTICAL PIPE DIRECTED DOWNWARD

Testing was performed with piping that ranged from 3/8" – 4" nominal pipe diameter. The test skid was unable to deliver a flowrate high enough to flood the 4" pipe directed downward (the highest flowrate tested was 405 lpm). Data from the testing performed is included in Table 4.

Unique #ers for Test Result	Nominal Pipe Size (inch)	Piping			90° Elbow			Water Temp (°C)	Flowrate Required to Flood 1 Foot Vertical Pipe Directed Downward Open on End (lpm)	Comment
		Pipe Schedule	ID (inch)	ID (mm)	Pipe Schedule	ID (inch)	ID (mm)			
178-180	0.38	80	0.42	10.74	40	0.49	12.52	22	4.5	Exact flooding flowrate was a somewhat difficult to determine due to use of centrifugal pump and hydraulics of the system.
165-167	0.75	80	0.74	18.85	40	0.82	20.93	22	9.3	
119-121	1.00	80	0.96	24.31	40	1.05	26.64	23	12.3	
93-95	1.50	80	1.50	38.10	40	1.61	40.89	22	39.5	
32-34	2.00	80	1.94	49.25	40	2.07	52.50	25	102.7	
194-198	3.00	40	3.07	77.93	40	3.07	77.93	24	378.0	

Table 4 - Test results of flowrate required to flood vertical pipe directed downward open on end

A common observation with all pipe sizes tested was that the measured flowrate immediately increased to a new value when the open ended vertical pipe became completely liquid filled/flooded. This occurs with the test configuration due to the fact that the hydraulics of the system change when the vertical pipe becomes liquid filled. It was common to observe two flowrates during the testing, the initial lower flowrate was typically present for just under 60 seconds (before the vertical pipe became liquid filled), and then a higher flowrate was present after the vertical pipe became liquid filled. As an example, when testing the 2" schedule 80 pipe, the initial flowrate was 102.7 lpm until the vertical pipe became liquid filled; when the pipe was liquid filled the flowrate immediately jumped to 105.6 lpm.

At the flooding flowrate, the horizontal pipe would flood first, then the air would be displaced from the 90° elbow, and then the vertical pipe directed downward would become liquid filled.

Because the air was already displaced from the 90° elbow prior to the vertical pipe flooding, the flowrates recorded in the Table 4 and represented in Graph 9 as the flowrate required to flood the vertical pipe were the first lower values (this is the flowrate where the pipe flooded). When the vertical pipe becomes liquid filled, the liquid head/backpressure that the centrifugal pump is pumping against decreases which in turn causes an increase in the flowrate.

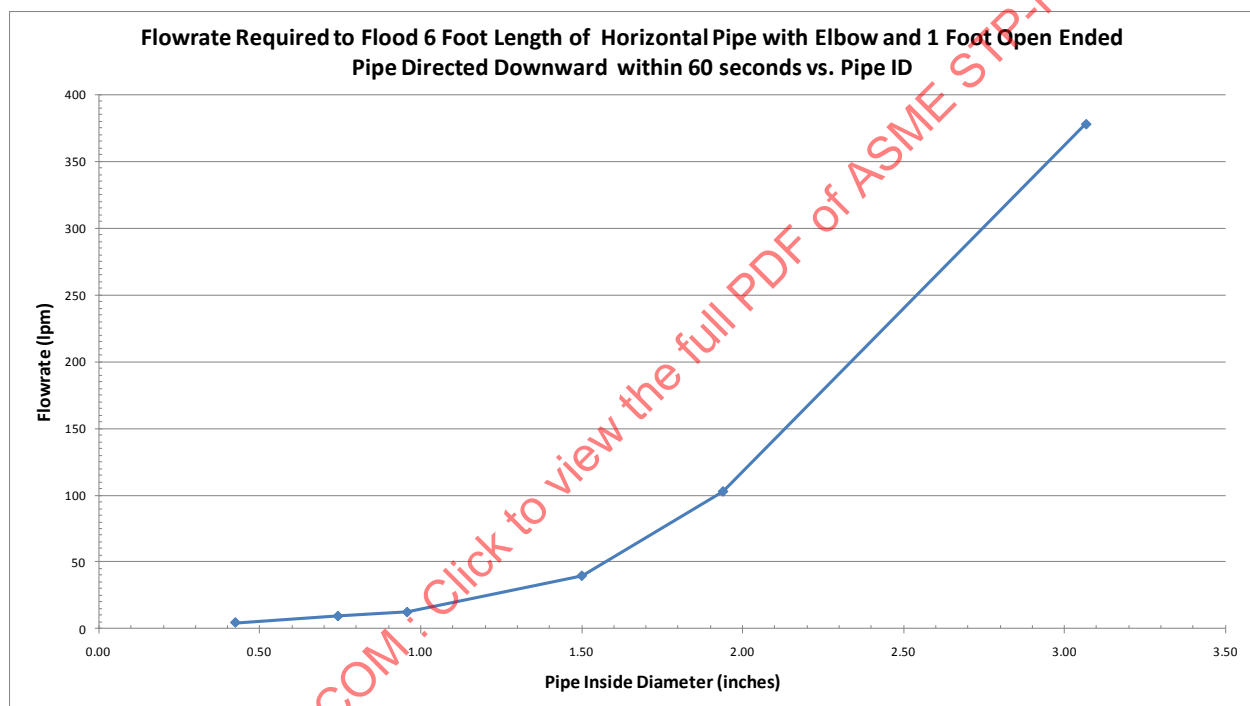
A common observation made in several instances is that once the vertical pipe was flooded, the flowrate could be reduced significantly while maintaining the vertical pipe in a flooded state. For example, after flooding the nominal 2" vertical piping, the flowrate was slowly reduced to as low as 34 lpm (less than half of the original flowrate required to flood the system) while still maintaining the system flooded. When the flowrate was reduced to 30 lpm, air entered into the system and the piping no longer remained flooded.

Due to the low operating speed of the centrifugal pump (controlled via the VFD) and the hydraulics of the system at the lower flowrates, the flooding flowrate values for the smaller 3/8"

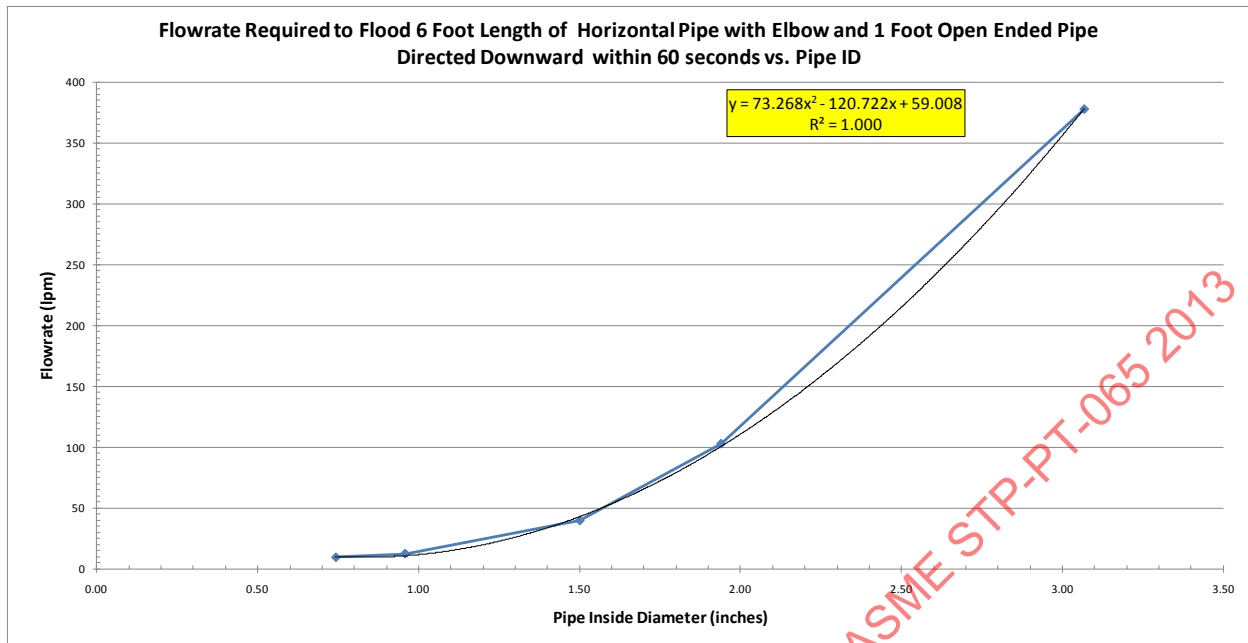
nominal piping were more erratic. The testing was performed in triplicate and the highest value was listed in Table 4. It is expected that the listed value represents a worse case flowrate for the nominal 3/8" piping. If additional testing is performed on smaller diameter piping, it may be beneficial to use a positive displacement style pump (eg. rotary lobe) with a smaller capacity so that the flow is not impacted as much by hydraulic changes.

Graph 9 is a plot of the flowrate required to flood piping with diameters ranging from a nominal 3/8" to 3".

Graph 10 is a similar plot, but the 3/8" data has been excluded (due to the more erratic flooding flowrates observed). A second order polynomial trend line has been added to this plot (second order polynomial chosen because second order provided the best fit for the data). The listed R^2 value for the trendline indicates that the trendline is a good fit of the data.



Graph 9 - Flowrate required to flood vertical piping open on end directed downward versus pipe ID



Graph 10 - Flowrate required to flood vertical piping open on end directed downward versus pipe ID with trendline

3.6. DISCUSSION OF DETERMINATION OF FLOWRATE REQUIRED TO FLOOD A 6 FOOT HORIZONTAL PIPE WITH A ONE FOOT OPEN ENDED VERTICAL PIPE DIRECTED DOWNWARD

As defined previously, the horizontal pipe with a 1 foot vertical open ended pipe directed downward was defined as “flooded” when all of the air was displaced from the horizontal pipe, the 90° elbow, and the vertical pipe directed downward within 60 seconds from the start of the pump.

At the flooding flowrate, the horizontal pipe would flood first, then the air would be displaced from the 90° elbow, and then the vertical pipe directed downward would become liquid filled.

More variability was observed in the time required for the open ended vertical pipe to become liquid filled as compared to the other tests that were performed. It was not uncommon for liquid to be flowing through the vertical pipe at the desired flowrate for more than 30 seconds before suddenly becoming liquid filled. Testing was performed in triplicate for each pipe size listed and in each case all piping was flooded an average of less than 60 seconds from starting the pump.

Once any portion of the vertical pipe became liquid filled, the whole line quickly became liquid filled (in approximately a second). Because of this observation, it is expected that little additional time would be required to flood a vertical pipe longer than the 1 foot spool piece evaluated in the testing at the flooding flowrate.

The equation of the trendline from Graph 10 can be used to estimate the flowrate required to flood a vertical open ended pipe within the range of inside diameters of approximately 0.75-3 inches. This is listed as Equation 2.

Equation 2

Legend:

- Open Ended Vertical Pipe Flooding Flowrate = flowrate required to flood a vertical pipe open on end directed downward (lpm)
- x = pipe inside diameter (inches)

3.7. RESULTS OF DETERMINATION OF FLOWRATE REQUIRED TO FLOOD A 6 FOOT HORIZONTAL PIPE WITH A TWO FOOT VERTICAL PIPE DIRECTED DOWNWARD THAT IS SEALED ON THE END

Testing was performed with piping that ranged from 3/8" – 4" nominal pipe diameter.

The test skid was unable to deliver a flowrate high enough to completely flood the 90° elbow in the test with the 4" pipe directed downward (the highest flowrate tested was 405 lpm). In the 4" test case, after 60 seconds both the horizontal pipe and vertical pipe were flooded, but an air bubble remained in the elbow.

In all cases testing began with the transparent piping drained and the pump off. When the pump started, water supplied to the system began to displace the air in the pipe. Because the end of the diptube was submersed 6 inches, bubbles from the displaced air were discharged into the water. With the pipe outlet submersed, there was no means for displaced air to be re-introduced back into the piping system. This was a significant difference between the open ended outlet and the sealed outlet.

As stated previously, the vertical pipe was defined as "flooded" when all of the air was displaced from the horizontal pipe, the 90° clear PVC elbow, and the vertical pipe. The testing determined the flowrate required to flood the system within 60 seconds of starting the pump. At the flowrates required to flood the piping in a 60 second time period, the horizontal portion of the piping flooded first, then the vertical piping flooded (liquid level started at the bottom of the vertical pipe and the liquid level increased from the bottom up), and then the last amount of air was displaced from the 90° clear PVC elbow.

When the liquid flowrate was sufficient to displace air from the vertical pipe, the volume of air displaced was replaced with water. This caused the liquid level in the submersed pipe to build up starting from the bottom of the pipe. As additional air was displaced, the liquid level in the vertical pipe continued to rise. The change in the vertical pipe liquid level impacted the hydraulics of the system which caused the flowrate to increase slowly (centrifugal pump running at a fixed speed throughout the test) as the vertical pipe became liquid filled. When the vertical portion of the pipe became completely liquid filled, but before the air was displaced from the 90° clear PVC elbow, the flowrate jumped up significantly (eg. when testing the 1" nominal pipe size, the flowrate immediately jumped from 6.0 lpm to 25.1 lpm) due to the hydraulics.

After the vertical portion of the pipe became liquid filled, a pocket of air remained at the top of the transparent 90° elbow. This remaining air was removed in small bubbles by the liquid flowing by. These bubbles were carried down the vertical pipe and discharged into the drum. This occurred until the last of the air was displaced from the 90° clear PVC elbow. As stated previously, the flowrate increased significantly when the last amount of air was displaced from the vertical portion of the pipe, but before the air was displaced from the 90° elbow. The air that remained in the 90° elbow after the vertical pipe was flooded was removed from liquid flowing