ABSTRACT

Title: CHARACTERIZATION OF THE MIL-F-24385F NOZZLE

Bryan Lawrence Hoskins, Master of Science, 2005

Directed By: Professor James A. Milke, Fire Protection Engineering

Aqueous Film Forming Foam has been a fire suppression agent in use for nearly forty years. During this period, there has been little emphasis on characterizing the flow from nozzles that have a throw of only a few meters. With environmental concerns starting to appear, it is important to understand how the foam behaves.

The research presented in this document attempts to quantify the mass flux and momentum of the foam. This was done using both experimental data and hand calculations. A range of nozzle angles were examined in an attempt to set bounds of the minimum and maximum expected values.

CHARACTERIZATION OF THE MIL-F-24385F NOZZLE

By

Bryan Lawrence Hoskins

Thesis submitted to the Faculty of the Graduate School of the University of Maryland, College Park, in partial fulfillment of the requirements for the degree of
Master of Science
2005

Advisory Committee:
Professor James A. Milke, chair
Dr. Brian Y. Lattimer
Professor André Marshall

Acknowledgements

I would like to acknowledge several people for their help on this project. Hughes Associates, Inc., provided the funding and lab space for this project. I am especially grateful for the help and guidance of Brian Lattimer and Alwin Kelley. I would also like to thank Professor Jim Milke for helping me through many of the problems that came up during the course of the research.

Table of Contents

List of Tables

List of Figures

Nomenclature

d	Drag coefficient
E	Expansion ratio
h	Height (m)
l	Length (m)
r	Radius (m)
Re	Reynolds number
t	Time (s)
u	Velocity in the x-direction (m/s)
v	Velocity in the y-direction (m/s)
V	Volume (m^3)
w	Velocity in the z-direction (m/s)
x	Distance or position (m) (e.g. width of grid)
y	Distance or position (m) (e.g. length of grid)
z	Distance or position (m) (e.g. height of nozzle)

Greek symbols

μ	Viscosity (N-s/m^2)
ρ	Density (kg/m^3)

Subscripts

a	Air
i	Initial
f	Final
f	Foam
l	Left side
o	Initial
r	Right side
w	Water

1 Introduction

Aqueous film-forming foam (AFFF) is a common suppression agent used for pool fires. The foam blankets the fuel surface and limits vapors from igniting. Also, the water content of the foam can somewhat cool the fire through its evaporation.

No research has been conducted to determine the properties of the foam jet for nozzles with throws of only a few meters[1]. However it is exactly this type of nozzle used in some approval standards of AFFF[2], as well as for other applications. As new formulations are developed, an understanding of how the foam jet applies foam to the fuel surface will enable companies to tailor their formulations to provide a foam with enhanced suppression capabilities.

The research covered in this document outlines the test series used to characterize one particular nozzle. Other nozzles will have foam jets that are similar, but not exactly the same, in behavior. The tests described in this document can be used as a basis for characterizing these nozzles with throws of only a few meters.

1.1 Forerunners of AFFF

The history of foam to fight fires dates back to the late part of the nineteenth century[3]. Sodium hydrogen carbonate and saponine with acidic aluminium sulphate were mixed to create a foam[3]. However this required two storage containers and was thus not as convenient as a single mixture would be. The foam was created through the chemical reaction rather than combining with air.

The first foam mixture not requiring the components to be stored separately prior to being used appeared in 1914. At this time, I. Stanzing and R. König developed a powder that could be mixed with water to produce foam[3]. This powder also relied on a chemical process, rather than mixing with air, to create the foam.

All of the early foam systems consisted of an acid, an alkaline, and a stabilizer that were stored in separate tanks and then piped into and mixed at the location where the foam was applied[4]. In the United States, these systems were principally manufactured by the Foamite Fire Foam Company[4].

The National Fire Protection Association first addressed the topic of foam for fire fighting in the 1921 version of *Standard on Protection of Fire Hazards Incident to the Use of Volatiles in Manufacturing Processe*[5]. This document was the forerunner of the current edition of NFPA 11. Thus, foam was being recognized in the early 1900's for the role it could play in suppression of fires.

By the middle of the 1930s, protein foam was in use[3]. Protein foam was the first to be aerated rather than chemical foam. It was the basis from which all future aerated foams would be designed. The protein foam was derived from organic materials, primarily hoof and horn meal[3]. The protein foam was found to be more effective than the chemical foams[3]. The aerated foam was out performing the traditional chemical foam, so more aerated foams were desired. The industry then started to search for new foam formulations.

1.2 Development of AFFF

In 1944, 3M acquired the patent rights to the forerunner of the electro-fluorination process. This is the process that enables the production of

AFFF. The potential application of this process to create foam for fire suppression was not immediately recognized. AFFF would not be invented for nearly two decades later[6]. The process needed to mature first.

After several years of research at 3M that yielded little success, a viable foam was created using electro-fluorination. One of the first products to stem from this research was Scotchgard in 1956. With successful products already developed, more were desired by 3M. Research continued to create additional products from the electro-flourination process.

In 1961, the Navy, in association with 3M, sought the fire fighting capabilities of fluorocarbon surfactants[6]. It had taken eighteen years since 3M purchased the patent for the electro-fluorination for the research on a fire fighting foam to begin. This joint research with the Navy led to the original formulation of AFFF[4,6]. The original concentrate was mixed with fresh water at a ratio of 25%[6]. The patent was issued to the Secretary of the Navy in 1966[6].

Since the development of AFFF was conducted in conjunction with the Navy, the first intended use was for the military. AFFF was designed to improve fire safety aboard aircraft carriers. There is a relatively small amount of fresh water available and one of the biggest risks comes from aircraft fires. An aircraft fire can consist of a pool fire beneath an airplane with the crew still onboard. A successful fire suppression agent needs to stop the spread of the fire as well as knock the fire down quickly. A foam agent, like AFFF, spreads across the fuel surface, limiting the fire spread and knocking down the fire. With these characteristics, less solution was needed than would have been the case if water alone had been applied to the surface. This smaller water usage was valuable in a location that had a limited supply of fresh water.

With the advent of AFFF, standardized tests were established to approve formulations. The United States military has used AFFF extensively and designed military specification (MILSPEC) MIL-F-23905 in 1963[7] to establish all requirements of foam concentrates used by the military. The current edition of the standard is MIL-F-24385F and is the version referenced in this paper. The MILSPEC standard specifies the packaging and labeling requirements as well as describing test procedures.

Approval standards have not been enough to prevent AFFF from facing its share of adversity. In the 1990s, environmental concerns started to appear with respect to components of the AFFF formulation. Several manufacturers, including 3M, reformulated their solutions to remove butyl carbitol, which was believed to be harmful[8]. This was just the beginning of the environmental problems that AFFF would face.

1.3 Need for Characterization

On May 16, 2000[9], 3M announced that they were pulling out of the AFFF market due to Environmental Protection Agency (EPA) concerns with respect to perfluoro-octane sulfonyl (PFOS). While the EPA did not ban PFOS, there were concerns that it was found to be persistent in the environment and slightly toxic[9]. PFOS is found in products aside from AFFF, including Scotchgard[9]. All 3M products containing PFOS were phased out by 2002[9]. Thus, production of the 3M concentrate containing PFOS has ceased.

AFFF was not dependent on PFOS in solution because other approved formulations existed on the market[9]. These products are produced by a process known as telomerization[9]. However 3M decided to withdraw from the market rather than reformulate and retest their product[9]. This created a void in the market as 3M had produced 65% of the AFFF in use[9].

The MILSPEC test required all AFFF formulations that were approved to be compatible with previously approved ones[2]. This enabled the government to mix old and new solutions if the supply contract changed from one vender to another. The foams that were not tested in accordance with the MILSPEC test did not have to be compatible with existing formulations[5]. With 3M leaving the market, many systems with the 3M products had to be completely redesigned for the replacement agents.

With the market now more open than it had been previously, new companies may try to get their formulations approved. For those companies attempting to create new formulations, they need to know how the foam jet from the MILSPEC nozzle behaves. Since future components of AFFF concentrates could conceivably suffer the same fate as PFOS, this demand could exist in the future as well.

There could be more environmental problems for AFFF after the fallout from PFOS is over with. There is already EPA concern that telomers may biodegrade into perfluoro octanyl acetate (PFOA)[9]. PFOA appears to have many of the same undesirable characteristics as PFOS[9]. No regulatory action against PFOA is currently being sought, but the EPA has asked the manufacturers to provide them with more information. If PFOA suffers the same fate as PFOS, then all processes that create AFFF will have been changed. It could even signal the end of AFFF with a new agent potentially being designed to replace it.

The fire fighting foam industry has recognized the potential for harmful environmental effects that may exist with their products. However they do not believe that the six-carbon molecules used in telomerized AFFF can break down into the eight-carbon molecule PFOA. To deal with the environmental concerns, the manufacturers formed the Fire Fighting Foam Coalition to work with the EPA and other environmental groups[9]. While these efforts will help protect the environment, it will probably lead to future situations like the ban of PSOS. When the need for reformulation arises, companies will want a way to know the effectiveness of their new product in comparison to the existing products before they pay for the full-scale test.

1.4 Considerations

Throughout the history of fire-fighting foam, several different types of products have been used. The initial foams were created by the use of chemical reactions. The more modern foams are created by entraining air into the solution. Over time, advances in science have made new and better formulations possible.

AFFF is currently the agent of choice for many pool fire applications. However, until MIL-F-23905, no standardized test method for approving foams existed. As will be discussed in the following chapters in greater detail, the tests outlined in the MILSPEC standard are dependent on human interaction with a fire. While this is useful, it does not establish a framework with which to understand the mechanisms that govern the behavior of the foam. How the foam jet behaves is not mentioned anywhere in MIL-F-24385F.

The application of foam to a surface is going to depend on the nozzle that is being used. These nozzles can be characterized to determine how the foam is leaving the nozzle and striking the fuel surface. While some work has been done with nozzles with throws of 20 m and greater, these tests proved to be inaccurate for nozzles with throws of only a few meters[1].

The nozzle used in the MILSPEC test has a throw of only a few meters[2]. Thus it needs to be characterized using methods other than those used for nozzles with large throws. Other nozzles designed for standardized tests and local applications of AFFF would have similar characteristics. Developing a test procedure to characterize the foam jet from these nozzles would be important to manufacturers of new solution formulations because they would have a better understanding of how their proposed product behaves in comparison to approved solutions. With environmental concerns appearing, new formulations may be needed to replace those that are deemed environmentally unfriendly.

1.5 Summary

Fire fighting foams have been used for over a century. As time progressed, the formulation of the foam changed rapidly, with AFFF appearing nearly 40 years ago. Since then, very little has been done to characterize the flow from the various nozzles used. Other agents have faded out of popularity and current formulations AFFF will, in all likelihood, also eventually cease to be the agent of choice. Whether it is due to environmental concerns or the invention of a superior agent, tests will be needed to judge the effectiveness of the new products. Understanding how the foam nozzle influences the foam jet will aid in this process.

2 Literature Review

The characterization of the foam jet from MILSPEC nozzle will help manufacturers better understand how their product will perform in the actual MIL-F-24385F tests. The important characteristics of the foam jet from the nozzle need to be established. Then, test methods to find these characteristics of nozzles with throws of only a few meters can be developed.

2.1 MILSPEC Test

MIL-F-24385F is the military specification that details the testing, packaging, procurement, storage, and inspection requirements for all AFFF solutions that can be procured by all departments and agencies of the Department of Defense[2]. The standard approves concentrates that are designed to be in solution at 3% or 6% with either fresh or sea water[2].

An approved agent must meet the MIL-F-24385F required qualification, materials, concentrate characteristics, fire performance, and marking[2]. Some of these requirements are not relevant to the actual functioning of the AFFF.

Instead, they deal with the packaging or procurement of the concentrate. For the purpose of this discussion, only those portions of the standard dealing with the performance and testing of the AFFF concentrate will be presented.

For the approval process, 378.5 L of 3% concentrate and 657 L of 6% concentrate need to be provided by the manufacturer[2]. This is added on to the cost of the testing itself, which makes the approval process rather expensive for the manufacturer. This cost is even more significant to the manufacturer if the concentrate does not pass the tests. In this event, the process starts all over again when a modification is made to the concentrate. The manufacturer also faces the initial research and development costs as well as the costs being applied again to produce the new solution. Understanding how the agent will perform before the actual test is conducted could save the manufacturers significant amounts of time and money.

From the supplied concentrate, several tests are conducted. These tests examine both the physical characteristics of the foam (foamability, pH, corrosion, etc.) as well as performance[2].

The performance tests[2] are specified for either a 2.60 m^2 or 4.65 m^2 pool. A layer of water sufficient to cover the bottom of the pool is applied to ensure that the pool is level. For the 2.60 m^2 pool 37.9 L, or 56.8 L for the 4.65 m^2 pool, of unleaded gasoline are poured into the pool and then ignited. Several variations to the foam solution are made to see how effective the agent is under all conditions. Table 2.1 [6] lists the required fire tests and the extinguishment times.

Table 2.1 MIL-F-24385F Test Requirements

Pool Size (m^2)	Concentrate Type	Concentration Strength	Concentration %	Water Type	Extinguishment Time (s)
2.60	Fresh or Aged	Full	3 or 6	Fresh	30
2.60	Fresh	Half	3 or 6	Fresh	45
2.60	Fresh or Aged	Full	3 or 6	Sea	30
2.60	Fresh	Half	3 or 6	Sea	45
2.60	Fresh	Quintuple	3 or 6	Sea	55
2.60	Aged	Half	3	Fresh	45
2.60	Aged	Half	3	Sea	45
2.60	Fresh with Compatible	Full	3 or 6	Fresh	30
2.60	Fresh with Compatible	Full	3 or 6	Sea	30
4.65	Fresh	Full	3 or 6	Sea	50

A fire fighter hired by the test lab uses a handheld nozzle to extinguish the fire within the given period of time. The standard does not specify how that person should attempt to extinguish the fire. How a fire fighter chooses to attack the fire could lead to the difference between an agent passing or failing the test. Thus, technique becomes important. The exact technique that will be used on the day that a particular agent is tested is unpredictable.

MIL-F-24385F specifies some physical properties the foam must have as well as setting performance goals for the foam in a model fire. However, there is no analysis that characterizes the foam jet from the nozzle.

2.2 Related Test Procedures

The MILSPEC test uses a nozzle that has a throw of only a few meters. No test methods have been developed to characterize nozzles of this type. In order to establish a successful test methodology, tests done for other types of foam nozzles, as well as sprinkler tests, need to be examined. The test methods used as well as the important variables in these tests can then serve to formulate tests for the foam nozzles of interest.

2.2.1 Foam Nozzles with Large Throws

The FOAMSPEX project examined the spray from six nozzles that had nominal flow rates that ranged from 11.4-1800 L/min. Aside from the UNI86 nozzle that had a nominal flow rate of 11.4 L/min, the lowest flow rate was 210 L/min. Also, the N1800 nozzle was the only one with a nominal flow rate over 900 L/min.

The footprint for all nozzles was characterized using six 0.47 m^2 pans. The first pan was positioned so that it was located a varying distance from the nozzle depending on the expected throw of the nozzle. Perpendicular to the plane with the nozzle were pans 1.5 m in either direction. Aligned with the nozzle and the first pan were pans 3 m from the main pan in either direction. Half way between the nozzle and the nearest pan was the final pan.

Aside from the UNI86 nozzle, the other nozzles all had throws of more than 20 m. The UNI86 nozzle had a throw of approximately 5 m. However the results were inconclusive due to the footprint being smaller than the collection area. The gradient was too steep to report reliable results.

The variables that were collected were expansion ratio, 25 % drain time, conversion percentage, throw length, throw width, fuel pick up percentage, viscosity, and droplet size. The expansion ratio, 25% drain time, viscosity, and droplet size were determined before the test. The droplet size was determined using a laser apparatus and the viscosity was measured using a rheometer. The other variables were collected during the test itself.

The width and length of the footprint were approximated by the amount of mass collected in each of the six pans. The fuel pickup and percent conversion were determined by the amount of fuel and foam found in small containers located near the main pan.

2.2.2 Sprinklers

All sprinkler standards detail criteria that apply to the physical characteristics and responses of the sprinkler head and to the water that leaves the sprinkler head. The requirements that involve the sprinkler head itself are not included here. However the requirements for the water flow from the sprinkler head can be considered as variables of interest to be determined by a new test procedure for foam nozzles.

2.2.2.1 Factory Mutual Approval Standard 2008

The Factory Mutual *Approval Standard foe Early Suppression Fast Response (ESFR) Automatic Sprinklers* specifies several criteria for the water flow from an approved sprinkler. Four different sections specify characteristics of the flow.

Section 4.26 specifies the water distribution from the sprinkler. A minimum volumetric flux from the sprinkler system (given various numbers of nozzles, their positioning, and pressure) is required. The flux shows how much water is falling within the target area over a given period of time.

Section 4.27 details the requirements for the impingement of adjacent sprinklers. For the characterization of the MILSPEC nozzle, only one nozzle will be used, so no impingement will take place.

Section 4.28 is very similar to section 4.26. It gives the minimum for the actual delivered density. The difference between the actual delivered density and the water distribution is that the actual density distribution is performed with a sample commodity and fire present.

Finally, Section 4.29 gives the minimum required thrust at given locations from the sprinkler head. The thrust is a force per unit area. It is measured by placing a load cell at prescribed locations and recording the force exerted by the water.

2.3 Foam Jet Characterization

Characterization of large throw foam nozzles and sprinklers has taken place. No known research has been conducted that looked at the characteristics of the foam as it leaves the MILSPEC (or similar) nozzle. While the test methods would be similar, there would be some differences. This was demonstrated when tests for large throw nozzles were attempted to be applied to a nozzle with a relatively small throw[1]. Any insight as to how and why agents perform in a given manner can only be speculated at. In this project, test methods were designed and used to find the mass distribution and momentum from the MILSPEC nozzle.

Understanding the foam jet from the MILSPEC nozzle would be needed most in the event that there was a need to approve several new formulations of AFFF or the development of a new type of foam. Within a century, several different agents rose to popularity before eventually falling out favor. As the new agents were used, new methods were needed to test and approve them.

Environmental concerns have also started to appear with respect to AFFF. If components of AFFF can no longer be manufactured, then new formulations will need to be designed and approved. A better understanding of the foam jet from various nozzles will be useful in formulating these new foam concentrates.

2.4 Summary

Environmental regulations or the development of new foam products will eventually create a demand for new approval testing to be conducted. For the new products to be the most useful and effective, an understanding of how the nozzle applies the foam is needed. Test series to determine this type of information has been used for foam nozzles with large throws and sprinklers. However it has not been used for foam nozzles with throws of only a few meters.

3 Method

The objective of this set of experiments was to characterize the foam jet from the MILSPEC nozzle. All tests needed to be reproducible and accurately measure the desired characteristics of the flow. Variables that were considered the most important were altered to see what effect they caused to these characteristics.

The important variables identified in foam and sprinkler tests mentioned in the literature review were volumetric flux, impingement, and thrust. A procedure for characterizing the foam jet foam a nozzle should determine these variables or equivalents.

The volumetric flux was a required characteristic in the previously referenced sprinkler tests. These tests are conducted using water, which has a known density. The results can be converted into a mass flux by multiplying the volumetric flux by the density. For tests involving foam, the mass flux is a more difficult measurement to take because the volume is rapidly changing due to drainage and breakdown of the bubbles. This mass flux will also show the extent to which the foam is spreading out before striking the surface. The area in which the foam falls will be referred to as the “footprint”.

Another characteristic of importance from the referenced sprinkler standards was impingement between adjacent nozzles. Since only one nozzle will be used in the tests presented in this document, impingement is not a factor. If multiple nozzles were needed to be operating simultaneously, then this would need to be addressed.

The thrust is the force at which the foam is striking a surface of interest. This value is comprised of two components. The first is the mass on the load cell that is causing some weight to be measured. These tests are conducted under steady-state conditions with the flow rate of water onto the load cell being equal to the flow rate off. Thus, this component is constant and not of interest. The second component is the momentum of the droplets as they strike the surface. The momentum can be calculated using the velocity times the mass.

In order to understand how the foam jet was operating, the velocity was needed. By knowing the three components of the velocity, it was possible to construct the trajectories of the particles as well as extrapolate the momentum components.

The FOAMSPEX project examined the footprint from the foam nozzle by placing pans in the expected footprint area. With enough pans located close enough together, it was possible to get an approximate foam footprint. However the set up used was not sufficient for nozzles with flow rates less than 200 L/min.

3.1 Apparatus

Two different types of tests were conducted for this project. The mass distribution and momentum tests had some equipment that was the same and some that was different. All tests took place at the same location.

3.1.1 Testing Location

Testing was conducted at an indoor facility. The tests took place in an area of approximately 15 m^2 within a larger laboratory area. It was not a draft-free environment nor was the ambient temperature strictly regulated.

3.1.2 Set-Up

The set-up of the experiments consisted of two parts. One part was the nozzle and tank assembly. The other part was the target area. The same nozzle and tank assembly were used for all tests. The target area varied for each type of test.

3.1.2.1 Nozzle and Tank Assembly

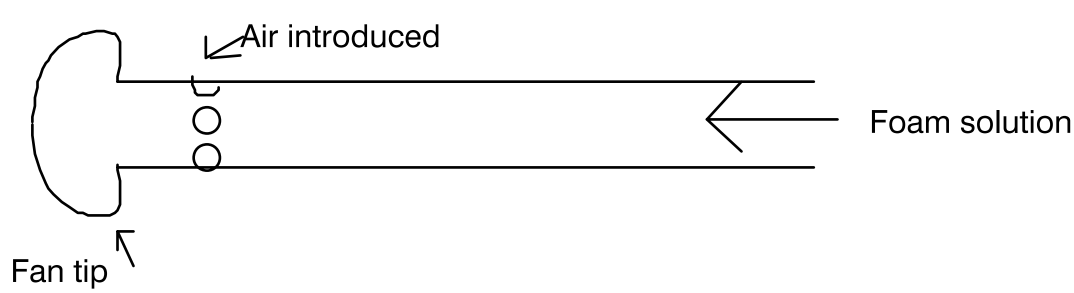
A 45 L tank was used to pressurize the foam solution with compressed nitrogen. There were two pressure gages; one was located at the tank and the other at the nozzle. Two valves controlled the flow of nitrogen and one valve enabled the foam solution to flow into the nozzle.

One valve for the flow of nitrogen allowed nitrogen to enter into the tank. This valve was kept open for the duration of every test. The other valve for the flow of nitrogen allowed the tank to be vented. This valve was closed for the duration of all tests and was only opened when the tank needed to be refilled with solution. The valve controlling the flow of the foam solution was located at the bottom of the tank. It was connected to the nozzle by tubing and was open for the duration of all tests.

The nozzle was designed in accordance with MIL-F-24385F and had a control valve and pressure gage. The pressure gage was the one from which the pressure of the foam solution was determined. A control valve near the nozzle regulated the flow of foam from the nozzle and it was the controlling mechanism for the amount of time that the tests were conducted.

The foam jet could be produced using either aspirated or nonaspirated foam. In most of the testing done for this project, aspirated foam was used. A schematic diagram of the nozzle is presented in Figure 3.1

Figure 3.1 Foam Nozzle



For aspirated foam, air was allowed to mix with the solution before it left the nozzle. This foam had visible bubbles and appeared more like an emulsion than a pure fluid. The nonaspirated foam was created by covering the holes that emit air into the nozzle with two layers of metallic tape. While some mixing between air and the solution occurred (both before and after the solution left the nozzle), the nonaspirated foam appeared to be more like a pure fluid than an emulsion.

For most of the tests, the tip of the nozzle was positioned 1 m above the ground by the use of cinder blocks, a wooden platform, and pieces of wood to adjust the angle of the nozzle. A ring stand assembly held the tip of the nozzle stationary. A level was used to determine that all angles were in accordance with the design for the given test.

The nozzle was placed over a containment area with plastic sides. A plastic sheet that could be held over the containment area, but in front of the nozzle was also present. Beyond the containment area was the target area.

3.1.2.2 Target area

While the target area was significantly different for each test, there were some common features to the target area for all tests. A blue tarp was laid on the ground in an attempt to limit the foam spread beyond the test area. After each test, as much foam as was possible was removed from the tarp. The exact set-up of equipment on top of the tarp varied for each test. However the coordinate system used was the same.

The coordinate system placed the nozzle arbitrarily at the origin. Due to this, the x-coordinates ranged from approximately -0.6 m to +0.6 m and the y-coordinates from 0.0 m to 3.2 m. These values were chosen after preliminary tests showed the width and length of the footprint from the nozzle for all conditions of interest. In all cases, the amount of foam falling outside of the grid area was determined to be negligible with respect to the amount of foam collected by extending the grid to cover all areas that received more than isolated foam particles.

To ensure that the nozzle was always square with the grid, a laser was aligned with the center of the grid in the x-direction. This line was then extended through the entire length of the nozzle. Since the base and tip of the nozzle were both centered with respect to the grid, the foam jet would not be favoring one side of the grid due to experimental set up. This ensured that the flow was centered on the y-axis and was the same for each trial. Once the nozzle orientation was established, the distance from the tip of the nozzle to the first test location could be measured with the value at the center of the grid being the value used to determine that coordinate. From here, all future test locations could be measured from this established position. The x-grid location was found by measuring the distance perpendicular to the y-axis.

3.1.2.2.1 Mass Distribution

Twelve 0.10 m wide, 2.44 m long metallic building studs were placed on top of the tarp with the open side of the studs facing upward. The studs were laid parallel with the nozzle creating twelve channels that were aligned with the main direction of the flow and acted as a guide for the placement of the PVC sections.

Two-hundred-twenty-eight 0.089 m diameter PVC pipe sections, approximately 0.06 m high, were placed in the studs 0.10 m (center-to-center) apart within each channel. Also, since the studs were 0.10 m wide, all grid points were 0.10 m apart in either the x- or y-direction. These PVC sections were used to keep the cups (described below) in position. The exact height of the PVC sections varied. However this was not considered important as long as the height was less than that of the cups because their only function was to keep the cups in position.

Plastic cups with a tapered shape were the next component of the mass footprint experimental set-up. The cups had a 0.10 m upper diameter, 0.06 m base diameter, 0.11 m height, and 0.473 L capacity.

3.1.2.2.2 Momentum

Three different test procedures were used to collect data on the velocity of the flow. The first method consisted of a digital video camera being placed at selected locations within the footprint area and recording close-up shots of the foam droplets. The second method also used digital video cameras. One was located at the side of the test area and a second one above the test area.

These cameras captured the entire flow and were used to determine the initial velocity of the jet. A third set of testing used the side camera to capture the basic shape of the jet.

3.2 Test Design

The mass distribution and momentum tests were designed to represent, as accurately as possible, the MILSPEC tests. This required consideration of both what was written in the standard and personal observations of actual MILSPEC tests.

The MILSPEC standard requires that the nozzle be held at hip height. This value will vary in accordance to the person that is performing the fire fighting duties for a particular test. To standardize this measurement in all tests, the tip of the nozzle was positioned so that it was one meter above the ground.

The foam concentrate used for all tests was 6% AFFF. The concentrate was then mixed thoroughly with 94 parts of water to ensure that the solution was relatively homogenous. This mixture was then placed in a tank and pressurized to 690 kPa (see below for explanation on pressure). Between 18.9 and 37.9 L of solution were placed in the tank at one time.

As required in the MILSPEC standard, the tests were conducted at 690 kPa at the nozzle. A cylinder with the foam water solution was pressurized using compressed nitrogen. Once the two valves were opened, the solution flowed out of the MILSPEC nozzle. It was observed that the initial flow of foam from the nozzle (regardless of the initial pressure) did not have the same consistency as the foam that came after the first few seconds. This initial foam appeared more aerated than the later foam. Also, the pressure at the nozzle would start above 690 kPa (as high as 1035 kPa) and then slowly drop to 690 kPa for some tests. While the steady-state pressure did not make a significant change in the foam jet (described below), the reason why the pressure drop was occurring, and the effects of this on the foam jet, were unknown. Foam at an unknown pressure with a varying density was not deemed reproducible. In order to assure that the foam for all tests was uniform and at the same pressure, a plastic sheet blocked the initial flow from the nozzle and directed the foam into a pool below the nozzle. Once the flow reached 690 kPa, the sheet was removed and the foam was allowed to fall into the test area.

During the MILSPEC test, the angle of the nozzle with respect to the horizon will vary as the fire fighter attempts to extinguish the fire. The fire fighter could wish to aim the foam jet at areas that are further away or closer than the level nozzle case. While walking forward or backward would be one way to approach this issue, another possibility is to alter the angle of the nozzle. Due to this fact, angles above and below zero degrees were considered.

After consulting with one of the fire fighters that had conducted the MILSPEC test and from personal observations, the minimum and maximum angles of the nozzle that are used in the MILSPEC tests are within fifteen degrees of the horizon. By conducting tests at the extreme angles and level cases, all other values for expected angles should fall within these results. Thus, for the tests described below, trials were run with the nozzle at -15°, 0°, and 15° with respect to the horizon.

The nozzle height, foam solution, pressure, coordinate system, and fan tip angle were the same for all test series. Within each series, the same nozzle angles (-15°, 0°, 15°) were examined. For most tests, aspirated foam was used. However some tests were conducted that used nonaspirated foam.

Since all variables were kept consistent for each test series, the results at each location could be compared. With this fact in mind, future tests were always conducted at locations that had been previously observed to receive a meaningful amount of foam.

3.2.1 Mass Distribution

The first series of tests were designed to examine the footprint to determine the mass distribution. With the knowledge of the distribution of mass within the footprint, the data from these tests could then be used to determine the locations to be measured in the momentum and velocity test.

The cups were bought in bulk with the hope that they would be nearly uniform. However the tare weights were found to vary from 7.8 to 9.8 g. The expansion of the foam and volume of the cups required all tests to be conducted for fifteen seconds or less to prevent the cups from overflowing. To get a meaningful gradient from adjacent cups, the mass of foam needed to be measured to 0.1 g accuracy. Thus, the potential difference in tare weights was greater than the resolution desired for the experiment. Therefore, a uniform tare weight could not be assumed for all of the cups.

In order to ensure that accurate foam masses were collected at each cup, the tare weight for the given cup was written on the side of the cup in permanent black marker. After each cup was marked, the cups were measured again to verify that the mass from the ink did not alter the tare weight. On the few occasions that this did happen, the cup was remarked with the new tare weight. The cup was then weighed again to demonstrate that the correct tare weight was recorded.

Once the cups were properly tared, they were placed in the grid of PVC pipe sections. For ease of data recording, the cups used in the experiment were placed sequentially, according to tare weight, from right to left starting at the base of the grid.

After each test, the cups were immediately weighed to limit the effect of evaporation. Any foam that collected on the side or bottom of the cups was removed before the mass was measured. After all of the cup weights were recorded, the cups were then emptied and dried. The cleaned cups were placed in the grid again for the next test.

Preliminary tests were conducted for each nozzle angle and foam type to determine how many rows and columns of cups would be needed to collect the full footprint from the foam jet. For all angles, the area immediately in front of the nozzle received negligible mass. The width of the footprint depended on which angle was being considered and whether the foam was aspirated or nonaspirated. The grid of PVC sections was positioned for each test so that the area receiving a measurable amount of foam would be within the grid for all tests. Locations beyond the expected footprint had no data collected due to the fact that no usable data was expected to fall in this location. It was found that a maximum of nineteen rows and twelve columns of cups were required to complete this task.

Eleven tests were conducted for both the aspirated and nonaspirated foam for which reliable data was collected. The duration of the tests and the exact placement of the cup grid varied depending on the footprint found in preliminary testing. Those values are given in Table 3.1.

Table 3.1 Mass Distribution Test Series Characteristics

Test #	Foam Type	Angle (Deg)	# of Tests	Min x (m)	Max x (m)	Min y (m)	Max y (m)	Time (s)
3-7	Asp	0	5	-0.56	0.56	0.90	2.70	15
10-12	Asp	-15	3	-0.56	0.56	0.60	2.40	10
15,16,18	Asp	15	3	-0.56	0.56	1.40	3.20	15
23-27	Nonasp	0	5	-0.56	0.56	0.40	2.20	5
28-30	Nonasp	-15	3	-0.56	0.56	0.40	2.20	5
31-33	Nonasp	15	3	-0.56	0.56	0.40	2.20	5

Five of these tests were conducted at 0º to see if there was repeatability. Three tests were performed at both -15º and 15º for each foam type in order to see if there was an anomalous test that would skew the data. The data was recorded at each cup with the grid locations of the cups given by the coordinates of the center of the cup. The time of each group of tests was chosen in order to prevent foam from flowing out of the cups.

3.2.2 Momentum

An experimental approach to measure the velocity was conducted. Tests looked at both the leading edge velocity as well as the velocity at the cup level.

3.2.2.1 Leading Edge

To find the initial velocity, a digital video camera was set up to the side of the test area and another one above the jet. The PVC sections used in the mass distribution tests were placed below the flow to act as a coordinate system for the overhead camera and a piece of fiberglass marked every 0.01 m was placed beyond the jet perpendicular to the side camera. The flow was initiated as it had been for the mass distribution tests. The leading edge of the foam was tracked to get an approximate initial velocity. Also, the side camera captured the trajectory of the jet.

3.2.2.2 Particle Trajectories and Size

The velocity of the aspirated foam and droplet size at a given cup location were determined using one digital video camera. The camera was placed at the side of the experiment to capture the component of the velocity in the y- and z-directions. A board with marks every 0.001 m in both directions was placed behind the cup of interest. The foam was then flowed from the nozzle as it had been for the mass distribution tests.

3.3 Other Variables

There were some variables that were considered to be either beyond the scope of this project or insignificant. The reasoning why these variables were omitted is covered in this section.

Even though the actual test involves human factors (fire fighting), the tests had to be standardized in such a manner that they accurately represented the MILSPEC test without human intervention because human behavior is not easily reproduced. The MILSPEC test is heavily dependent on the operator of the nozzle. Standardizing variations between operator technique would have been too complicated.

Personal observations of the test MILSPEC test revealed that both moving forward or backward and altering the nozzle angle are used in order to apply the foam to the pool fire. While the fire fighter walking around will affect the jet properties, the assumption being used in this analysis is that these effects do not significantly alter the physics of the flow before spreading and that the flow can be approximated from a stationary nozzle. Furthermore, the human movement varied greatly from test to test and could not be accurately reproduced. With all of these considerations in mind, a moving nozzle was not modeled in these experiments.

Another unaccounted variable from the MILSPEC test was the interaction of the foam jet with fire or fuels. Since the jet characterization dealt with the properties immediately before impact rather than the spreading process, the interaction with the fuel would be negligible. However the fire existing in the actual test creates a dynamic environment above the fuel bed. Incoming foam would be evaporated and have its trajectory changed in ways that do not occur under ambient conditions. This is part of the reasoning why sprinkler standards test for the actual delivered density.

If the fire is excluded, the need for instantaneous measurements is not needed. A grid can be made and, after the test has been conducted for a sufficient amount of time, the mass at each grid point can be measured. These measurements can take minutes to gather without a loss in accuracy. Thus the data collection process has excluded many of the variables of the fire in a manner that is reproducible and efficient. This ambient data can then be combined with a fire simulator to predict how the fire will alter the foam jet. The goal of this project was to establish baseline properties. Once this data is obtained, then work could be done to study the effect of the fire environment on the foam jet.

The foam jet was only characterized for a pressure of 690 kPa at ambient conditions. Originally, varying the pressure had been considered. However, after preliminary tests, this variation was not accounted for in the actual testing sequence. Altering the pressure by 140 kPa caused the foam distribution to shift approximately 0.10 m in the y-direction and no observed change was seen in the x-direction. Thus, the observed results from the tests at different pressures were not believed to significantly alter the foam footprint. Due to this observation, it was decided to not conduct the test series with different pressures. Future research could look more closely at what role pressure plays in determining the characteristics of the foam jet.

Consideration was also given to the fan tip being rotated. Slight rotations of the fan tip were observed during the MILSPEC test. These rotations did not cause the foam jet to change in a noticeable manner. It would be possible for the fan tip to be rotated 90º and this would presumably have a significant impact on the foam jet, as the gravity vector would be acting perpendicular to the standard case. Also, the fan tip would be spreading the flow vertically rather than horizontally. Therefore, it is assumed that there would be some effects from rotating the fan tip even a slight amount. However the differences in the flow caused by this rotation were not considered in this investigation. Future research could analyze what effect the orientation of the fan tip has with regard to the flow. For these tests, the fan tip was checked with a level before each test to ensure that it was at zero degrees rather than some other angle.

No tests were done for the velocity or momentum of the nonaspirated foam. These tests were not conducted because the solution appeared to behave similar to that of pure water and the mass distribution had a severe gradient. Therefore, it was not considered to be of interest for this project. A complete treatment of this topic is covered in the seventh chapter.

3.4 Summary

Experiments to determine the mass footprint, velocity, and momentum of the foam jet have been described. These properties serve to characterize the foam jet that flows from the MILSPEC nozzle. The experiments are designed to reflect, as accurately as possible, the conditions present in the actual MILSPEC test in a reproducible manner.

4 Data

This set of experiments was intended to identify the physical properties of the foam jet from the MILSPEC nozzle at ambient conditions. The data from the mass distribution and momentum tests are presented below. Most tests were conducted using aspirated foam at 0º, -15º, 15º. The exception to this statement is half of the mass distribution tests were conducted using nonaspirated foam.

4.1 Mass Distribution

The mass distribution tests were conducted as described in the previous chapter. The cups were weighed and the measured mass as well as the foam mass were recorded on the data sheet. A sample data sheet used is available in Appendix A. All data was collected by hand and the foam weight was manually calculated by subtracting the tare weight recorded on the side of the cup from the measured weight with foam in the cup.

While twenty-two tests are presented below, the numbering of the tests extends to thirty-three. The eleven omitted tests were not included for one of a few reasons. First, the grid of cups that was present was not sufficient to capture all of the areas where foam was falling. Second, tests that experienced timing errors were not included. Third, tests that were contaminated by dye being used in an unrelated experiment were not reported. The dye, which was mixed with the solution, caused the footprint to become narrower and shorter. Fourth, for one test, a lab worker helping weigh the cups inadvertently knocked over a column of cups that had not been completely weighed. Tests suffering from one of these four types of errors were excluded to ensure that the data could be considered reliable. No test was excluded for reasons except for those described above.

For both aspirated and nonaspirated foam, five tests were run with the nozzle at 0º. These tests were designed to show the repeatability of the results. Then, three tests for both the nozzle at –15º and 15º were conducted.

4.1.1 Aspirated Foam

The aspirated foam had noticeable bubbles and appeared white in color. The footprint extended from nearly 0.60 to 3.20 m away from the nozzle when all angles are examined. The width of the footprint was approximately 0.60 m in either direction from the nozzle.

4.1.1.1 Zero Degrees above the Horizon

Five tests were conducted with the MILSPEC nozzle parallel with the floor. These were tests 3-7 of the test series. Each test lasted for fifteen seconds. The total amount of mass collected for all of the cups in each test and a contour plot of the mass footprint is available in Appendix B. Presented in Tables 4.1-4.3 are the mass distribution for test 3, the average mass per cup for tests 3-7, and the center of mass for tests 3-7. Table 4.4 gives the maximum amount of foam collected in a given up and the total foam collected in all cups for each test.

Table 4.1 Test 3 Raw Mass Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	tr	0.1	0.2	0.3	0.6	0.6	0.4	0.3	0.3	0.3	0.1	tr
1.00	0.1	0.2	0.2	0.5	0.6	0.7	0.7	0.5	0.5	0.2	0.1	0.1
1.10	tr	0.2	0.5	0.7	1.0	1.0	1.0	1.1	1.0	0.4	0.1	tr
1.20	0.1	0.3	1.2	1.1	1.1	2.2	2.1	1.4	1.6	0.6	0.1	tr
1.30	0.1	0.9	1.9	2.1	1.9	2.1	2.3	3.6	2.3	1.1	0.3	0.1
1.40	0.4	2.0	4.7	3.9	2.5	3.5	5.0	7.3	3.4	1.4	0.2	tr
1.50	0.4	2.8	9.6	7.5	3.9	3.5	9.0	13.1	6.8	2.0	0.2	0.1
1.60	0.5	4.6	13.7	11.7	4.6	4.6	12.3	32.6	11.8	2.1	0.3	0.1
1.70	0.4	7.3	25.3	15.9	5.6	6.7	18.5	54.7	21.7	2.6	tr	no
1.80	1.1	9.6	31.5	16.3	7.1	8.0	22.2	56.5	22.5	2.7	0.2	0.1
1.90	1.2	11.5	33.7	18.0	8.4	8.1	16.5	55.7	21.5	1.5	tr	tr
2.00	1.8	12.6	28.6	15.1	8.6	7.1	9.4	21.6	7.8	0.6	no	no
2.10	1.5	18.8	26.5	14.6	9.3	6.1	5.5	7.3	1.3	tr	no	no
2.20	2.0	21.9	30.7	13.2	7.2	3.6	2.8	1.3	0.1	no	no	no
2.30	2.8	25.3	28.7	9.5	2.9	0.7	0.6	0.2	tr	no	no	no
2.40	3.1	23.4	25.2	6.6	1.1	tr	tr	tr	0.1	no	no	no
2.50	1.7	13.7	9.5	1.2	tr	tr	tr	0.1	0.1	no	no	no
2.60	tr	2.2	1.3	tr	tr	no	no	no	0.1	no	no	no
2.70	tr	0.1	tr	tr	no	no	no	no	tr	no	no	no

All measurements in g tr=trace amount of foam no=no change in mass

Table 4.2 Tests 3-7 Raw Mass Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.1	0.2	0.2	0.3	1.0	0.4	0.3	0.2	0.3	0.1	0.0
1.00	0.0	0.2	0.3	0.4	0.5	0.8	0.7	0.5	0.5	0.3	0.1	0.1
1.10	0.1	0.3	0.5	0.7	0.8	1.2	0.8	0.7	0.7	0.4	0.1	0.0
1.20	0.2	0.4	1.0	1.0	1.1	1.6	1.4	1.1	1.0	0.5	0.3	0.1
1.30	0.3	0.9	1.9	2.1	1.9	1.9	1.8	2.0	1.8	1.1	0.4	0.1
1.40	0.5	1.8	3.7	3.9	3.0	2.4	2.8	3.6	2.9	1.9	0.7	0.2
1.50	0.9	3.6	7.4	7.6	4.6	3.1	4.3	6.1	5.7	3.5	1.0	0.4
1.60	1.0	5.7	13.3	12.4	6.0	4.2	5.9	13.6	10.4	6.3	2.0	0.3
1.70	1.5	10.1	20.2	19.1	7.8	4.3	7.7	20.3	19.0	10.4	2.3	0.3
1.80	2.2	12.5	24.9	21.7	8.2	5.8	9.3	23.2	26.9	15.5	3.6	0.7
1.90	2.6	14.9	26.0	22.5	8.1	6.1	9.0	23.7	30.6	18.6	5.0	0.6
2.00	2.0	15.0	23.4	15.4	7.6	6.8	8.0	16.8	25.8	18.4	7.0	0.4
2.10	1.8	13.3	19.8	12.5	7.6	6.5	7.1	12.8	28.2	14.6	6.2	0.2
2.20	1.3	13.7	19.4	10.9	6.6	5.4	5.6	10.1	23.0	12.5	3.9	0.1
2.30	1.2	12.7	18.7	7.9	4.0	3.1	3.3	6.2	15.1	7.6	1.5	0.0
2.40	1.1	9.6	16.0	7.3	2.2	1.1	1.4	3.2	7.2	2.6	0.1	0.0
2.50	0.6	6.7	9.3	4.6	0.8	0.2	0.2	0.6	1.3	0.4	0.0	0.0
2.60	0.0	2.0	4.4	1.8	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0
2.70	0.0	0.4	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g

Table 4.3 Tests 3-7 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	1.94	1.94	0.12
Y Right	1.90	1.89	0.13
X Left	-0.31	-0.31	0.05
X Right	0.24	0.23	0.06

Table 4.4 Aspirated Foam 0º Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
3	56.5	1196.9
4	55.5	1149.6
5	69.5	1217.2
6	55.6	1224.3
7	46.9	1209.2

All five tests had similar distributions. Test 3 will be used as an example for examining the footprint. As can be seen in Figure 4.1, the footprint (with the values being in grams) consisted of two regions. The region on the right was more concentrated while the region on the left was more elongated. The foam principally falls in the y direction from 1.4 to 2.6 m. Values as small as 0.1 g were collected from 0.90 to 2.70 m. In the x-direction, the main foam concentrations are in regions from –0.60 to 0.40 m. Figure 4.2 shows the average mass collected in tests 3-7.

Figure 4.1 Aspirated Foam 0º Mass Distribution Results

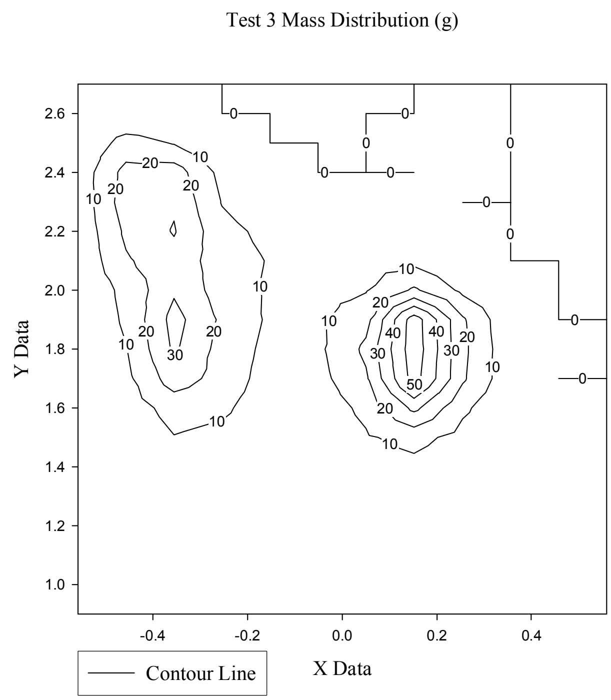
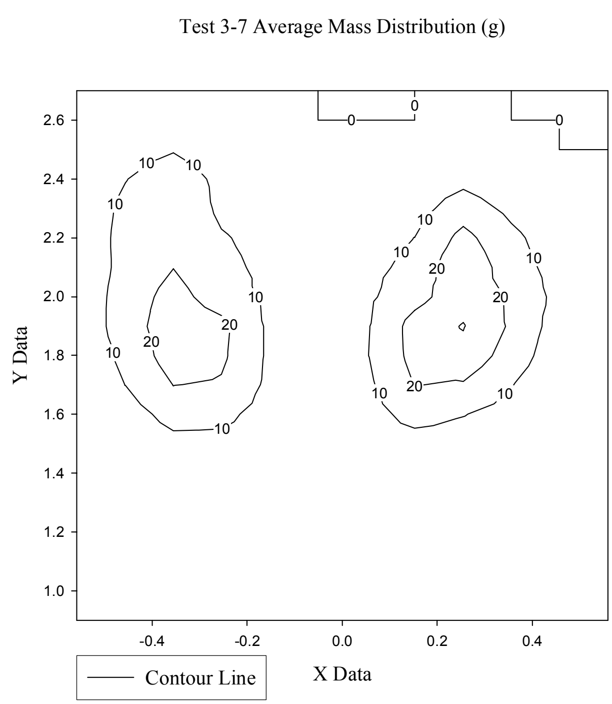


Figure 4.2 Tests 3-7 Average Mass Distribution



4.1.1.2 Fifteen Degrees below the Horizon

With the MILSPEC nozzle positioned at -15º, three tests were conducted. The tests, numbers 10-12, lasted 10 s. Ten seconds was used rather than the 15 s duration of the 0º case due to the cups over flowing when exposed to the –15º jet for the longer time period. The mass per cup collected and contour maps of this data are available in Appendix C. Presented in Table 4.5 is the raw data for test 10. Table 4.6 contains the raw data for the average value collected in each cup over the three tests. Table 4.7 shows the location of the center of mass for each jet in the three tests. For each test, the maximum amount of foam collected in a single cup and the total amount of foam collected is shown in Table 4.8.

Table 4.5 Test 10 Raw Mass Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	tr	0.1	0.1	0.1	0.1	0.2	0.7	0.3	0.1	0.1	0.1	tr
0.70	no	tr	0.1	0.2	0.2	0.6	0.7	0.4	0.3	0.2	0.1	tr
0.80	no	tr	0.2	0.8	0.6	0.6	1.3	0.5	0.5	0.3	0.1	0.1
0.90	no	0.1	0.4	0.8	1.2	1.4	2.7	0.9	0.9	0.4	tr	0.1
1.00	0.1	0.1	0.5	3.2	3.4	2.1	4.3	1.4	1.1	1.1	0.3	0.1
1.10	no	0.1	1	7.8	16.1	3.3	5.2	3	2.0	2.2	0.4	0.1
1.20	no	0.1	1.8	24	42	5.4	4.7	6.6	11.6	6.7	0.8	0.1
1.30	no	tr	2.3	44.0	39.1	6.9	6.5	11.9	40.5	19.8	1.1	0.1
1.40	no	0.1	2.7	49.8	20.2	7.9	1.3	24.0	43.4	45.2	1.7	tr
1.50	no	0.1	0.4	14.7	7.9	5.1	12	33.7	51.6	25.3	1.0	no
1.60	no	no	no	0.6	0.6	1.7	4.5	19.0	14.4	3.5	0.1	tr
1.70	no	no	tr	tr	tr	0.1	0.5	2.1	1.5	tr	no	no
1.80	no	no	no	no	no	no	no	tr	0.1	tr	no	no
1.90	no	no	no	no	no	no	no	no	no	no	no	no
2.00	no	no	no	no	no	no	no	no	no	no	no	no
2.10	no	no	no	no	no	no	no	no	no	no	no	no
2.20	no	no	no	no	no	no	no	no	no	no	no	no
2.30	no	no	no	no	no	no	no	no	no	no	no	no
2.40	no	no	no	no	no	no	no	no	no	no	no	no

All measurements in g   tr=trace amount of foam no=no change in mass

Table 4.6 Test 10-12 Raw Mass Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	0.1	0.1	0.1	0.2	0.5	0.2	0.1	0.1	0.0	0.0
0.70	0.0	0.0	0.1	0.2	0.2	0.4	0.7	0.4	0.2	0.2	0.0	0.0
0.80	0.0	0.0	0.1	0.5	0.4	0.4	0.8	0.5	0.4	0.2	0.1	0.0
0.90	0.1	0.0	0.2	0.5	0.8	0.9	1.5	0.8	0.7	0.3	0.1	0.0
1.00	0.0	0.1	0.4	1.7	2.0	1.9	2.5	1.4	1.3	0.8	0.3	0.1
1.10	0.0	0.0	0.8	3.9	7.9	2.9	3.4	2.7	3.7	2.3	0.4	0.0
1.20	0.0	0.1	1.5	16.0	22.4	4.9	4.2	5.7	10.1	6.0	0.9	0.1
1.30	0.0	0.1	2.0	33.2	39.8	6.8	6.5	10.2	34.2	18.1	1.2	0.1
1.40	0.0	0.1	1.9	43.5	35.7	5.7	6.1	17.9	46.4	39.8	1.2	0.0
1.50	0.0	0.0	0.8	24.0	24.6	7.6	10.6	22.1	52.5	31.4	0.9	0.0
1.60	0.0	0.0	0.2	11.6	13.3	4.5	5.1	13.8	24.3	7.4	0.1	0.0
1.70	0.0	0.0	0.0	2.8	4.6	1.4	1.2	1.9	2.2	0.2	0.0	0.0
1.80	0.0	0.0	0.0	0.2	0.5	0.2	0.1	0.0	0.1	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g

Table 4.7 Test 10-12 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	1.36	1.36	0.07
Y Right	1.40	1.40	0.02
X Left	-0.19	-0.19	0.00
X Right	0.24	0.24	0.01

Table 4.8 Aspirated Foam -15º Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
10	51.6	750.3
11	51.0	714.8
12	55.0	774.4

Due to the similarities of the mass footprints, test 10 will be used as an example for trends present with all three footprints. As can be seen in Figure 4.3, unlike the 0º case, the two regions of high mass concentrations for the –15º were approximately the same shape. The regions were about 0.50 m in the y-direction and between 0.30-0.40 m in the x-direction. Despite the similarities in the shape, the region on the left was closer to the nozzle than the region on the right. Figure 4.4 shows the shape of the footprint from the average amount of foam collected in the three tests.

Figure 4.3 Aspirated Foam -15º Mass Distribution Results

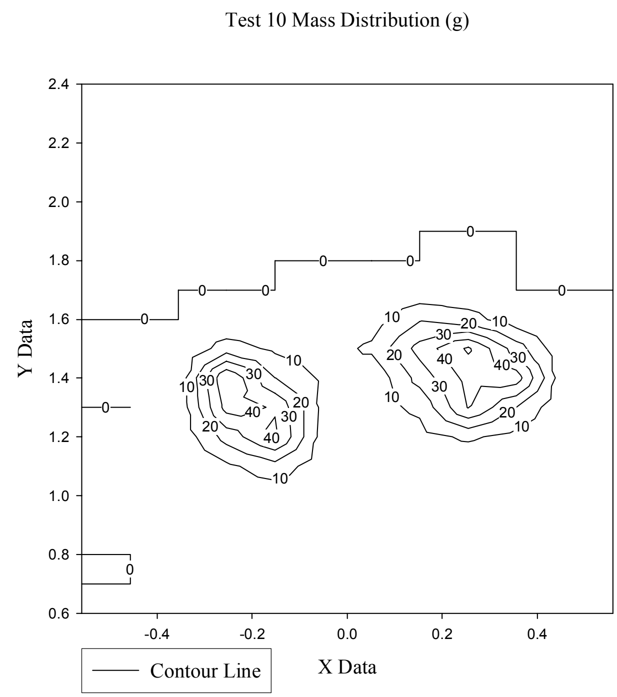
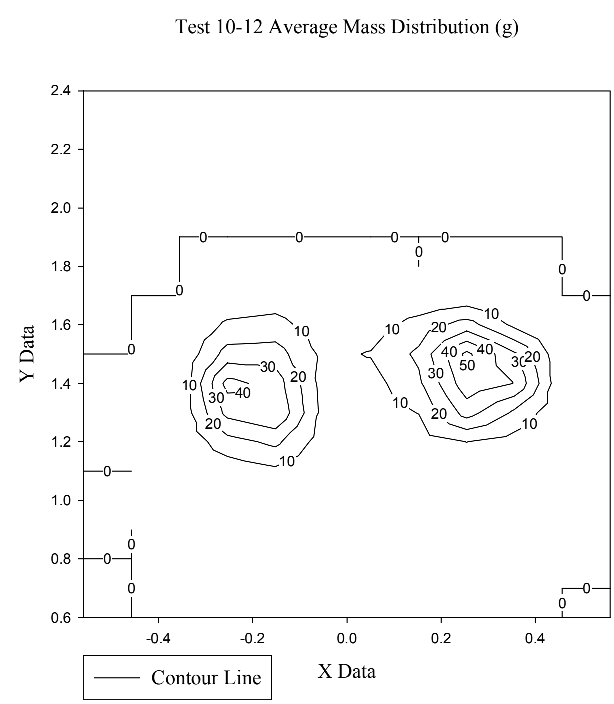


Figure 4.4 Tests 10-12 Average Mass Distribution



4.1.1.3 Fifteen Degrees above the Horizon

The three tests conducted with the nozzle at 15º were numbers 15, 16, and 18. These tests were conducted for 15 s, as had been the case with the 0º case. Tables 4.9-4.10 contain the raw amount of mass collected for test 15 and the average of the three tests respectively. Table 4.11 shows the location of the center of mass for each jet in the three tests. Table 4.12 gives the total mass collected by all cups as well as the maximum foam mass in a single cup for each test.

Table 4.9 Test 15 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.1	0.4	0.5	0.5	0.7	1.5	1.5	0.9	0.6	0.6	0.3	0.2
1.50	0.3	0.6	0.9	1.2	1.0	1.8	1.4	1.0	0.9	0.6	0.3	0.2
1.60	0.4	1.3	2.0	2.2	1.2	2.8	1.6	1.6	1.4	1.1	0.5	0.4
1.70	0.6	2.6	4.2	3.2	2.7	1.9	2.8	1.9	1.9	1.9	1.3	0.5
1.80	1.1	3.2	8.4	4.5	2.9	2.4	2.9	3.1	3.3	3.0	1.5	0.6
1.90	1.1	5.2	13.6	9.8	2.9	2.6	3.3	3.3	4.0	3.3	2.6	0.4
2.00	1.6	6.3	15.7	10.2	4.0	3.2	3.5	4.4	6.5	6.1	3.1	0.9
2.10	1.8	1.9	21.9	15.4	5.1	3.8	3.9	4.6	6.1	7.9	6.2	2.1
2.20	3.8	12.0	22.5	13.6	4.6	3.6	4.3	5.3	7.5	12.0	8.3	3.5
2.30	4.4	15.6	21.7	15.9	3.6	4.5	5.9	6.8	8.3	16.2	13.1	4.0
2.40	5.0	11.2	17.5	9.5	3.8	5.5	6.5	7.5	11.1	19.8	16.9	5.6
2.50	5.1	17.9	11.6	5.8	4.2	6.0	7.1	8.3	9.4	21.5	24.5	5.7
2.60	3.1	13.3	8.9	4.3	4.3	6.5	9.4	8.2	10.2	20.6	26.5	9.9
2.70	1.7	9.2	5.0	3.2	3.3	7.2	11.5	10.4	8.2	19.2	32.1	8.2
2.80	1.0	5.3	4.1	0.8	2.5	5.7	10.5	11.3	6.5	10.9	16.9	3.8
2.90	0.8	2.1	1.8	0.9	1.6	3.8	7.8	9.0	4.6	6.0	7.6	1.8
3.00	0.1	0.1	0.4	0.5	1.1	2.6	6.1	7.1	2.9	2.4	2.4	0.3
3.10	tr	0.2	0.2	0.1	0.4	1.2	4.2	3.1	1.2	0.3	0.2	tr
3.20	tr	tr	tr	tr	tr	0.1	1.5	1.1	Tr	tr	tr	tr

All measurements in g tr=trace amount of foam no=no change in mass

Table 4.10 Test 15-18 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.2	0.5	0.6	0.5	0.8	1.1	1.0	0.8	0.6	0.6	0.3	0.2
1.50	0.5	0.8	1.1	1.2	1.1	1.5	1.2	1.0	1.0	0.8	0.4	0.2
1.60	0.5	1.6	2.4	2.0	1.3	1.9	1.5	1.5	1.4	1.3	0.6	0.3
1.70	1.3	3.1	4.6	2.8	1.9	1.9	2.1	1.7	2.0	2.1	1.4	0.4
1.80	1.5	5.1	7.4	4.4	2.4	2.1	2.3	2.9	3.5	3.5	1.8	0.7
1.90	1.8	7.3	13.4	6.5	2.6	2.5	2.7	3.0	4.2	4.6	2.5	0.5
2.00	1.3	10.1	16.6	8.6	3.5	2.7	3.1	4.0	6.4	6.6	3.7	1.5
2.10	1.8	7.4	22.0	11.4	3.9	3.3	3.6	4.3	6.9	9.1	6.1	1.8
2.20	3.6	10.9	21.5	11.4	3.6	3.2	3.8	5.0	8.8	12.8	8.5	2.9
2.30	4.2	12.8	17.2	10.5	3.5	4.1	4.9	5.6	8.9	16.3	12.1	3.9
2.40	4.2	11.5	14.5	7.1	3.3	4.8	5.4	5.7	9.7	19.3	14.8	5.2
2.50	4.7	13.6	11.4	5.4	3.9	5.0	6.1	7.1	10.0	20.1	21.2	5.7
2.60	4.0	12.9	8.0	3.8	3.8	5.4	7.9	7.4	10.3	20.7	23.8	7.0
2.70	2.9	10.9	5.9	3.0	3.3	5.7	8.7	8.6	9.2	17.4	24.8	7.0
2.80	2.5	7.2	5.3	1.2	2.5	4.9	8.9	10.1	8.5	12.9	15.0	4.1
2.90	1.6	4.3	3.0	1.5	1.8	4.0	7.1	9.0	7.4	7.1	7.8	1.9
3.00	0.1	1.5	1.4	0.9	1.0	2.5	6.4	7.8	5.6	3.4	2.1	0.5
3.10	0.1	0.5	0.4	0.3	0.7	1.3	5.2	5.9	3.6	1.7	0.3	0.1
3.20	0.0	0.0	0.0	0.0	0.1	0.4	2.2	3.8	2.2	0.5	0.0	0.0

All measurements in g

Table 4.11 Test 15-18 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	2.28	2.28	0.05
Y Right	2.48	2.48	0.04
X Left	-0.33	-0.33	0.03
X Right	0.31	0.31	0.00

Table 4.12 Aspirated Foam 15° Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
15	32.1	1174.5
16	29.4	1113.7
18	24.7	1139.4

The complete data collected as well as contour graphs of the data are available in Appendix D. The three tests were all similar, so test 15 will be discussed below.

As can be seen in Figure 4.5, there were once again two regions of concentrated mass. For this case, the regions were farther apart than they had been for the previous two nozzle angles. The regions were approximately 1.0 m long and 0.50 m wide. Once again, the region on the left was closer to the nozzle than the one on the right, but the region on the right had the highest concentration of mass. Figure 4.6 is the footprint of the average data.

Figure 4.5 Aspirated Foam 15º Mass Distribution Results

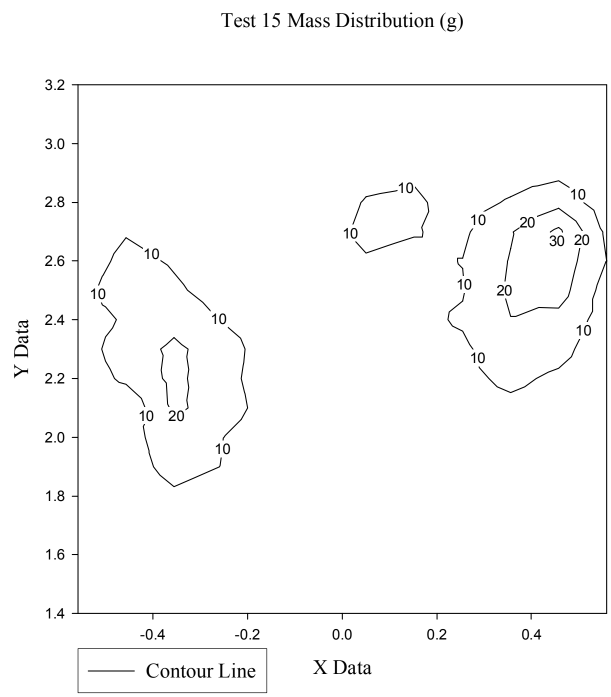
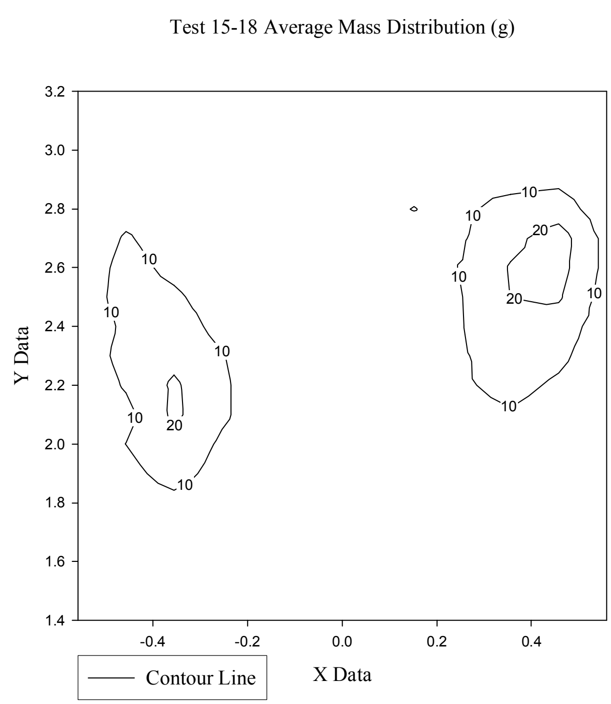


Figure 4.6 Tests 15-18 Average Mass Distribution



4.1.2 Nonaspirated Foam

The nonaspirated foam was white in color and did not have noticeable bubbles. The footprint was not as wide or as long as had been the case with the aspirated foam. The flow appeared similar to that of water.

4.1.2.1 Zero Degrees above the Horizon

Five tests using nonaspirated foam were conducted with the MILSPEC nozzle parallel to the floor. The tests were numbered 23-27 and lasted for 5 s each. The amount of mass collected in each cup and the contour graphs of this data is available in Appendix E. Table 4.13 shows the raw data from test 23 and Table 4.14 shows the raw data from the average of the five tests. Also, Table 4.15 gives the location of the center of mass for each of the jets (treating the distribution as both a single jet and two jets) in all five tests. The maximum amount of foam collected in a single cup as well as the total amount of foam collected by all cups for each test is shown in Table 4.16.

Table 4.13 Test 23 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	no	no	no	0.1	0.8	0.3	0.2	0.1	0.1	no	no	no
0.50	no	no	no	1.8	1.6	2.0	1.8	0.9	0.1	no	no	no
0.60	no	no	0.1	43.3	34.7	8.9	8.7	5.0	0.3	0.1	no	no
0.70	no	0.1	tr	1.9	31.7	50.9	56.0	78.5	5.2	0.1	no	no
0.80	no	no	no	tr	1.3	29.6	55.3	12.1	0.2	0.1	no	no
0.90	no	no	no	tr	0.1	1.3	2.6	0.5	0.2	tr	no	no
1.00	no	no	no	no	0.1	0.1	0.2	0.1	0.1	no	no	no
1.10	no	no	no	no	no	no	no	no	no	no	no	no
1.20	no	no	no	no	no	no	no	no	no	no	no	no
1.30	no	no	no	no	no	no	no	no	no	no	no	no
1.40	no	no	no	no	no	no	no	no	no	no	no	no
1.50	no	no	no	no	no	no	no	no	no	no	no	no
1.60	no	no	no	no	no	no	no	no	no	no	no	no
1.70	no	no	no	no	no	no	no	no	no	no	no	no
1.80	no	no	no	no	no	no	no	no	no	no	no	no
1.90	no	no	no	no	no	no	no	no	no	no	no	no
2.00	no	no	no	no	no	no	no	no	no	no	no	no
2.10	no	no	no	no	no	no	no	no	no	no	no	no
2.20	no	no	no	no	no	no	no	no	no	no	no	no

All measurements in g tr=trace amount of foam no=no change in mass

Table 4.14 Tests 23-27 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.3	0.3	0.4	0.1	0.1	0.0	0.0	0.0
0.50	0.0	0.0	0.0	0.5	0.5	1.1	1.3	0.8	0.2	0.1	0.0	0.0
0.60	0.0	0.0	0.1	16.4	27.0	4.8	7.6	4.4	3.8	0.1	0.0	0.0
0.70	0.0	0.0	0.0	5.3	38.0	42.2	46.3	63.0	36.0	0.4	0.0	0.0
0.80	0.0	0.0	0.0	0.1	2.0	27.3	56.9	44.6	1.6	0.1	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.1	2.2	5.8	2.3	0.2	0.1	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.3	0.1	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g

Table 4.15 Tests 23-27 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	0.69	0.69	0.02
Y Right	0.74	0.74	0.01
X Left	-0.12	-0.12	0.01
X Right	0.13	0.12	0.02
Y Total	0.72	0.72	0.01
X Total	0.03	0.03	0.04

Table 4.16 Nonaspirated Foam 0º Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
23	78.5	439.2
24	76.9	433.9
25	69.6	449.8
26	64.8	453.2
27	62.6	450.8

Due to the similarity in the footprints, test 23 will be used to demonstrate the features of the mass distribution for the nonaspirated, 0º case. As can be seen in Figure 4.7, the distribution consisted of the largest concentration being on the right side of the footprint. A "tail" extended to the left and towards the nozzle. The principle mass distribution was located within an area approximately 0.60 m (-0.30 to 0.30 m) wide by 0.40 m (0.50 to 0.90 m) long. Figure 4.8 similarly shows the footprint from the average data.

Figure 4.7 Nonaspirated Foam 0º Mass Distribution Results

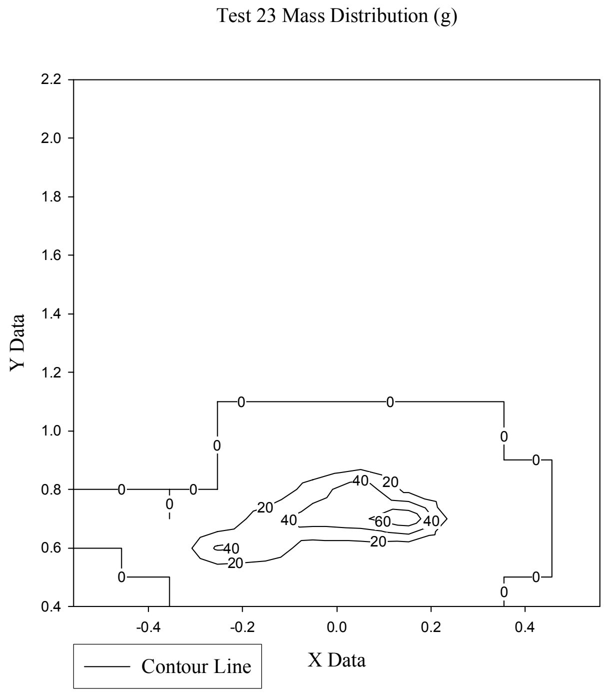
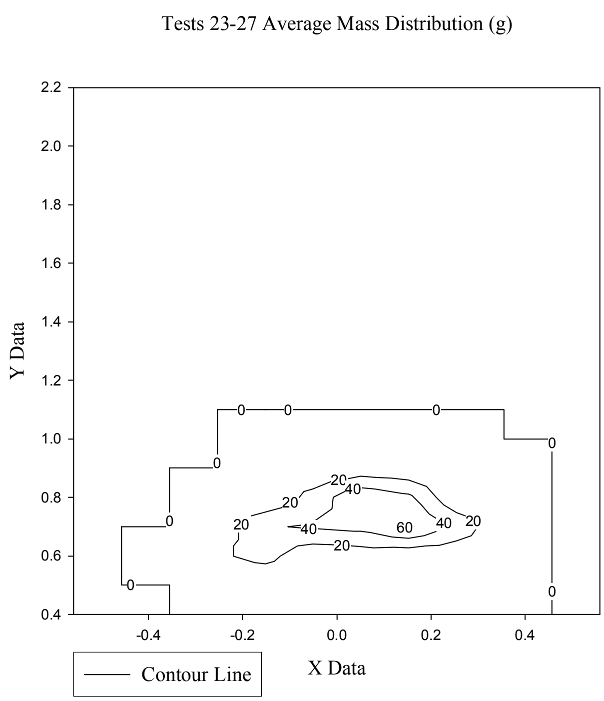


Figure 4.8 Tests 23-27 Average Mass Distribution



4.1.2.2 Fifteen Degrees below the Horizon

Tests 28-30 were three tests conducted with nonaspirated foam and the nozzle angle at -15°. As had been the case with the 0° tests, each test lasted for 5 s. The raw data from test 28 is shown in Table 4.17 and the raw data from the average of the three tests is in Table 4.18. Table 4.19 contains the location of the center of mass for each test. Table 4.20 shows the maximum amount of foam collected in a single cup as well as the total amount of foam collected by all of the cups for each test.

Table 4.17 Test 28 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	no	no	no	tr	0.3	1.2	2.4	0.7	0.5	0.1	no	no
0.50	no	no	0.1	2.8	47.2	8.6	16.3	32.0	9.6	0.1	no	no
0.60	no	no	no	1.9	56.8	59.1	91.0	84.2	2.3	0.1	no	no
0.70	no	no	no	0.1	0.6	14.3	50.1	5.0	0.2	tr	0.1	no
0.80	no	no	no	no	0.2	0.5	2.0	0.4	tr	no	no	no
0.90	no	no	no	no	no	no	no	no	no	no	no	no
1.00	no	no	no	no	no	no	no	no	no	no	no	no
1.10	no	no	no	no	no	no	no	no	no	no	no	no
1.20	no	no	no	no	no	no	no	no	no	no	no	no
1.30	no	no	no	no	no	no	no	no	no	no	no	no
1.40	no	no	no	no	no	no	no	no	no	no	no	no
1.50	no	no	no	no	no	no	no	no	no	no	no	no
1.60	no	no	no	no	no	no	no	no	no	no	no	no
1.70	no	no	no	no	no	no	no	no	no	no	no	no
1.80	no	no	no	no	no	no	no	no	no	no	no	no
1.90	no	no	no	no	no	no	no	no	no	no	no	no
2.00	no	no	no	no	no	no	no	no	no	no	no	no
2.10	no	no	no	no	no	no	no	no	no	no	no	no
2.20	no	no	no	no	no	no	no	no	no	no	no	no

All measurements in g   tr=trace amount of foam no=no change in mass

Table 4.18 Tests 28-30 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.2	1.0	1.9	0.8	0.2	0.1	0.0	0.0
0.50	0.0	0.0	0.0	1.5	26.0	7.0	16.7	28.7	9.5	0.1	0.0	0.0
0.60	0.0	0.0	0.0	2.0	60.6	55.7	90.0	78.0	1.4	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.1	0.6	13.1	47.5	5.1	0.2	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.1	0.5	1.5	0.4	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g

Table 4.19 Tests 28-30 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	0.59	0.59	0.01
Y Right	0.60	0.60	0.01
X Left	-0.11	-0.11	0.00
X Right	0.10	0.10	0.00
Y Total	0.59	0.59	0.01
X Total	0.02	0.02	0.00

Table 4.20 Nonaspirated Foam -15º Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
28	91.0	490.8
29	99.9	421.3
30	81.9	440.0

Appendix F contains the raw data of mass collected per cup for each test as well as the contour plots of the mass distribution. All three tests had similar footprint size and magnitudes. For the discussion here, test 28 (Figure 4.9) will be used to illustrate the trends found within all of the tests. A single, large concentration of foam was found to the right of the nozzle. A "tail" extended to the left as had been seen in the 0º tests. The principle footprint extended from approximately –0.25 to 0.25 m in the x-direction and from 0.40 to 0.80 m in the y-direction. Figure 4.10 shows the average distribution for tests 28-30.

Figure 4.9 Nonaspirated Foam -15º Mass Distribution Results

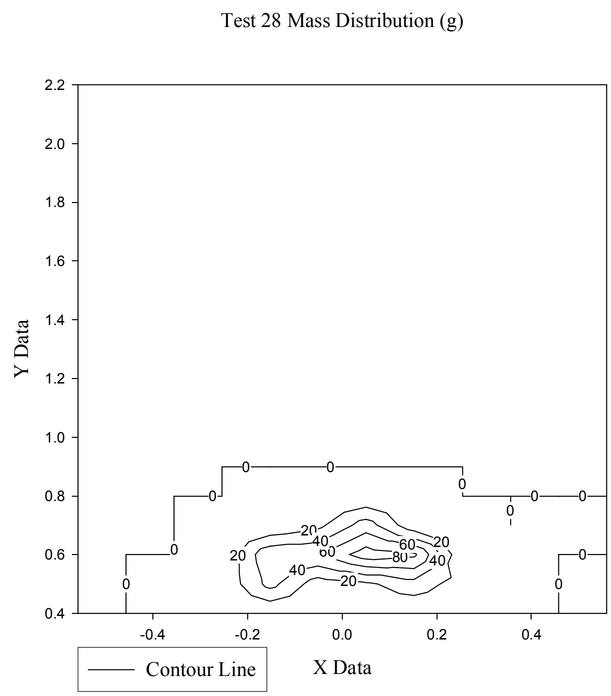
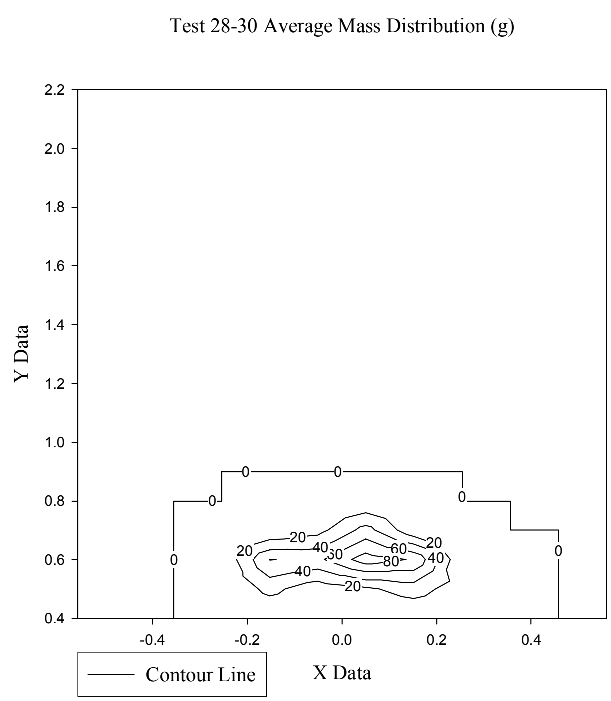


Figure 4.10 Tests 28-30 Average Mass Distribution



4.1.2.3 Fifteen Degrees above the Horizon

Three tests, lasting 5 s each, were conducted with the MILSPEC nozzle rotated 15º above the horizon and using nonaspirated foam. These tests were numbered 31-33. Table 4.21-4.23 gives the mass collected in each cup for test 31, the average mass collected in each cup for tests 31-33, and the center of mass for each of the three tests. Table 4.24 gives the total foam collected by all cups and the maximum value received by a single cup for all tests. The complete data for the mass collected at each cup and contour plots of this data are available in Appendix G.

Table 4.21 Test 31 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	no	no	tr	tr	2.1	2.1	8.2	33.9	0.3	0.1	no	no
0.50	no	no	no	0.1	87.7	45.5	179.4	76.5	0.3	0.1	tr	no
0.60	no	no	no	no	0.8	8.0	22.5	1.1	0.1	tr	0.2	no
0.70	no	no	no	no	0.1	tr	0.1	0.1	no	no	no	no
0.80	no	no	no	no	no	no	no	no	no	no	no	no
0.90	no	no	no	no	no	no	no	no	no	no	no	no
1.00	no	no	no	no	no	no	no	no	no	no	no	no
1.10	no	no	no	no	no	no	no	no	no	no	no	no
1.20	no	no	no	no	no	no	no	no	no	no	no	no
1.30	no	no	no	no	no	no	no	no	no	no	no	no
1.40	no	no	no	no	no	no	no	no	no	no	no	no
1.50	no	no	no	no	no	no	no	no	no	no	no	no
1.60	no	no	no	no	no	no	no	no	no	no	no	no
1.70	no	no	no	no	no	no	no	no	no	no	no	no
1.80	no	no	no	no	no	no	no	no	no	no	no	no
1.90	no	no	no	no	no	no	no	no	no	no	no	no
2.00	no	no	no	no	no	no	no	no	no	no	no	no
2.10	no	no	no	no	no	no	no	no	no	no	no	no
2.20	no	no	no	no	no	no	no	no	no	no	no	no

All measurements in g tr=trace amount of foam no=no change in mass

Table 4.22 Test 31-33 Raw Data

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	4.8	2.5	9.0	34.1	0.2	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	83.5	50.1	183.6	69.6	0.2	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	0.6	7.1	21.0	0.9	0.1	0.0	0.1	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g

Table 4.23 Test 31-33 Center of Mass

	Avg (m)	Mean (m)	SD
Y Left	0.50	0.50	0.00
Y Right	0.49	0.49	0.00
X Left	-0.11	-0.11	0.00
X Right	0.08	0.08	0.00
Y Total	0.50	0.50	0.00
X Total	0.02	0.02	0.00

Table 4.24 Nonaspirated Foam 15º Mass Distribution Results

Test	Maximum Single Cup Foam Mass (g)	Total Mass Collected (g)
31	179.4	469.3
32	187.4	467.3
33	184.1	468.1

All three tests had similar results. The results from test 31 will now be discussed to illustrate the trends seen from this data. As had been the case with the other nonaspirated cases, there was one main concentration of foam on the right side of the distribution with a "tail" extended to the left. This trend is clearly visible in Figure 4.11. The footprint extended for approximately 0.50 m (–0.25 to 0.25) m in the x-direction and 0.20 m (0.40 to 0.60 m) in the y-direction. Of the nonaspirated test series, these distributions had the greatest gradients and concentrations of mass. Figure 4.12 shows the average mass distribution for tests 31-33.

Figure 4.11 Aspirated Foam 15º Mass Distribution Results

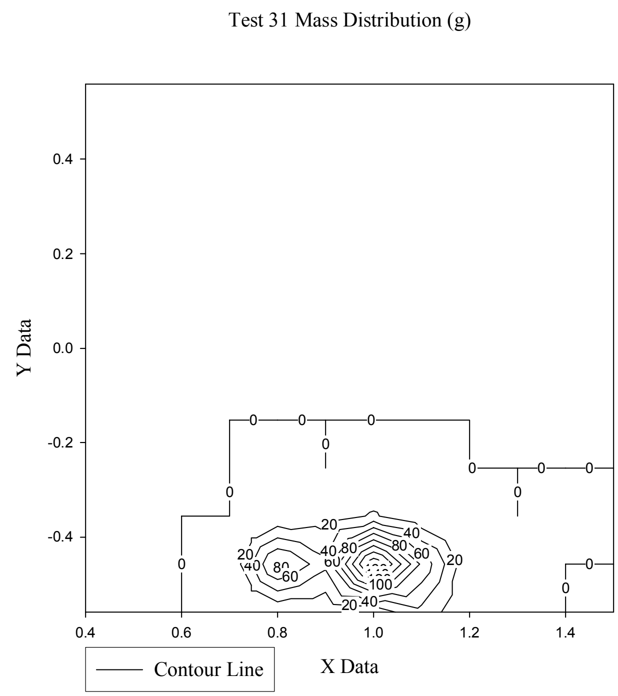
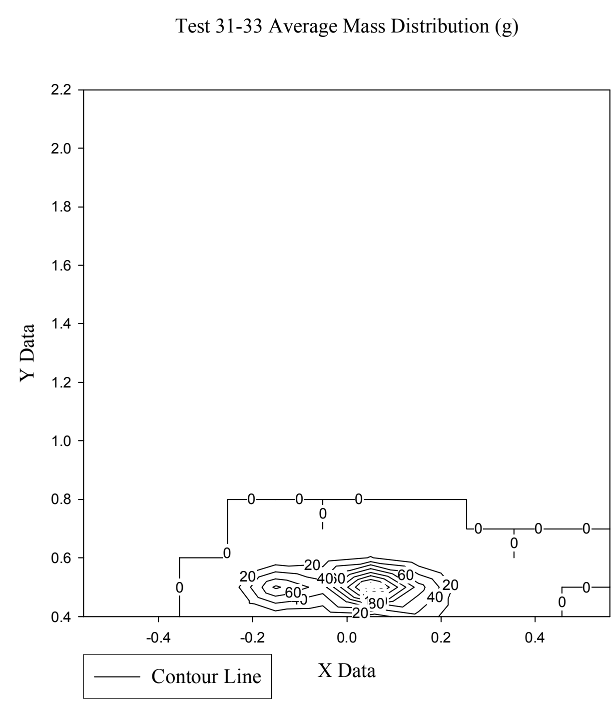


Figure 4.12 Tests 31-33 Average Mass Distribution



4.2 Momentum

Data was collected for the experimental measurement of velocity. Expected values were also determined with the use of the theory presented in the following chapter. These results were then compared with the results from the mass distribution test to see how accurately they predicted what was observed.

Four different types of experiments were conducted. The first examined the velocity of the leading edge of the foam. The second experiments conducted attempted to demonstrate the approximate shape of the jet. The third set of tests examined the trajectories at which the particles were striking the cups. Finally, the fourth type of experiment was used to demonstrate the approximate particle size at the cup level.

4.2.1 Leading Edge Velocity

In order to determine the leading edge velocity, a digital video camera was positioned above the flow and a second digital video camera was located at the side of the flow. A pulse of foam was allowed to leave the nozzle for approximately 3 s and the foam stream was then blocked for approximately 2 s. This was repeated five times for all nozzle angles. Also, tests were conducted with the cameras at approximately 0.2 m and 1.0 m.

The position of the leading edge of the foam was recorded for each frame that was visible for the cameras. Each frame was 1/30 s for the overhead camera and 1/60 s for the side camera. In each case, two sets of trials were conducted. The early flow tests had the cameras positioned near the nozzle. The late flow tests had the cameras positioned to capture the flow as it struck the ground. For the overhead camera, the x-coordinate (for both sides of the nozzle) and the y-coordinate of the leading edge were recorded. For the side camera, the y- and z-coordinates were recorded. The raw data, as well as some analysis of the data described in a later chapter, is available in Appendices H-K as well as in Tables 4.25-4.28. In the overhead camera views, the position of the leading edge was recorded by noting the location of the minimum x-coordinate (x_l), maximum x-coordinate (x_r), and the y-coordinate (y). The velocity was the change of the respective position with respect to time. This is shown in Figure 4.13. Similarly, for the side camera, the horizontal location of the leading edge is the y-coordinate (y) and the vertical location of the leading edge is the z-coordinate (z). This is shown in Figure 4.14.

Figure 4.13 Overhead Camera Diagram

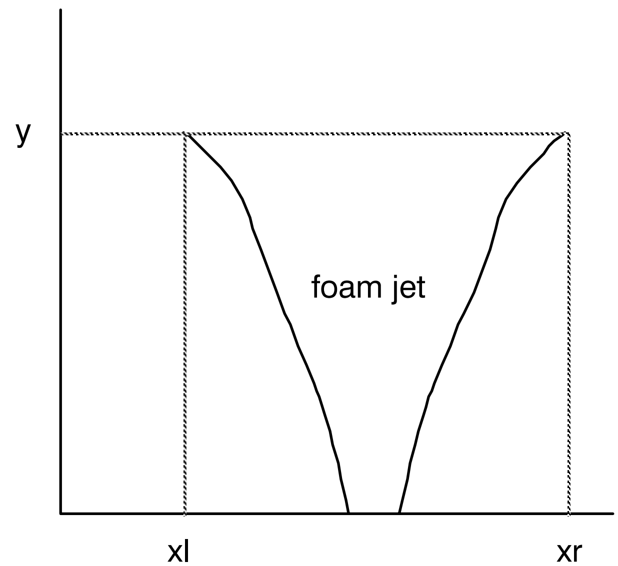


Figure 4.14 Side Camera Diagram

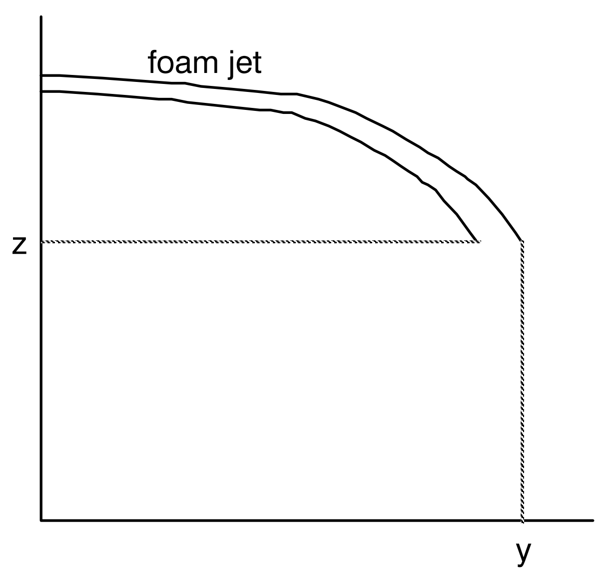


Table 4.25 Early Flow Overhead Camera Data

0 m, 0.2 m, 2m		time step =1/30 s	
0º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.05	0.04	0.00
	-0.08	0.08	0.18
Pulse 2	-0.05	0.01	0.10
	-0.09	0.08	0.25
Pulse 3	-0.04	0.06	0.16
	-0.11	0.10	0.30
Pulse 4	-0.06	0.04	0.01
	-0.12	0.09	0.19
Pulse 5	-0.06	0.08	0.11
	-0.10	0.13	0.28
-15º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.05	0.02	0.09
	-0.07	0.08	0.25
Pulse 2	-0.10	0.05	0.14
	-0.14	0.08	0.31
Pulse 3	-0.07	0.04	0.10
	-0.12	0.09	0.24
Pulse 4	-0.07	0.01	0.00
	-0.11	0.08	0.16
Pulse 5	-0.06	0.03	0.10
	-0.14	0.06	0.26
15º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.05	0.03	0.04
	-0.11	0.06	0.23
Pulse 2	-0.07	0.07	0.05
	-0.10	0.11	0.22
Pulse 3	-0.07	0.04	0.01
	-0.13	0.09	0.14
Pulse 4	-0.04	0.08	0.09
	-0.10	0.11	0.24
Pulse 5	-0.08	0.06	0.00
	-0.13	0.16	0.14

Table 4.26 Late Flow Overhead Camera Data

0 m, 1.0 m, 2m   time step =1/30 s

0º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.21	0.22	0.90
	-0.25	0.25	1.02
	-0.29	0.29	1.17
Pulse 2	-0.18	0.20	0.82
	-0.24	0.23	0.95
	-0.28	0.27	1.09
Pulse 3	-0.18	0.15	0.91
	-0.21	0.21	1.00
	-0.24	0.24	1.13
	-0.29	0.26	1.24
Pulse 4	-0.20	0.19	0.87
	-0.22	0.21	1.03
	-0.23	0.25	1.14
Pulse 5	-0.21	0.20	0.92
	-0.24	0.22	1.06
	-0.28	0.27	1.19
-15º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.14	0.19	0.93
	-0.17	0.20	1.03
	-0.20	0.22	1.14
	-0.22	0.23	1.23
Pulse 2	-0.14	0.16	0.85
	-0.16	0.19	0.96
	-0.19	0.24	1.05
	-0.24	0.27	1.14
Pulse 3	-0.14	0.17	0.95
	-0.16	0.19	1.03
	-0.19	0.23	1.13
	-0.25	0.26	1.22
Pulse 4	-0.17	0.18	0.99
	-0.20	0.22	1.08
	-0.25	0.25	1.18
	-0.27	0.29	1.27

Pulse 5	-0.16	0.17	0.89
	-0.19	0.19	0.98
	-0.23	0.22	1.05
	-0.26	0.26	1.14
	-0.29	0.28	1.22
15º	x_l (m)	x_r (m)	y (m)
Pulse 1	-0.28	0.28	0.95
	-0.32	0.31	1.08
Pulse 2	-0.29	0.29	0.99
	-0.32	0.31	1.13
Pulse 3	-0.27	0.28	0.97
	-0.32	0.32	1.09
Pulse 4	-0.27	0.24	0.98
	-0.31	0.29	1.14
Pulse 5	-0.28	0.26	1.02
	-0.33	0.29	1.12

Table 4.27 Early Flow Side Camera Data

2 m, 0.3 m, 0.5 m   time step =1/60 s

0º	y (m)	z (m)
Pulse 1	0.25	0.99
	0.33	0.98
Pulse 2	0.26	1.00
	0.33	0.99
Pulse 3	0.25	0.99
	0.34	0.99
Pulse 4	0.27	1.00
	0.34	0.99
Pulse 5	0.28	0.99
	0.36	0.99
-15º	y (m)	z (m)
Pulse 1	0.25	0.81
	0.33	0.78
	0.40	0.76

	0.48	0.73
	0.55	0.71
Pulse 2	0.28	0.82
	0.35	0.80
	0.43	0.76
	0.52	0.73
Pulse 3	0.24	0.85
	0.33	0.81
	0.41	0.79
	0.49	0.76
	0.55	0.74
Pulse 4	0.28	0.82
	0.34	0.79
	0.42	0.77
	0.51	0.75
	0.58	0.71
Pulse 5	0.23	0.86
	0.30	0.83
	0.39	0.79
	0.47	0.77
	0.54	0.75
15º	y (m)	z (m)
Pulse 1	0.29	1.05
	0.36	1.06
Pulse 2	0.31	1.06
	0.39	1.07
Pulse 3	0.29	1.07
	0.36	1.07
Pulse 4	0.29	1.07
	0.37	1.07
Pulse 5	0.28	1.05
	0.36	1.06

Table 4.28 Late Flow Side Camera Data

2 m, 1.1 m, 0.5 m		time step =1/60 s
0º	y (m)	z (m)
Pulse 1	1.05	0.77
	1.11	0.73
	1.16	0.70
	1.22	0.66
	1.28	0.63
Pulse 2	1.04	0.75
	1.09	0.72
	1.16	0.68
	1.21	0.66
	1.27	0.63
Pulse 3	1.05	0.76
	1.10	0.74
	1.17	0.71
	1.23	0.68
	1.30	0.65
Pulse 4	1.07	0.75
	1.15	0.72
	1.21	0.70
	1.26	0.67
	1.33	0.64
Pulse 5	1.06	0.72
	1.12	0.68
	1.19	0.66
	1.26	0.63
-15º	y (m)	z (m)
Pulse 1	1.08	0.31
	1.14	0.26
Pulse 2	1.07	0.30
	1.12	0.26
Pulse 3	1.09	0.29
	1.16	0.23
Pulse 4	1.08	0.28
	1.13	0.23

Pulse 5	1.09	0.30
	1.15	0.26
15º	y (m)	z (m)
Pulse 1	1.01	1.02
	1.06	0.99
	1.12	0.95
	1.18	0.93
	1.22	0.90
Pulse 2	1.03	1.00
	1.07	0.98
	1.14	0.96
	1.20	0.93
	1.25	0.91
Pulse 3	1.03	0.99
	1.08	0.97
	1.14	0.94
	1.19	0.93
Pulse 4	1.04	1.00
	1.10	0.99
	1.15	0.96
	1.21	0.93
Pulse 5	1.02	0.99
	1.07	0.97
	1.14	0.95
	1.18	0.92
	1.23	0.90

4.2.2 Side View of Jet

For the side view of the jet, a digital video camera was positioned at –3.0 m, 1.0 m, .75 m. The jet was allowed to leave the nozzle with a solid backdrop in the view of the camera. Figure 4.15 shows the 0º case.

Figure 4.15 Jet Profile

4.2.3 Particle Trajectories

The test locations were chosen to be representative of different aspects of the footprint. Areas that received both high and low concentrations of foam were examined. Similarly, locations were chosen from the right and left side as well as the front and the back of the footprint. The locations of these tests are shown in Figures 4.16-4.18 as well as in Appendices L-N.

Figure 4.16 Aspirated Foam 0º Trajectory Test Locations

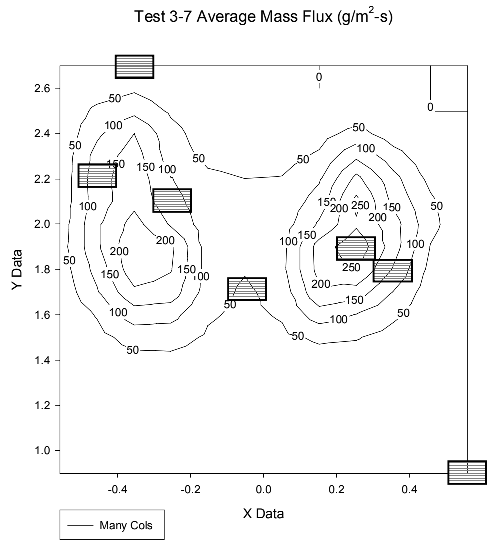


Figure 4.17 Aspirated Foam -15º Trajectory Test Locations

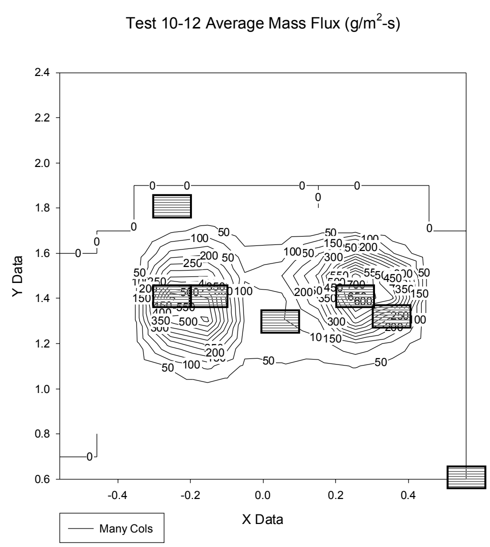
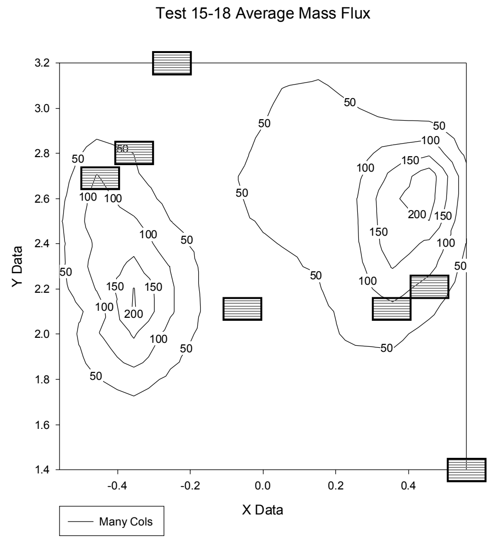


Figure 4.18 Aspirated Foam 15º Trajectory Test Locations



From each of the 21 tests, five foam particles were randomly selected that were visible in consecutive frames and landed within the cup. Only particles that landed in the cup were selected in order to obtain a more accurate estimation of their size. Particles closer to the camera appeared larger than they actually were with respect to the grid placed behind the cup.

The initial position, final position, particle length, and particle height were recorded by hand for all of the droplets. A sample data sheet is available in Appendix O. The raw data, as well as some analysis of the data described in a later chapter, is presented in Appendix P for the 0º case, Appendix Q for the –15º case, and Appendix R for the 15º case. The data for the 0º case is also presented in Tables 4.29-4.35.

Table 4.29 Test 1 Particle Location and Size Data

Test 1	Angle= 0º		x = 0.56 m		y = 0.9 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	0.4	-6.3	1.6	-10.1	1.2	4.3
Particle B	5.6	-3.8	8.4	-11.0	0.9	2.0
Particle C	-2.3	-5.4	0.2	-10.9	0.7	5.1
Particle D	1.9	0.0	2.6	-6.4	0.7	3.5
Particle E	3.3	-0.5	5.7	-7.1	0.5	3.3

Table 4.30 Test 2 Particle Location and Size Data

Test 2	Angle= 0º		x= 0.36 m		y= 1.8m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	3.8	-2.3	5.4	-6.2	0.5	3.8
Particle B	-4.5	0.0	1.3	-6.1	1.2	4.7
Particle C	5.1	0.0	7.9	-7.2	0.9	6.2
Particle D	-5.5	-0.9	-3.4	-5.8	1.2	4.4
Particle E	4.8	-3.3	7.2	-8.8	0.9	5.6

Table 4.31 Test 3 Particle Location and Size Data

Test 3	Angle= 0º		x= 0.25 m		y= 1.9 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	1.4	-3.8	4.1	-8.6	0.7	3.7
Particle B	-4.6	-1.7	-1.0	-7.3	0.8	6.1
Particle C	5.1	-3.7	7.7	-7.8	0.8	7.8
Particle D	1.3	-1.9	2.8	-6.9	0.5	5.3
Particle E	2.3	-3.1	4.4	-7.2	0.6	6.1

Table 4.32 Test 4 Particle Location and Size Data

Test 4	Angle= 0º		x= -0.05 m		y= 1.7 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	1.6	-3.4	3.5	-7.4	0.6	5.1
Particle B	1.4	-4.3	2.7	-6.8	0.6	3.5
Particle C	-2.6	-0.5	0.6	-5.4	0.3	3.7
Particle D	2.5	-5.4	5.4	-11.2	0.5	4.1
Particle E	0.1	-4.9	3.8	-10.9	0.7	4.2

Table 4.33 Test 5 Particle Location and Size Data

Test 5	Angle= 0º		x= -0.25 m		y= 2.1 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	-4.3	0.8	-0.7	-5.2	0.7	4.4
Particle B	-2.0	0.2	2.1	-6.1	1.1	4.8
Particle C	-6.2	-3.8	-2.7	-8.1	0.7	4.1
Particle D	-6.2	-3.8	-3.9	-7.8	0.8	2.5
Particle E	-3.1	0.2	0.4	-5.1	1.1	2.1

Table 4.34 Test 6 Particle Location and Size Data

Test 6	Angle= 0º		x= -0.46 m		y= 2.2 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	0.0	-1.1	1.9	-5.4	0.8	3.1
Particle B	-5.4	-2.8	-1.4	-5.3	0.4	6.9
Particle C	-2.3	0.0	0.9	-5.7	0.5	5.2
Particle D	0.6	-2.8	2.7	-7.2	0.5	4.8
Particle E	1.0	-0.8	4.6	-5.8	0.9	3.8

Table 4.35 Test 7 Particle Location and Size Data

Test 7	Angle= 0º		x= -0.36 m		y= 2.7 m	
	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Height (cm)	Length (cm)
Particle A	-1.1	-3.7	3.6	-8.1	0.9	5.2
Particle B	-2.8	-2.1	4.1	-7.9	0.7	2.1
Particle C	-1.2	-2.9	6.4	-10.9	0.7	4.2
Particle D	4.7	-3.3	8.4	-7.7	0.4	5.6
Particle E	0.2	-1.4	3.9	-3.8	0.3	4.4

4.2.4 Particle Size Distribution

As was mentioned in the previous section, the particle height and length for five particles from each test were recorded and the data is presented in Appendices P-R. Furthermore, two tests were chosen to get a better understanding of the distribution of droplet sizes. Each test lasted approximately five seconds.

The height and length of every particle that was visible in two consecutive frames that landed within the cup were recorded. This data is presented in Appendix S for test 2 (0º, 0.36 m, 1.8 m) and in Appendix T for test 5 (0º, -0.25 m, 2.1 m). Included in the two Appendices are analysis described in a later chapter. The particles tended to be considerably longer than they were high. This data is also presented in Tables 4.29-4.35.

4.3 Summary

The data collected for the mass distribution, velocity, and momentum have been presented. For aspirated foam, the mass distribution was found to consist of two elliptical concentrations that were not symmetric. The mass distribution of nonaspirated foam consisted of a single concentration of mass on the right of the grid with a "tail" extending to the left.

The momentum was found using both hand calculations and experimental data. Values for the hand calculations were approximated by observations of the foam jet. These values were then used to find the velocity and momentum of particles within the flow.

5 Theory

The experimental results yielded raw data that applied to the specific tests conducted in the course of this experiment. This section of the document will attempt to examine the first principles that govern the observed results. From here, the data can be used as a predictive tool.

5.1 Equations

The momentum of the foam jet was found by using the mass flux data. A particle's acceleration was found by calculating all of the forces acting on it. Treating the flow as single particles not affecting each other was assumed. Since the foam is aerated before leaving the nozzle, it was not expected to behave as a pure fluid with the actual properties lying somewhere in between. Therefore, the potential forces acting on the particles included wind, gravity, and drag.

The experiments were conducted at an indoor test facility. Therefore, no wind was assumed to have been present. While there were some drafts, they were assumed to be a secondary effect. Gravity caused a constant acceleration of 9.81 m/s^2 in the z-direction. For the 0º case, the drag force caused an acceleration of $\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot u \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the x-direction,

$\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot v \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the y-direction, and

$\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot w \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the z-direction where d=0.44 if the Reynolds number is greater than 1000. This is the case for all velocities and radii of interest as will be covered later in this chapter.

Combining all of the forces, the equations for the change in acceleration are:

$0+\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot u \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the x-direction,

$0+\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot v \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the y-direction, and

$-9.81+\frac{-0.5 \cdot \rho_a \cdot d \cdot \pi \cdot r^2 \cdot w \cdot \left(u^2+v^2+w^2\right)^{0.5}}{\rho_f \cdot 4/3 \cdot \pi \cdot r^3}$ in the z-direction.

Since the velocity of the particle at a given instant is dependent on the velocity at that instant, small time steps were used to calculate the acceleration at any time. Multiplying the acceleration and the time step gave the change in velocity. Adding this to the velocity from the previous time step gave the velocity at that instant. Similarly, multiplying the velocity by the time step gave the change in position. When this was added to the previous position, the new position of the particle was known. The process was repeated until the particle had reached a position (an individual cup) of interest. Then, the process was repeated with a different initial velocity for the next position of interest. For each initial velocity, the mass from the corresponding cup was assumed to be the appropriate number of particles that had that given initial velocity.

The initial velocities were adjusted for different angles. The u-velocity component for the ±15º cases was the same as the 0º case because the nozzle was not rotated in that direction. Since the nozzle was rotated about the x-axis, the other components changed. The v-velocity component was calculated by taking the v-velocity component from the 0º case and multiplying it by the cosine of the nozzle angle. The w-velocity component was determined by multiplying the v-velocity component from the 0º case and multiplying it by the sine of the nozzle angle.

For the ±15º cases, the initial velocity was then used to calculate the final positions of the droplets using the acceleration equations presented above. The mass flow rate for each location from the 0º case was then applied to the corresponding position for each of the ±15º cases. The distance between the adjacent final positions was then used to find the mass flux for all locations in the new footprints.

5.2 Assumptions

As was previously discussed, the forces acting on the particles were used to approximate the position and velocity of the particles. With this information and the mass flow rate, the momentum could be calculated at any point.

Some assumptions are required in order to use the equations for acceleration. First, the particles were assumed to be the same size and spherical. While this was not true, it will give an approximate solution. Based on video recorded at the cup level, the radius of the particles was assumed to be 0.01 m. Second, the density of the foam was the density of water divided by the expansion ratio. Since the foam was primarily water, this assumption was fairly accurate.

With these assumptions made, the initial velocity for each particle needed to be made. These values for the 0º case are presented in Appendix U. They were found by altering the initial values until the final location of the particle corresponded to one of the cups. An example of a particle's path to a given cup (0.9 m, -0.56 m for aspirated foam at 0º) is shown in Appendix V.

The mass flow rate was assumed to be the mass collected in the cup divided by the duration of the experiment. These mass flow rates for the average 0º case are given in Appendix W.

The initial velocities were then used to predict the location of the particle with the different nozzle angle. The v component of the velocity for the 0º case was multiplied by the cosine of the nozzle angle to determine the new v velocity component and it was multiplied by the sine of the nozzle angle to determine the new w velocity component. The u velocity component was assumed to remain the same. The same cup as shown in Appendix V is again shown in Appendix X to demonstrate how the final position with the -15º nozzle angle is determined. The final position of all particles is available in Appendix Y for the 0º case, Appendix Z for the –15º case, and in Appendix AA for the 15º case.

If the radius of the droplets was altered, the initial velocity needed to land at a given location would change. Table 5.1 shows the required initial v-velocity (in m/s) to reach each row for the 0º case for several different radii.

Table 5.1 Initial Velocities for Different Radii

	Distance (m)					
radius (m)	-	0.1	0.05	0.01	0.005	0.0025
	0.9	2.01	2.03	2.17	2.37	2.90
	1.0	2.24	2.26	2.43	2.68	3.34
	1.1	2.46	2.49	2.69	2.99	3.82
	1.2	2.69	2.72	2.95	3.32	4.33
	1.3	2.92	2.95	3.23	3.66	4.88
	1.4	3.14	3.18	3.50	4.00	5.49
	1.5	3.37	3.41	3.79	4.37	6.14
	1.6	3.59	3.64	4.07	4.74	6.85
	1.7	3.82	3.88	4.36	5.13	7.62
	1.8	4.05	4.11	4.65	5.54	8.45
	1.9	4.28	4.34	4.95	5.96	9.37
	2.0	4.51	4.58	5.25	6.39	10.35
	2.1	4.73	4.82	5.56	6.85	11.44
	2.2	4.96	5.05	5.88	7.32	12.63
	2.3	5.19	5.29	6.19	7.80	13.90
	2.4	5.42	5.53	6.52	8.31	15.32
	2.5	5.65	5.76	6.85	8.83	16.85
	2.6	5.89	6.01	7.19	9.38	18.57
	2.7	6.11	6.25	7.53	9.98	20.40

Measurements are in initial velocities (m/s)

The drag coefficient of 0.44 is valid when the Reynolds number is greater than 1,000. For this case, the Reynolds number is approximated as:

$$\mathrm{Re} = \frac{\rho_f * V * l}{\mu} = \frac{\frac{\rho_w}{E} * V * l}{\mu} = \frac{\frac{1000 \frac{kg}{m^3}}{10.5} * 1\frac{m}{s} * 0.01m}{1.85 \cdot 10^{-5} \frac{kg}{m \cdot s}} \approx 50{,}000$$

Where l is assumed to be the radius of the droplet. While the characteristic length could be related to the path of travel or droplet, this would only increase the Re. The smallest velocity of any of the droplets was over 1 m/s, so the other droplets would have a greater Re. Since the assumptions made led to a conservative Re which is more than an order of magnitude larger than the critical Re, the drag coefficient can be assumed to be 0.44 for all droplets of interest.

5.3 Application

The theory discussed above was applied to the 0º case. The initial velocities were adjusted so that the 0.01 m radius droplets would fall at the location of the cups. From here, the number of droplets per second that would strike the cup was calculated.

5.3.1 Trajectory

The trajectories were calculated by applying the acceleration equations presented above in the x-, y-, and z-directions. From here, the velocity was calculated every 0.001 s by taking the acceleration and multiplying it by 0.001 s. The change in position was similarly calculated by taking the initial velocity and multiplying it by 0.001 s.

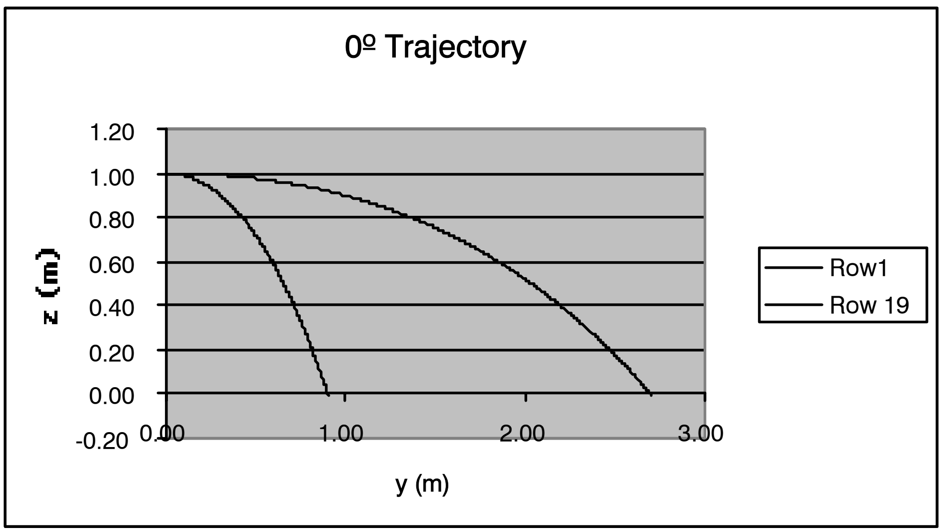
Table 5.2 shows these calculations for the first five time steps for the cup located in the lower right-hand portion of the grid. This process was continued until the z-position of the droplet is negative. Where 0 m was the value assigned to the level of the cup.

Table 5.2 Particle Iteration – Five Steps

x=-.56 m	y= 0.9 m	r= 0.01 m	u_o= -1.36 m/s		v_o= 2.19 m/s	
t	u (m/s)	v (m/s)	w (m.s)	x (m)	y (m)	z (m)
0.001	-1.36	2.19	-0.01	0.00	0.00	1.00
0.002	-1.36	2.19	-0.02	0.00	0.00	1.00
0.003	-1.36	2.19	-0.03	0.00	0.01	1.00
0.004	-1.36	2.18	-0.04	-0.01	0.01	1.00
0.005	-1.36	2.18	-0.05	-0.01	0.01	1.00

This process was conducted for all 228 cups. With this data, the trajectories can be graphed. Figure 5.1 shows the trajectory for the centerline of the 0º case with the bounding droplets. The graph is of the y-position versus the z-position.

Figure 5.1 0º Trajectories

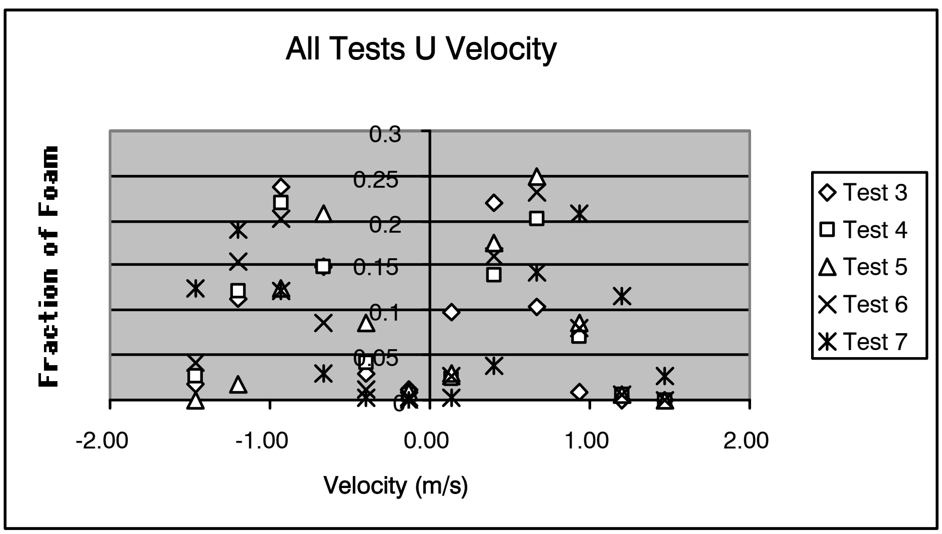


The theoretical trajectories are near parabolic. The dominant components of the motion are in the y- and z-directions.

5.3.2 Predicted Mass Distribution

From the theory developed to find the trajectories, the initial u-velocity in a given column of cups was approximately the same for each cup. Similarly, the initial v-velocity in a given row of cups was approximately the same for each cup. From here, the mass collected in each row and column was plotted. These values are presented in Figures 5.2 and 5.3 below.

Figure 5.2 U-Velocities



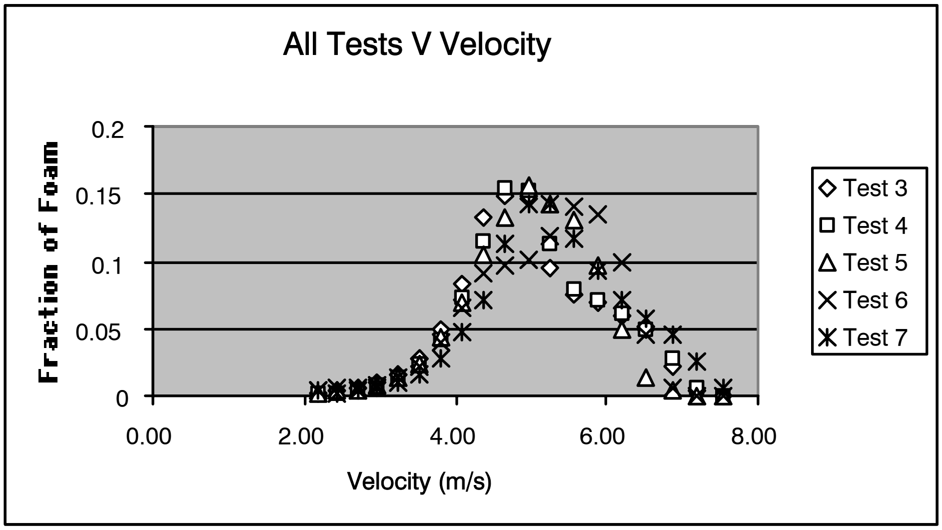


Figure 5.3 V-Velocities

The distribution appears to be nearly Gaussian. As such, Gaussian equations were developed that fit the data. The equations developed were

$0.25 \cdot e^{\frac{-(-0.9-x)^2}{0.09}} + 0.25 \cdot e^{\frac{-(0.6-x)^2}{0.09}}$ and $0.16 \cdot e^{\frac{-(5-x)^2}{1.1}}$.

5.4 Summary

The theory was applied to the data for the 0º case and from this the initial values needed to reach a given cup were calculated. This led to a distribution of mass with a given initial velocity. This data was then approximated by Gaussian equations.

Equations were developed that fit the data for the 0º case. For this to be useful, it needs to have a predictive value. In the next chapter, the equations will be applied to the ±15º cases to demonstrate the validity of the theory.

6 Discussion

Tests were conducted to determine the mass distribution and momentum of the aspirated foam jet from the MILSPEC nozzle. The mass distribution of the nonaspirated foam jet was also found to a limited extent. All characteristics were found with the tip of the nozzle tip one meter above the ground with the nozzle angle parallel to the ground as well as ±15º.

The raw data was transformed into values that could be generalized rather than be specific to the individual test. These transformations, as well as interpretations of the data, are presented in this chapter. Beyond the analysis of the data, consideration is given to the limitations of the data.

6.1 Mass Distribution

The amount of mass collected in each cup in and of itself does not demonstrate the accuracy of the measurements. Nor does it give the data in a form that can be applied to a situation where the grid includes cups with a diameter other than 0.10 m.

6.1.1 Collected Mass

The raw data presented previously was for the amount of foam in each cup. While the intent was to collect all of the foam, some mass did not fall within the cups. It is unknown how much mass was not collected by the cups. In accordance with the MILSPEC standard, the flow rate from the nozzle was tested and found to be 0.118 L/s. With the assumption that the foam was primarily water, the total mass expected for each test was calculated by multiplying the flow rate, density, and time together. Table 6.1 shows the mass collected, expected, and the percentage of the expected mass collected for each test.

Table 6.1 Mass Distribution Collected Foam Results

Test #	Collected (g)	Expected (g)	%
Aspirated, 0º			
3	1196.9	1770	67.6
4	1149.6	1770	64.9
5	1217.2	1770	68.8
6	1224.3	1770	69.2
7	1209.2	1770	68.3
Avg 3-7	1199.4	1770	67.8
Aspirated, -15º			
10	750.3	1180	63.6
11	714.8	1180	60.6
12	774.4	1180	65.6
Avg 10-12	746.5	1180	63.3
Aspirated, 15º			
15	1174.5	1770	66.4
16	1113.7	1770	62.9
18	1139.4	1770	64.4
Avg 15-18	1142.5	1770	64.5
Nonaspirated, 0º			
23	439.2	590	74.4
24	433.9	590	73.5
25	449.8	590	76.2
26	453.2	590	76.8
27	450.8	590	76.4
Avg 23-27	445.4	590	75.5
Nonaspirated, -15º			
28	490.8	590	83.2
29	421.3	590	71.4
30	440.0	590	74.6
Avg 28-30	450.7	590	76.4
Nonaspirated, 15º			
31	469.3	590	79.5
32	467.3	590	79.2
33	468.1	590	79.3
Avg 31-33	468.2	590	79.4

As can be seen in the table, approximately two-thirds to four-fifths of the mass was actually collected. This raises the question of where the missing mass was located and how it altered the footprint of each distribution.

A source of missing mass could come from the collection devices used. Since the cups had circular openings, there were gaps between cups caused by their curvature. Since a fine grid was used, the amount of foam falling within the 0.0103 m^2 square area of the grid per cup, but not within the 0.00709 m^2 area of the cup, could be considered to be at a rate equal to that of the mass collected within the cup if the gradients were not severe. The equivalent mass can be found by multiplying the collected mass by the ratio of the grid square to cup opening (1.43) for each cup. These values for each test as well as contour graphs of the results are available in Appendices AB-AG. This equivalent mass, the expected mass and the percentage are presented in Table 6.2.

Table 6.2 Mass Distribution Equivalent Foam Collected Results

Test #	Collected (g)	Expected (g)	%
Aspirated, 0º			
3	1711.6	1770	96.7
4	1643.9	1770	92.9
5	1740.6	1770	98.3
6	1750.7	1770	98.9
7	1729.2	1770	97.7
Avg 3-7	1715.2	1770	96.9
Aspirated, -15º			
10	1072.9	1180	90.9
11	1022.2	1180	86.6
12	1107.4	1180	93.8
Avg 10-12	1067.5	1180	90.5
Aspirated, 15º			
15	1679.5	1770	94.9
16	1592.6	1770	90.0
18	1629.3	1770	92.1
Avg 15-18	1633.8	1770	92.3
Nonaspirated, 0º			
23	628.1	590	106.5
24	620.5	590	105.2
25	643.2	590	109.0
26	648.1	590	109.8
27	644.6	590	109.3
Avg 23-27	636.9	590	107.9
Nonaspirated, -15º			
28	701.8	590	119.0
29	602.5	590	102.1
30	629.2	590	106.6
Avg 28-30	644.5	590	109.2
Nonaspirated, 15º			
31	671.1	590	113.7
32	668.2	590	113.3
33	669.4	590	113.5
Avg 31-33	669.6	590	113.5

With the mass value changed to reflect the shape of the cup openings, all tests had at least 90% of the expected mass collected and a maximum of 120% collected. While 100% would have been the expected value, several factors prevented this from being a reality.

First, the duration of each test is not the exact value given. The time was determined manually with the use of a stopwatch and the operator then stopping when time had been reached. The mass flux from the nozzle was calculated as 118 g/s. With the tests lasting 15 s or less, assuming an error of ±0.5 s per test, the results could be off by 3.3% due to timing irregularities. For the five-second duration tests, a 0.5 s error leads to a 10% error in the expected mass.

Second, the equivalent mass was based on the assumption that the distribution in the area immediately around the cups was the same as the distribution within the cups. While this is most likely the case for the aspirated foam, the gradients for the nonaspirated foam were much steeper. If the foam jet happened to be striking the cup directly, the percent collected would be greater than expected.

Third, as can be seen in Appendices B-G, several cups in each trial (especially in the aspirated tests) received trace amounts of foam. A trace amount of foam was defined as a visible amount of foam in the cup, but the measured weight was equal to the tare weight. This could account for several grams when integrated over the entire grid.

Fourth, the tare weight and foam mass were only known to the nearest tenth of a gram. The difference was then given in tenths of a gram. A possible error of ±0.05 g per measurement per cup exists. With 228 cups, rounding errors could be larger than 20 g.

Finally, several secondary effects could have played a role in the equivalent mass being different than expected. The density of the foam solution is not exactly that of water, so the exact mass flow rate is not 118 g/s. Furthermore, some foam possibly fell outside of the collection area or foam splashed out of the cups. Another concern was evaporation. This was tested to see how significant a factor it was.

To test the evaporation rate of the foam, several informal trials were conducted. Cups with foam were weighed and then allowed to set for 1 to

24 hours. In all cases, the approximate evaporation rate was 0.1 g/hr. The total time to weigh all cups was approximately one hour. To lessen the effect of evaporation, cups from the areas with greatest mass were weighed first. No adjustments to the data to account for evaporation were performed.

6.1.1.1 Mass Flux

The equivalent mass collected per cup is still specific to these tests only. Time is not accounted for nor is the value given for an average area. This can be accomplished by dividing the equivalent foam collected by the time of the test and the 0.001 m^2 area. These calculated values for each test as well as the contour graphs are available in Appendices AH-AM. These graphs were the basis for the choice of locations for the momentum tests. The transformation of the raw data to the mass flux data for the average, aspirated, 0º case is shown in Tables 6.3. All other angles followed the same process.

Table 6.3 Aspirated Foam 0^o Mass Flux Data

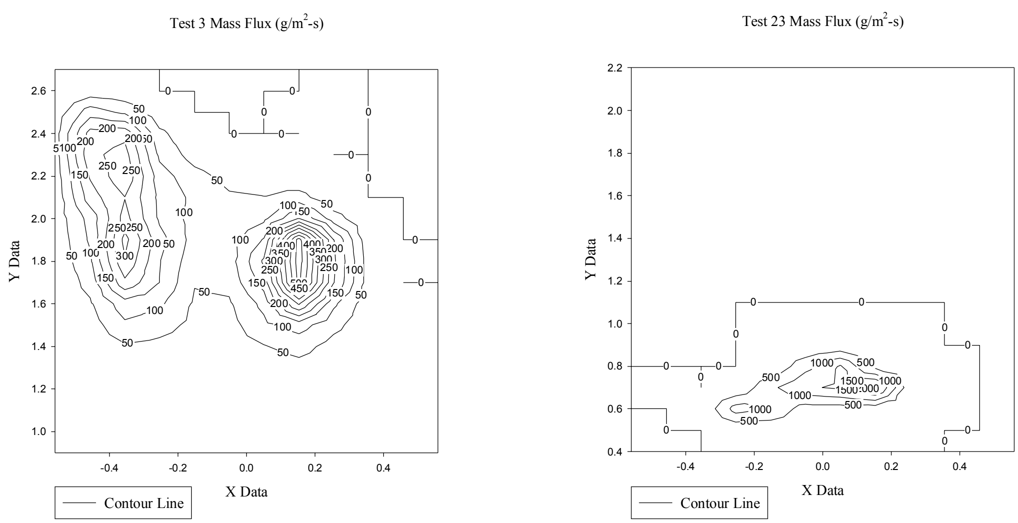
D(m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.4	1.1	2.1	2.3	3.2	9.4	3.9	2.8	2.3	2.8	0.9	0.2
1.00	0.4	1.5	2.8	3.9	4.7	7.7	6.8	4.3	4.3	2.4	0.9	0.9
1.10	0.9	2.6	4.5	6.2	7.5	11.1	7.5	6.8	6.4	3.6	1.3	0.4
1.20	1.7	3.9	9.0	9.0	10.7	15.4	12.8	10.3	9.4	4.9	2.4	0.8
1.30	2.4	8.8	17.6	19.9	17.8	17.4	16.5	19.1	17.3	10.3	3.6	1.3
1.40	4.3	16.5	34.9	36.2	27.9	22.7	25.9	33.9	27.4	18.2	6.6	1.5
1.50	8.4	33.9	69.6	70.9	43.1	28.7	40.3	56.8	53.3	33.0	9.6	3.4
1.60	9.6	53.6	124.7	116.5	56.1	39.0	55.1	127.2	97.9	59.1	18.6	3.2
1.70	13.9	94.3	189.6	178.9	73.1	40.7	72.2	190.2	178.4	97.5	21.8	3.0
1.80	20.8	117.2	233.1	203.3	76.7	54.2	87.0	217.4	252.6	145.2	34.1	6.2
1.90	24.6	139.9	243.8	211.4	75.8	57.0	84.0	222.4	287.1	174.0	47.3	5.4
2.00	19.1	140.8	219.2	144.2	71.5	64.1	75.0	157.7	241.9	172.7	65.8	3.9
2.10	16.7	124.5	186.0	117.2	71.5	60.6	66.2	120.2	264.4	136.7	58.5	2.1
2.20	12.2	128.8	181.7	102.4	61.7	50.3	52.9	94.7	215.5	117.0	36.8	0.6
2.30	11.4	119.3	175.0	74.5	37.9	28.9	30.6	58.1	141.2	71.1	13.9	0.0
2.40	10.3	89.6	150.0	68.5	21.0	10.5	12.8	30.4	67.9	24.4	1.1	0.0
2.50	6.0	62.8	87.2	42.8	7.7	2.3	2.3	6.0	11.8	3.8	0.0	0.0
2.60	0.2	18.9	40.9	16.5	2.1	0.4	0.2	0.0	1.1	0.4	0.0	0.0
2.70	0.0	3.4	8.8	3.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0

All measurements in g/m^2-s

6.1.2 Analysis

The footprint for all aspirated foam tests differed significantly from the footprint for all nonaspirated foam tests. The aspirated foam tests had two peak regions of mass flux that extended principally in the y-direction. Meanwhile, the nonaspirated foam tests had a single peak region with the mass flux extending principally in the x-direction. Figure 6.1 shows representative examples of each.

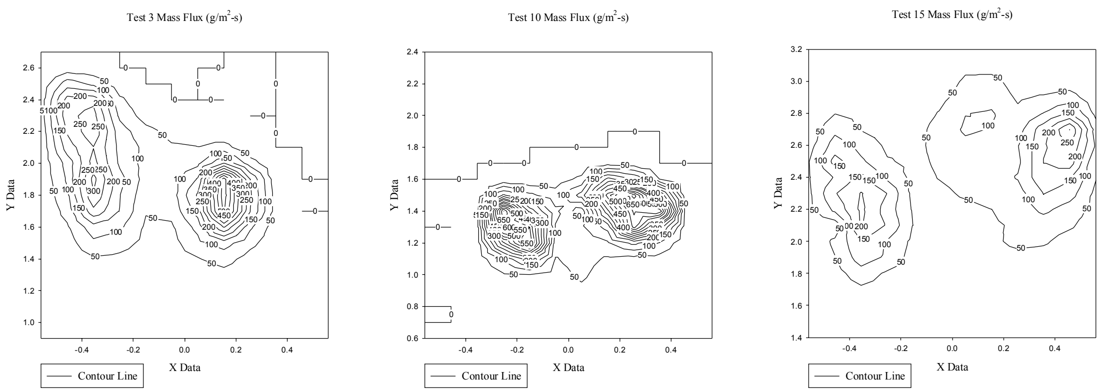
Figure 6.1 Mass Flux for Aspirated and Nonaspirated Foam



6.1.2.1 Aspirated Foam

Three different nozzle angles were examined. As the nozzle angle increased for the aspirated foam, the mass flux had smaller gradients over a larger area. Also, the distance of the footprint to the nozzle also increased with the angle. Figure 6.2 shows the three different footprints.

Figure 6.2 Mass Flux for Aspirated Foam



As expected, the distance of the mass flux peaks increased as the nozzle angle increased. When the nozzle was pointed downward, the initial velocity had a negative z-component that became greater with the contribution of gravity. The 0º case only had a negative z-component due to gravity. Not even accounting for the lesser y-component of the velocity, the –15º case should have had a footprint that fell closer to the nozzle than the 0º case. For the 15º case, the initial z-component of velocity was positive, but the initial y-component was less than the 0º case. Due to the small mass of the foam particles, the distance traveled due to the increased z-component was greater than the difference in the y-component from the 0º case.

The smallest gradients were expected for the cases where the foam traveled farthest. Relative to the footprint area, the foam emerged from a “point” source and fanned out. Since the initial speed and density of the jet was the same for all cases, the further the footprint was located from the nozzle, the longer the foam was in the air. Since the foam was in the air longer, the foam could spread out farther. With the foam spread out over a greater area, the density of the mass flux at a given point was less.

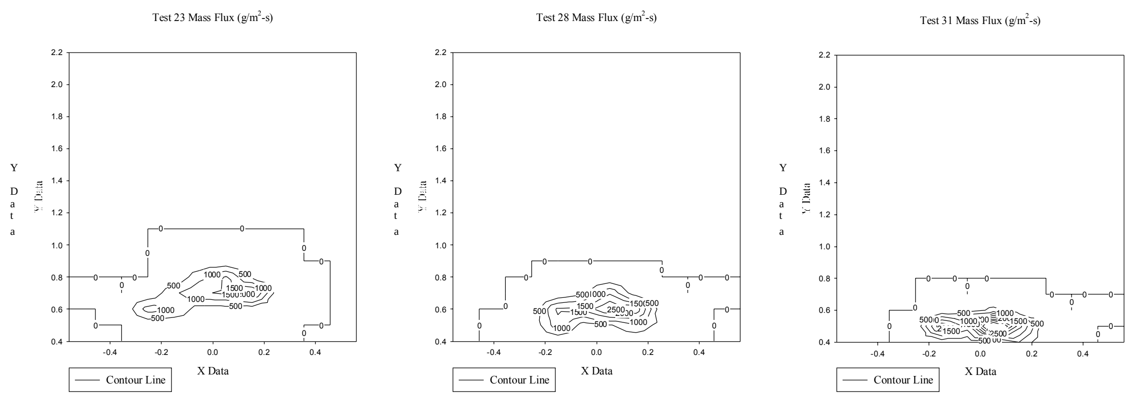
6.1.2.2 Nonaspirated Foam

All three nozzle angles resulted in profiles with similar mass flux gradients. The ±15º cases saw the distance of the peak to the nozzle being closer than the 0º case.

Unlike the aspirated foam that was mainly a collection of individual bubbles, the nonaspirated foam appeared to be a liquid. Due to this, the jet behaved more like that of a fluid. The arguments for why the 0º case should have a footprint further from the nozzle than the –15º case given in the aspirated foam section apply here as well. The lesser initial y-component and negative z-component cause the footprint to be closer to the nozzle. For the 15º case, the mass of the stream is greater than that of the individual fluid particles. Because of this, the stream is not at an elevation above the nozzle angle for as great of a period of time. For the nonaspirated foam, the difference in the initial y-components of the velocities for the 0º and 15º tests prevents the foam in the 15º case from travelling as far as it does in the 0º case.

For all nozzle angles, the mass flux gradients are very steep. The profiles have the same approximate size and maximum values. These similarities are most likely due to a lack of resolution. Without finer resolution, it is not possible to say exactly how the mass flux is varying with position. The exact value at a given position may not be accurately predicted by the mapping. This could be the cause of the single peak rather than the two peaks seen with the aspirated foam. However the location of the center of mass presented two chapters previously indicate that there are probably two jets present. The equipment and time that were needed to fully capture this data were not possible within the scope of this investigation. Future research could examine the footprint of the nonaspirated foam jet. Without the mass distribution for nonaspirated foam, the momentum measurement could not be accurately made. Examples of the three profiles are available in Figure 6.3.

Figure 6.3 Mass Flux for Nonaspirated Foam



6.2 Momentum

The experiments conducted examined the shape of the jet, the leading edge velocity, the trajectories of particles at the cup level, and the size of particles at the cup level. These tests were conducted with the nozzle at all three angles for aspirated foam.

6.2.1 Side View of Jet

The side view of the jet demonstrated the approximate shape of the path that the particles take. For all three nozzle angles, the path appears parabolic. In the 0º case, the foam initially travels primarily in the y-direction. After approximately 0.4 m, the foam starts to descend much more rapidly. For the

–15º case, the jet immediately has a significant decrease in height; the parabolic arc is less noticeable. Finally, for the 15º case, the jet initially rises until approximately 0.4 m. At this point, the droplets start to descend. This behavior is shown in Figures 6.4-6.6.

Figure 6.4 0º Jet Profile

Figure 6.5 –15º Jet Profile

Figure 6.6 15° Jet Profile

6.2.2 Leading Edge Velocity

The leading edge velocity was captured by the method described in the previous chapter. Two cameras were used to track particles as they moved. The change in position divided by the time step determined the velocity for each particle. These velocities are presented in Appendices H-K as well as in Tables 6.4-6.7.

Table 6.4 Early Flow Overhead Camera Data

0 m, 0.2 m, 2m time step =1/30 s

0º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.04	0.00			
	-0.08	0.08	0.18	-0.9	1.2	5.4
Pulse 2	-0.05	0.01	0.10			
	-0.09	0.08	0.25	-1.2	2.1	4.5
Pulse 3	-0.04	0.06	0.16			
	-0.11	0.10	0.30	-2.1	1.2	4.2
Pulse 4	-0.06	0.04	0.01			
	-0.12	0.09	0.19	-1.8	1.5	5.4
Pulse 5	-0.06	0.08	0.11			
	-0.10	0.13	0.28	-1.2	1.5	5.1
-15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.02	0.09			
	-0.07	0.08	0.25	-0.6	1.8	4.8
Pulse 2	-0.10	0.05	0.14			
	-0.14	0.08	0.31	-1.2	0.9	5.1
Pulse 3	-0.07	0.04	0.10			
	-0.12	0.09	0.24	-1.5	1.5	4.2
Pulse 4	-0.07	0.01	0.00			
	-0.11	0.08	0.16	-1.2	2.1	4.8
Pulse 5	-0.06	0.03	0.10			
	-0.14	0.06	0.26	-2.4	0.9	4.8
15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.03	0.04			
	-0.11	0.06	0.23	-1.8	0.9	5.7
Pulse 2	-0.07	0.07	0.05			
	-0.10	0.11	0.22	-0.9	1.2	5.1
Pulse 3	-0.07	0.04	0.01			
	-0.13	0.09	0.14	-1.8	1.5	3.9
Pulse 4	-0.04	0.08	0.09			
	-0.10	0.11	0.24	-1.8	0.9	4.5
Pulse 5	-0.08	0.06	0.00			
	-0.13	0.16	0.14	-1.5	3.0	4.2

Table 6.5 Late Flow Overhead Camera Data

0 m, 1.0 m, 2m time step =1/30 s

0º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.21	0.22	0.90			
	-0.25	0.25	1.02	-1.2	0.9	3.6
	-0.29	0.29	1.17	-1.2	1.2	4.5
Pulse 2	-0.18	0.20	0.82			
	-0.24	0.23	0.95	-1.8	0.9	3.9
	-0.28	0.27	1.09	-1.2	1.2	4.2
Pulse 3	-0.18	0.15	0.91			
	-0.21	0.21	1.00	-0.9	1.8	2.7
	-0.24	0.24	1.13	-0.9	0.9	3.9
	-0.29	0.26	1.24	-1.5	0.6	3.3
Pulse 4	-0.20	0.19	0.87			
	-0.22	0.21	1.03	-0.6	0.6	4.8
	-0.23	0.25	1.14	-0.3	1.2	3.3
Pulse 5	-0.21	0.20	0.92			
	-0.24	0.22	1.06	-0.9	0.6	4.2
	-0.28	0.27	1.19	-1.2	1.5	3.9
-15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.14	0.19	0.93			
	-0.17	0.20	1.03	-0.9	0.3	3.0
	-0.20	0.22	1.14	-0.9	0.6	3.3
	-0.22	0.23	1.23	-0.6	0.3	2.7
Pulse 2	-0.14	0.16	0.85			
	-0.16	0.19	0.96	-0.6	0.9	3.3
	-0.19	0.24	1.05	-0.9	1.5	2.7
	-0.24	0.27	1.14	-1.5	0.9	2.7
Pulse 3	-0.14	0.17	0.95			
	-0.16	0.19	1.03	-0.6	0.6	2.4
	-0.19	0.23	1.13	-0.9	1.2	3.0
	-0.25	0.26	1.22	-1.8	0.9	2.7
Pulse 4	-0.17	0.18	0.99			
	-0.20	0.22	1.08	-0.9	1.2	2.7
	-0.25	0.25	1.18	-1.5	0.9	3.0
	-0.27	0.29	1.27	-0.6	1.2	2.7

Pulse 5	-0.16	0.17	0.89			
	-0.19	0.19	0.98	-0.9	0.6	2.7
	-0.23	0.22	1.05	-1.2	0.9	2.1
	-0.26	0.26	1.14	-0.9	1.2	2.7
	-0.29	0.28	1.22	-0.9	0.6	2.4
15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.28	0.28	0.95			
	-0.32	0.31	1.08	-1.2	0.9	3.9
Pulse 2	-0.29	0.29	0.99			
	-0.32	0.31	1.13	-0.9	0.6	4.2
Pulse 3	-0.27	0.28	0.97			
	-0.32	0.32	1.09	-1.5	1.2	3.6
Pulse 4	-0.27	0.24	0.98			
	-0.31	0.29	1.14	-1.2	1.5	4.8
Pulse 5	-0.28	0.26	1.02			
	-0.33	0.29	1.12	-1.5	0.9	3.0

Table 6.6 Early Flow Side Camera Data

2 m, 0.3 m, 0.5 m time step =1/60 s

0º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.25	0.99		
	0.33	0.98	4.8	-0.6
Pulse 2	0.26	1.00		
	0.33	0.99	4.2	-0.6
Pulse 3	0.25	0.99		
	0.34	0.99	5.4	0.0
Pulse 4	0.27	1.00		
	0.34	0.99	4.2	-0.6
Pulse 5	0.28	0.99		
	0.36	0.99	4.8	0.0
-15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.25	0.81		
	0.33	0.78	4.8	-1.8
	0.40	0.76	4.2	-1.2

	0.48	0.73	4.8	-1.8
	0.55	0.71	4.2	-1.2
Pulse 2	0.28	0.82		
	0.35	0.80	4.2	-1.2
	0.43	0.76	4.8	-2.4
	0.52	0.73	5.4	-1.8
Pulse 3	0.24	0.85		
	0.33	0.81	5.4	-2.4
	0.41	0.79	4.8	-1.2
	0.49	0.76	4.8	-1.8
	0.55	0.74	3.6	-1.2
Pulse 4	0.28	0.82		
	0.34	0.79	3.6	-1.8
	0.42	0.77	4.8	-1.2
	0.51	0.75	5.4	-1.2
	0.58	0.71	4.2	-2.4
Pulse 5	0.23	0.86		
	0.30	0.83	4.2	-1.8
	0.39	0.79	5.4	-2.4
	0.47	0.77	4.8	-1.2
	0.54	0.75	4.2	-1.2
15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.29	1.05		
	0.36	1.06	4.2	0.6
Pulse 2	0.31	1.06		
	0.39	1.07	4.8	0.6
Pulse 3	0.29	1.07		
	0.36	1.07	4.2	0.0
Pulse 4	0.29	1.07		
	0.37	1.07	4.8	0.0
Pulse 5	0.28	1.05		
	0.36	1.06	4.8	0.6

Table 6.7 Late Flow Side Camera Data

2 m, 1.1 m, 0.5 m time step =1/60 s

0º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.05	0.77		
	1.11	0.73	3.6	-2.4
	1.16	0.70	3.0	-1.8
	1.22	0.66	3.6	-2.4
	1.28	0.63	3.6	-1.8
Pulse 2	1.04	0.75		
	1.09	0.72	3.0	-1.8
	1.16	0.68	4.2	-2.4
	1.21	0.66	3.0	-1.2
	1.27	0.63	3.6	-1.8
Pulse 3	1.05	0.76		
	1.10	0.74	3.0	-1.2
	1.17	0.71	4.2	-1.8
	1.23	0.68	3.6	-1.8
	1.30	0.65	4.2	-1.8
Pulse 4	1.07	0.75		
	1.15	0.72	4.8	-1.8
	1.21	0.70	3.6	-1.2
	1.26	0.67	3.0	-1.8
	1.33	0.64	4.2	-1.8
Pulse 5	1.06	0.72		
	1.12	0.68	3.6	-2.4
	1.19	0.66	4.2	-1.2
	1.26	0.63	4.2	-1.8
-15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.08	0.31		
	1.14	0.26	3.6	-3.0
Pulse 2	1.07	0.30		
	1.12	0.26	3.0	-2.4
Pulse 3	1.09	0.29		
	1.16	0.23	4.2	-3.6
Pulse 4	1.08	0.28		
	1.13	0.23	3.0	-3.0

Pulse 5	1.09	0.30		
	1.15	0.26	3.6	-2.4
15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.01	1.02		
	1.06	0.99	3.0	-1.8
	1.12	0.95	3.6	-2.4
	1.18	0.93	3.6	-1.2
	1.22	0.90	2.4	-1.8
Pulse 2	1.03	1.00		
	1.07	0.98	2.4	-1.2
	1.14	0.96	4.2	-1.2
	1.20	0.93	3.6	-1.8
	1.25	0.91	3.0	-1.2
Pulse 3	1.03	0.99		
	1.08	0.97	3.0	-1.2
	1.14	0.94	3.6	-1.8
	1.19	0.93	3.0	-0.6
Pulse 4	1.04	1.00		
	1.10	0.99	3.6	-0.6
	1.15	0.96	3.0	-1.8
	1.21	0.93	3.6	-1.8
Pulse 5	1.02	0.99		
	1.07	0.97	3.0	-1.2
	1.14	0.95	4.2	-1.2
	1.18	0.92	2.4	-1.8
	1.23	0.90	3.0	-1.2

For all three nozzle angels, the foam left the nozzle as a fluid. The leading edge velocity varied from 4.9-5.1 m/s. After approximately 0.1-0.2 m in the y-direction, the jet appeared more like two jets. There were dark white lines on the edges of the flow and a semitransparent region in the middle. At approximately 0.4 in the y-direction, the foam was travelling as particles.

By this point, the velocity of the foam had slowed to approximately 3-4 m/s. The slowest velocities were found for the particles from the nozzle at 15º. From this point onward, the foam travels as particles.

6.2.3 Particle Trajectories

As was discussed in the previous chapter, twenty-one tests were conducted with a digital video camera located at cup level focused on individual cups. The initial and final position for five particles was recorded. From these images, trajectories, as well as the speed, of the particles were determined.

The trajectories were calculated by dividing the change in the vertical position (z) by the change in the horizontal position (y) of the particle. This information is available in Appendices P-R as well as in Tables 6.8-6.10. While the particle is also moving perpendicular to the camera lens, this value is much less than the other two directions.

Table 6.8 Aspirated 0º Particle Trajectory Data

Angle= 0º		x= 0.56 m		y= 0.9 m	
Test 1	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	0.4	-6.3	1.6	-10.1	-3.2
Particle B	5.6	-3.8	8.4	-11.0	-2.6
Particle C	-2.3	-5.4	0.2	-10.9	-2.2
Particle D	1.9	0.0	2.6	-6.4	-9.1
Particle E	3.3	-0.5	5.7	-7.1	-2.8
Predicted					-2.5
Angle= 0º		x= 0.36 m		y= 1.8 m	
Test 2	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	3.8	-2.3	5.4	-6.2	-2.4
Particle B	-4.5	0.0	1.3	-6.1	-1.1
Particle C	5.1	0.0	7.9	-7.2	-2.6
Particle D	-5.5	-0.9	-3.4	-5.8	-2.3
Particle E	4.8	-3.3	7.2	-8.8	-2.3
Predicted					-1.3
Angle= 0º		x= 0.25 m		y= 1.9 m	
Test 3	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	1.4	-3.8	4.1	-8.6	-1.8
Particle B	-4.6	-1.7	-1.0	-7.3	-1.6
Particle C	5.1	-3.7	7.7	-7.8	-1.6
Particle D	1.3	-1.9	2.8	-6.9	-3.3
Particle E	2.3	-3.1	4.4	-7.2	-2.0
Predicted					-1.2
Angle= 0º		x= -0.05 m		y= 1.7 m	
Test 4	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	1.6	-3.4	3.5	-7.4	-2.1
Particle B	1.4	-4.3	2.7	-6.8	-1.9
Particle C	-2.6	-0.5	0.6	-5.4	-1.5

Particle D	2.5	-5.4	5.4	-11.2	-2.0
Particle E	0.1	-4.9	3.8	-10.9	-1.6
Predicted					-1.4
Angle= 0º		x= -0.25 m		y= 2.1 m	
Test 5	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	-4.3	0.8	-0.7	-5.2	-1.7
Particle B	-2.0	0.2	2.1	-6.1	-1.5
Particle C	-6.2	-3.8	-2.7	-8.1	-1.2
Particle D	-6.2	-3.8	-3.9	-7.8	-1.7
Particle E	-3.1	0.2	0.4	-5.1	-1.5
Predicted					-1.2
Angle= 0º		x= -0.46 m		y= 2.2 m	
Test 6	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	0.0	-1.1	1.9	-5.4	-2.3
Particle B	-5.4	-2.8	-1.4	-5.3	-0.6
Particle C	-2.3	0.0	0.9	-5.7	-1.8
Particle D	0.6	-2.8	2.7	-7.2	-2.1
Particle E	1.0	-0.8	4.6	-5.8	-1.4
Predicted					-1.1
Angle= 0º		x= -0.36 m		y= 2.7 m	
Test 7	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	-1.1	-3.7	3.6	-8.1	-0.9
Particle B	-2.8	-2.1	4.1	-7.9	-0.8
Particle C	-1.2	-2.9	6.4	-10.9	-1.1
Particle D	4.7	-3.3	8.4	-7.7	-1.2
Particle E	0.2	-1.4	3.9	-3.8	-0.6
Predicted					-0.9

Table 6.9 Aspirated -15º Particle Trajectory Data

Angle= -15º		x= 0.56 m		y= 0.6 m	
Test 8	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	1.3	-0.8	3.5	-6.5	-2.6
Particle B	-6.5	0.2	-4.8	-6.3	-3.8
Particle C	-2.3	-3.4	-0.7	-9.1	-3.6
Particle D	4.9	-1.7	6.7	-6.9	-2.9
Particle E	-0.1	-0.9	1.0	-4.7	-3.5
Predicted					-2.5
Angle= -15º		x= 0.36 m		y= 1.3 m	
Test 9	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	5.6	-2.3	8.7	-8.3	-1.9
Particle B	0.9	-3.0	2.1	-7.4	-3.7
Particle C	4.6	-2.3	6.9	-8.4	-2.7
Particle D	3.7	-3.1	6.9	-8.7	-1.8
Particle E	0.3	-1.2	2.4	-8.8	-3.6
Predicted					-1.4
Angle= -15º		x= 0.25 m		y= 1.4 m	
Test 10	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	1.2	-1.7	3.2	-6.8	-2.6
Particle B	3.2	-3.6	5.8	-7.9	-1.7
Particle C	1.8	-4.1	5.4	-10.3	-1.7
Particle D	4.6	-3.9	7.6	-8.9	-1.7
Particle E	4.3	-3.4	6.6	-7.8	-1.9
Predicted					-1.4
Angle= -15º		x= -0.05 m		y= 1.3 m	
Test 11	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	0.0	-3.3	2.9	-7.7	-1.5
Particle B	-2.7	-0.8	1.3	-7.6	-1.7
Particle C	-3.7	-2.9	0.4	-6.9	-1.0

Particle D	1.2	-3.1	3.4	-7.8	-2.1
Particle E	0.9	-2.2	2.9	-6.4	-2.1
Predicted					-1.4
Angle= -15º		x= -0.15 m		y= 1.4 m	
Test 12	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	0.1	-1.5	3.7	-6.1	-1.3
Particle B	-2.4	-0.7	2.8	-8.6	-1.5
Particle C	-0.8	-2.0	4.1	-8.3	-1.3
Particle D	-4.7	-2.4	-2.6	-6.9	-2.1
Particle E	-2.4	-0.7	3.8	-7.1	-1.0
Predicted					-1.4
Angle= -15º		x= -0.25 m		y= 1.4 m	
Test 13	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	-2.2	-5.1	0.4	-8.3	-1.2
Particle B	-6.1	-0.5	-1.9	-3.4	-0.7
Particle C	0.0	-2.0	4.1	-6.9	-1.2
Particle D	1.1	-2.2	4.3	-6.1	-1.2
Particle E	0.0	-3.3	3.9	-6.7	-0.9
Predicted					-1.4
Angle= -15º		x= -0.25 m		y= 1.3 m	
Test 14	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	2.6	-3.4	4.4	-7.3	-2.2
Particle B	-1.7	-2.4	2.1	-6.9	-1.2
Particle C	-2.7	-2.3	0.3	-7.2	-1.6
Particle D	-5.4	-3.7	-2.1	-6.4	-0.8
Particle E	-3.4	-3.6	-1.9	-6.2	-1.7
Predicted					-1.4

Table 6.10 Aspirated 15º Particle Trajectory Data

Angle= 15º		x= 0.56 m		y= 1.4 m	
Test 15	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	-1.0	1.0	1.2	-4.4	-2.5
Particle B	0.0	-2.1	1.2	-7.1	-4.2
Particle C	3.9	-1.8	5.1	-6.4	-3.8
Particle D	-3.3	-3.3	-2.1	-7.6	-3.6
Particle E	-5.4	-2.9	-3.6	-8.1	-2.9
Predicted					-2.7
Angle= 15º		x= 0.46 m		y= 2.2 m	
Test 16	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	4.4	-3.4	6.9	-9.1	-2.3
Particle B	0.9	-1.1	2.3	-6.8	-4.1
Particle C	3.8	-3.6	5.2	-7.1	-2.5
Particle D	0.1	-3.0	2.2	-6.8	-1.8
Particle E	-2.4	-1.6	-0.5	-4.9	-1.7
Predicted					-1.5
Angle= 15º		x= 0.36 m		y= 2.1 m	
Test 17	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	0.1	-3.3	2.2	-8.8	-2.6
Particle B	-0.3	-3.4	1.2	-8.7	-3.5
Particle C	0.0	-1.2	1.9	-5.2	-2.1
Particle D	-0.7	-0.8	1.1	-5.7	-2.7
Particle E	3.4	-2.8	4.1	-5.3	-3.6
Predicted					-1.6
Angle= 15º		x= -0.05 m		y= 2.1 m	
Test 18	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	-5.4	-4.3	-2.9	-9.1	-1.9
Particle B	0.8	-3.1	3.3	-6.1	-1.2
Particle C	-2.3	-2.4	0.4	-7.3	-1.8

Particle D	0.2	-3.4	4.9	-10.5	-1.5
Particle E	-2.3	-4.4	-0.6	-8.9	-2.6
Predicted					-1.6
Angle= 15º		x= -0.36 m		y= 2.8 m	
Test 19	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	3.7	-4.2	7.7	-8.9	-1.2
Particle B	3.9	-4.4	5.5	-6.9	-1.6
Particle C	-3.3	-1.4	-0.7	-4.8	-1.3
Particle D	2.9	-3.2	5.1	-6.2	-1.4
Particle E	1.7	-2.4	4.9	-4.1	-0.5
Predicted					-1.3
Angle= 15º		x= -0.46 m		y= 2.7 m	
Test 20	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	4.8	0.9	8.5	-5.7	-1.8
Particle B	4.3	-2.4	7.4	-8.5	-2.0
Particle C	-3.2	-2.3	1.2	-8.5	-1.4
Particle D	-4.6	-2.7	-1.4	-8.8	-1.9
Particle E	-5.9	-0.8	-1.4	-6.7	-1.3
Predicted					-1.4
Angle= 15º		x= -0.25 m		y= 3.2 m	
Test 21	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Slope
Particle A	1.4	-2.1	4.7	-8.5	-1.9
Particle B	1.7	-1.8	4.8	-8.2	-2.1
Particle C	-0.6	-0.3	2.1	-6.4	-2.3
Particle D	3.2	-3.5	5.2	-9.9	-3.2
Particle E	-0.9	-0.1	2.9	-6.7	-1.7
Predicted					-1.6

The predicted slopes are also presented in the table. The predictions are from the hand calculations treating the particles as spheres, described in previous chapters and later in this chapter. The predicted slope is calculated in basically the same manner as was presented above. The change in the z position immediately before the foam strikes the cup is divided by the change in the y position.

The speed of the particle was determined by dividing the change in the position of the particle for each direction by the time step (1/60 s) between frames. The square root of the sum of the squares is presented as the speed in Appendices P-R as well as in Tables 6.11-6.13.

Table 6.11 Aspirated 10º Particle Speed Data

Angle= 0º		x= 0.56 m		y= 0.9 m	
Test 1	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	0.4	-6.3	1.6	-10.1	2.4
Particle B	5.6	-3.8	8.4	-11.0	4.6
Particle C	-2.3	-5.4	0.2	-10.9	3.6
Particle D	1.9	0.0	2.6	-6.4	3.9
Particle E	3.3	-0.5	5.7	-7.1	4.2
Predicted					4.3
Angle= 0º		x= 0.36 m		y= 1.8 m	
Test 2	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	3.8	-2.3	5.4	-6.2	2.5
Particle B	-4.5	0.0	1.3	-6.1	5.1
Particle C	5.1	0.0	7.9	-7.2	4.6
Particle D	-5.5	-0.9	-3.4	-5.8	3.2
Particle E	4.8	-3.3	7.2	-8.8	3.6
Predicted					4.8
Angle= 0º		x= 0.25 m		y= 1.9 m	
Test 3	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	1.4	-3.8	4.1	-8.6	3.3
Particle B	-4.6	-1.7	-1.0	-7.3	4.0
Particle C	5.1	-3.7	7.7	-7.8	2.9
Particle D	1.3	-1.9	2.8	-6.9	3.1
Particle E	2.3	-3.1	4.4	-7.2	2.8
Predicted					4.8
Angle= 0º		x= -0.05 m		y= 1.7 m	
Test 4	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	1.6	-3.4	3.5	-7.4	2.7
Particle B	1.4	-4.3	2.7	-6.8	1.7
Particle C	-2.6	-0.5	0.6	-5.4	3.5

Particle D	2.5	-5.4	5.4	-11.2	3.9
Particle E	0.1	-4.9	3.8	-10.9	4.2
Predicted					4.7
Angle= 0º		x= -0.25 m		y= 2.1 m	
Test 5	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	-4.3	0.8	-0.7	-5.2	4.2
Particle B	-2.0	0.2	2.1	-6.1	4.5
Particle C	-6.2	-3.8	-2.7	-8.1	3.3
Particle D	-6.2	-3.8	-3.9	-7.8	2.8
Particle E	-3.1	0.2	0.4	-5.1	3.8
Predicted					5.0
Angle= 0º		x= -0.46 m		y= 2.2 m	
Test 6	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	0.0	-1.1	1.9	-5.4	2.8
Particle B	-5.4	-2.8	-1.4	-5.3	2.8
Particle C	-2.3	0.0	0.9	-5.7	3.9
Particle D	0.6	-2.8	2.7	-7.2	2.9
Particle E	1.0	-0.8	4.6	-5.8	3.7
Predicted					5.1
Angle= 0º		x= -0.36 m		y= 2.7 m	
Test 7	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	-1.1	-3.7	3.6	-8.1	3.9
Particle B	-2.8	-2.1	4.1	-7.9	5.4
Particle C	-1.2	-2.9	6.4	-10.9	6.6
Particle D	4.7	-3.3	8.4	-7.7	3.4
Particle E	0.2	-1.4	3.9	-3.8	2.6
Predicted					5.4

Table 6.12 Aspirated -15° Particle Speed Data

Angle= -15°		x= 0.56 m		y= 0.6 m	
Test 8	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	1.3	-0.8	3.5	-6.5	3.7
Particle B	-6.5	0.2	-4.8	-6.3	4.0
Particle C	-2.3	-3.4	-0.7	-9.1	3.6
Particle D	4.9	-1.7	6.7	-6.9	3.3
Particle E	-0.1	-0.9	1.0	-4.7	2.4
Predicted					4.3
Angle= -15°		x= 0.36 m		y= 1.3 m	
Test 9	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	5.6	-2.3	8.7	-8.3	4.1
Particle B	0.9	-3.0	2.1	-7.4	2.7
Particle C	4.6	-2.3	6.9	-8.4	3.9
Particle D	3.7	-3.1	6.9	-8.7	3.9
Particle E	0.3	-1.2	2.4	-8.8	4.7
Predicted					4.8
Angle= -15°		x= 0.25 m		y= 1.4 m	
Test 10	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	1.2	-1.7	3.2	-6.8	3.3
Particle B	3.2	-3.6	5.8	-7.9	3.0
Particle C	1.8	-4.1	5.4	-10.3	4.3
Particle D	4.6	-3.9	7.6	-8.9	3.5
Particle E	4.3	-3.4	6.6	-7.8	3.0
Predicted					4.8
Angle= -15°		x= -0.05 m		y= 1.3 m	
Test 11	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	0.0	-3.3	2.9	-7.7	3.2
Particle B	-2.7	-0.8	1.3	-7.6	4.7
Particle C	-3.7	-2.9	0.4	-6.9	3.4

Particle D	1.2	-3.1	3.4	-7.8	3.1
Particle E	0.9	-2.2	2.9	-6.4	2.8
Predicted					4.7
Angle= -15º		x= -0.15 m		y= 1.4 m	
Test 12	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	0.1	-1.5	3.7	-6.1	3.5
Particle B	-2.4	-0.7	2.8	-8.6	5.7
Particle C	-0.8	-2.0	4.1	-8.3	4.8
Particle D	-4.7	-2.4	-2.6	-6.9	3.0
Particle E	-2.4	-0.7	3.8	-7.1	5.3
Predicted					4.8
Angle= -15º		x= -0.25 m		y= 1.4 m	
Test 13	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	-2.2	-5.1	0.4	-8.3	2.5
Particle B	-6.1	-0.5	-1.9	-3.4	3.1
Particle C	0.0	-2.0	4.1	-6.9	3.8
Particle D	1.1	-2.2	4.3	-6.1	3.0
Particle E	0.0	-3.3	3.9	-6.7	3.1
Predicted					4.8
Angle= -15º		x= -0.25 m		y= 1.3 m	
Test 14	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	2.6	-3.4	4.4	-7.3	2.6
Particle B	-1.7	-2.4	2.1	-6.9	3.5
Particle C	-2.7	-2.3	0.3	-7.2	3.4
Particle D	-5.4	-3.7	-2.1	-6.4	2.6
Particle E	-3.4	-3.6	-1.9	-6.2	1.8
Predicted					4.8

Table 6.13 Aspirated 15º Particle Speed Data

Angle= 15º		x= 0.56 m		y= 1.4 m	
Test 15	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	-1.0	1.0	1.2	-4.4	3.5
Particle B	0.0	-2.1	1.2	-7.1	3.1
Particle C	3.9	-1.8	5.1	-6.4	2.9
Particle D	-3.3	-3.3	-2.1	-7.6	2.7
Particle E	-5.4	-2.9	-3.6	-8.1	3.3
Predicted					4.3
Angle= 15º		x= 0.46 m		y= 2.2 m	
Test 16	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	4.4	-3.4	6.9	-9.1	3.7
Particle B	0.9	-1.1	2.3	-6.8	3.5
Particle C	3.8	-3.6	5.2	-7.1	2.3
Particle D	0.1	-3.0	2.2	-6.8	2.6
Particle E	-2.4	-1.6	-0.5	-4.9	2.3
Predicted					4.7
Angle= 15º		x= 0.36 m		y= 2.1 m	
Test 17	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	0.1	-3.3	2.2	-8.8	3.5
Particle B	-0.3	-3.4	1.2	-8.7	3.3
Particle C	0.0	-1.2	1.9	-5.2	2.7
Particle D	-0.7	-0.8	1.1	-5.7	3.1
Particle E	3.4	-2.8	4.1	-5.3	1.6
Predicted					4.6
Angle= 15º		x= -0.05 m		y= 2.1 m	
Test 18	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	-5.4	-4.3	-2.9	-9.1	3.2
Particle B	0.8	-3.1	3.3	-6.1	2.3
Particle C	-2.3	-2.4	0.4	-7.3	3.4

Particle D	0.2	-3.4	4.9	-10.5	5.1
Particle E	-2.3	-4.4	-0.6	-8.9	2.9
Predicted					4.6
Angle= 15º		x= -0.36 m		y= 2.8 m	
Test 19	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	3.7	-4.2	7.7	-8.9	3.7
Particle B	3.9	-4.4	5.5	-6.9	1.8
Particle C	-3.3	-1.4	-0.7	-4.8	2.6
Particle D	2.9	-3.2	5.1	-6.2	2.2
Particle E	1.7	-2.4	4.9	-4.1	2.2
Predicted					5.0
Angle= 15º		x= -0.46 m		y= 2.7 m	
Test 20	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	4.8	0.9	8.5	-5.7	4.5
Particle B	4.3	-2.4	7.4	-8.5	4.1
Particle C	-3.2	-2.3	1.2	-8.5	4.6
Particle D	-4.6	-2.7	-1.4	-8.8	4.1
Particle E	-5.9	-0.8	-1.4	-6.7	4.5
Predicted					4.9
Angle= 15º		x= -0.25 m		y= 3.2 m	
Test 21	Initial y (cm)	Initial z (cm)	Final y (cm)	Final z (cm)	Speed (m/s)
Particle A	1.4	-2.1	4.7	-8.5	4.3
Particle B	1.7	-1.8	4.8	-8.2	4.3
Particle C	-0.6	-0.3	2.1	-6.4	4.0
Particle D	3.2	-3.5	5.2	-9.9	4.0
Particle E	-0.9	-0.1	2.9	-6.7	4.6
Predicted					4.6

Presented with this data are also predicted values. The predictions come from the hand calculations treating the particles as spheres, described in previous chapters and later in this chapter. The speed is calculated by taking the square root of the sum of the squares of all three velocity components.

The angle at which the incoming foam enters the cup is generally estimated to be shallower than the experiments indicate, while the velocity is over estimated. The primary cause of these discrepancies is probably due to the assumptions made with respect to the particle shape.

The assumption made in the hand calculation was that the particle was a sphere. However, as will be discussed more in the following section, this was not the case. A fluid travelling through air assumes the most aerodynamical shape. This alters the rate at which the velocities change with respect to one another. Thus, the angle of impact and velocity will change.

A partial explanation for the over estimation of the speed comes from the inclusion of third velocity component in the predicted value and not in the experimental value. It was excluded from the experimental value because the size of the time step (1/60s) was much smaller than any reliable estimation of the velocity in that direction. To examine the importance of this component, test 1 will be considered.

Test 1 is located at the maximum x and minimum y locations of the 0º grid. The initial v-velocity is the smallest for all of the 0º cases, while the initial u-velocity is the greatest. Furthermore, the predicted speed at the cup is the smallest of all cups used in the seven tests. Thus, the relative weight of the u-velocity for this test is greater than it is in all other tests. Using all three velocity components, the predicted speed is 4.3 m/s. Excluding the u-velocity, the predicted speed is 4.1 m/s.

6.2.4 Particle Size Distribution

The particle size was collected for five particles in each of the 21 tests. Additionally, all particles that met the criteria discussed in the previous chapter were recorded for tests 2 and 5. This data is presented in Appendices P-T and in Table 6.14.

Table 6.14 Aspirated 0º Particle Size Data

x= 0.56 m		y= 0.9 m	
Test 1	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	1.2	4.3	1.05
Particle B	0.9	2.0	0.67
Particle C	0.7	5.1	0.78
Particle D	0.7	3.5	0.69
Particle E	0.5	3.3	0.54
x= 0.36 m		y= 1.8 m	
Test 2	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.5	3.8	0.56
Particle B	1.2	4.7	1.08
Particle C	0.9	6.2	0.98
Particle D	1.2	4.4	1.06
Particle E	0.9	5.6	0.95
x= 0.25 m		y= 1.9 m	
Test 3	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.7	3.7	0.70
Particle B	0.8	6.1	0.90
Particle C	0.8	7.8	0.98
Particle D	0.5	5.3	0.63
Particle E	0.6	6.1	0.74
x= -0.05 m		y= 1.7 m	
Test 4	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.6	5.1	0.70
Particle B	0.6	3.5	0.62
Particle C	0.3	3.7	0.40
Particle D	0.5	4.1	0.58
Particle E	0.7	4.2	0.73

x= -0.25 m		y= 2.1 m	
Test 5	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.7	4.4	0.74
Particle B	1.1	4.8	1.03
Particle C	0.7	4.1	0.72
Particle D	0.8	2.5	0.67
Particle E	1.1	2.1	0.78
x= -0.46 m		y= 2.2 m	
Test 6	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.8	3.1	0.72
Particle B	0.4	6.9	0.59
Particle C	0.5	5.2	0.62
Particle D	0.5	4.8	0.61
Particle E	0.9	3.8	0.83
x= -0.36 m		y= 2.7 m	
Test 7	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.9	5.2	0.92
Particle B	0.7	2.1	0.58
Particle C	0.7	4.2	0.73
Particle D	0.4	5.6	0.55
Particle E	0.3	4.4	0.42

Table 6.15 Aspirated 0º Test 2 Particle Size Data

Test 2	Height (cm)	Length (cm)	Eq. Radius (cm)
Particle 1	1.3	4.5	1.13
Particle 2	0.6	3.8	0.64
Particle 3	0.6	4.8	0.69
Particle 4	1.2	4.7	1.08
Particle 5	0.9	6.2	0.98
Particle 6	1.2	4.4	1.06
Particle 7	0.9	5.6	0.95

Particle 8	0.6	4.1	0.65
Particle 9	1.2	6.0	1.17
Particle 10	1.6	8.2	1.58
Particle 11	1.2	5.8	1.16
Particle 12	1.4	7.2	1.38
Particle 13	0.8	3.7	0.76
Particle 14	0.9	5.5	0.94
Particle 15	0.6	5.1	0.70
Particle 16	0.8	4.3	0.80
Particle 17	0.4	6.3	0.57
Particle 18	1.1	4.4	1.00
Particle 19	0.4	4.8	0.52
Particle 20	0.3	3.9	0.40
Particle 21	0.8	5.1	0.85
Particle 22	0.6	5.6	0.72
Particle 23	0.4	4.2	0.50
Particle 24	1.7	5.8	1.46
Particle 25	0.6	3.5	0.62
Particle 26	0.9	5.8	0.96
Particle 27	0.5	4.1	0.58
Particle 28	0.6	4.7	0.68
Particle 29	0.7	3.5	0.69
Particle 30	0.4	6.0	0.56
Particle 31	0.3	4.4	0.42
Particle 32	0.8	5.1	0.85
Particle 33	0.3	4.4	0.42
Particle 34	0.8	4.2	0.80
Particle 35	0.7	3.4	0.68
Particle 36	0.8	5.1	0.85
Particle 37	0.5	6.1	0.66
Particle 38	0.4	4.3	0.51
Particle 39	0.3	4.1	0.41
Particle 40	0.7	3.1	0.66
Particle 41	1.0	4.1	0.92
Particle 42	0.4	5.1	0.53
Particle 43	0.3	5.7	0.46
Particle 44	0.4	3.7	0.48

Table 6.16 Aspirated 0º Test 5 Particle Size Data

Test 5	Height (cm)	Length (cm)	Eq. Radius (cm)
Particle 1	0.7	4.4	0.74
Particle 2	0.8	3.6	0.76
Particle 3	1.1	4.8	1.03
Particle 4	1.2	6.0	1.17
Particle 5	0.8	4.1	0.79
Particle 6	0.5	5.1	0.62
Particle 7	0.7	4.1	0.72
Particle 8	0.4	3.2	0.46
Particle 9	0.5	3.7	0.56
Particle 10	1.1	4.1	0.98
Particle 11	0.7	2.8	0.64
Particle 12	0.6	2.6	0.56
Particle 13	0.8	2.5	0.67
Particle 14	0.7	3.8	0.70
Particle 15	0.7	4.3	0.73
Particle 16	0.4	2.8	0.44
Particle 17	0.6	4.1	0.65
Particle 18	0.4	4.7	0.52
Particle 19	1.1	4.3	0.99
Particle 20	1.2	5.1	1.11
Particle 21	1.6	3.4	1.18
Particle 22	1.1	2.1	0.78
Particle 23	0.4	3.2	0.46
Particle 24	1.2	3.4	0.97
Particle 25	0.8	7.3	0.96
Particle 26	0.6	3.4	0.61
Particle 27	0.3	1.8	0.31
Particle 28	1.5	3.4	1.13
Particle 29	0.4	2.3	0.41
Particle 30	1.2	3.3	0.96
Particle 31	0.7	2.8	0.64
Particle 32	0.6	2.5	0.55
Particle 33	0.4	0.8	0.29
Particle 34	0.6	4.1	0.65

Particle 35	0.8	3.6	0.76
Particle 36	1.1	2.4	0.82
Particle 37	0.6	2.6	0.56
Particle 38	1.4	3.8	1.12
Particle 39	0.8	3.1	0.72
Particle 40	0.7	3.2	0.66

Table 6.17 Aspirated -15º Particle Size Data

x= 0.56 m		y= 0.6 m	
Test 8	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.8	5.3	0.86
Particle B	1.3	3.7	1.05
Particle C	0.4	4.9	0.53
Particle D	0.7	6.1	0.82
Particle E	0.9	4.8	0.90
x= 0.36 m		y= 1.3 m	
Test 9	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.7	4.6	0.75
Particle B	0.3	5.1	0.44
Particle C	0.6	2.8	0.57
Particle D	0.7	4.3	0.73
Particle E	0.4	6.3	0.57
x= 0.25 m		y= 1.4 m	
Test 10	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.4	4.7	0.52
Particle B	0.9	3.7	0.83
Particle C	0.4	4.6	0.52
Particle D	1.2	3.9	1.02
Particle E	0.6	5.4	0.71

x= -0.05 m		y= 1.3 m	
Test 11	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.6	4.1	0.65
Particle B	0.3	2.8	0.36
Particle C	0.4	3.4	0.47
Particle D	0.6	3.2	0.60
Particle E	0.4	1.4	0.35
x= -0.15 m		y= 1.4 m	
Test 12	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.6	3.2	0.60
Particle B	0.7	5.1	0.78
Particle C	0.5	2.7	0.50
Particle D	0.4	2.8	0.44
Particle E	0.6	3.9	0.64
x= -0.25 m		y= 1.4 m	
Test 13	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.7	4.1	0.72
Particle B	0.6	1.8	0.50
Particle C	0.7	2.5	0.61
Particle D	1.1	6.4	1.13
Particle E	0.9	3.1	0.78
x= -0.25 m		y= 1.3 m	
Test 14	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.6	3.3	0.61
Particle B	1.1	5.1	1.05
Particle C	1.3	3.4	1.03
Particle D	0.7	2.8	0.64
Particle E	0.6	2.9	0.58

Table 6.18 Aspirated 15º Particle Size Data

x= 0.56 m		y= 1.4 m	
Test 15	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	1.1	5.1	1.05
Particle B	0.8	5.8	0.89
Particle C	0.7	2.2	0.59
Particle D	0.3	4.1	0.41
Particle E	0.3	2.8	0.36
x= 0.46 m		y= 2.2 m	
Test 16	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.7	3.1	0.66
Particle B	0.9	4.6	0.89
Particle C	0.6	3.8	0.64
Particle D	0.7	5.2	0.78
Particle E	0.4	4.8	0.52
x= 0.36 m		y= 2.1 m	
Test 17	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.8	3.6	0.76
Particle B	0.6	3.6	0.62
Particle C	0.4	3.2	0.46
Particle D	0.4	2.4	0.42
Particle E	0.5	2.8	0.51
x= -0.05 m		y= 2.1 m	
Test 18	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.5	3.8	0.56
Particle B	0.4	2.7	0.43
Particle C	0.8	4.1	0.79
Particle D	0.6	5.2	0.71
Particle E	0.7	4.2	0.73

x= -0.36 m		y= 2.8 m	
Test 19	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.4	4.9	0.53
Particle B	0.6	4.6	0.68
Particle C	0.7	2.9	0.64
Particle D	0.8	3.3	0.73
Particle E	0.3	3.2	0.38

x= -0.46 m		y= 2.7 m	
Test 20	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	0.6	3.7	0.63
Particle B	0.7	3.1	0.66
Particle C	1.1	3.6	0.93
Particle D	1.2	4.1	1.03
Particle E	1.1	2.0	0.77

x= -0.25 m		y= 3.2 m	
Test 21	Height (cm)	Length (cm)	Eq Radius (cm)
Particle A	1.3	4.7	1.14
Particle B	0.8	6.4	0.92
Particle C	0.9	5.8	0.96
Particle D	1.4	3.9	1.13
Particle E	0.6	4.6	0.68

The equivalent radius was determined based on the particles being considered cylinders. The volume was calculated by: $V = \pi \cdot \left(\frac{h}{2}\right)^2 \cdot l$, where h is the height of the droplet and l is the length. This volume was then used to find the radius of a sphere with the same volume by: $r = \left(\frac{V}{\frac{4}{3}\cdot\pi}\right)^{(1/3)}$.

The equivalent radii tended to range from approximately 0.5 to 1 cm. For test 2, the mean equivalent radius was 0.78 cm with a standard deviation of 0.29 cm and for test 5, the mean and standard deviation were 0.73 cm and 0.24 cm respectively. While on the higher end of the spectrum, a 1 cm radius was chosen for use in the hand calculations for two reasons.

In the foam tank, there are no individual particles. When the jet expands, individual particles become visible as the fluid breaks into particles. Presumably, as time progresses, the largest particles continue to break up until an optimal size is reached. Therefore, assuming the droplet is initially at the small end of the spectrum of the final droplet size is not as accurate as a value at the higher end.

Droplet size is not believed to be constant. The particles are not actually spheres because the shape of the droplets is aerodynamically more efficient than a sphere. Because of this, drag is less of a factor. In order to have the approximately correct final velocity for a droplet, a slightly larger volume must be used.

6.3 Theory

Four different types of data were generated from the theory. The first was the radius needed to reach each cup location. The second was the path of the particles. The third was the predicted mass flux. The mass flux was determined from the mass distribution tests described previously and the trajectories. The fourth was two estimations of the initial average velocity.

6.3.1 Radius Variation

The droplets left the nozzle and were collected at the locations found in the mass distribution tests. The cause of the droplets falling at these different locations was probably due to differences in one of two characteristics. These characteristics of the droplets are the initial velocity and the radius. The effect of altering the initial velocity will be discussed later. This section examines the effect of altering the radius.

The 0° aspirated case will be examined as the baseline case. The radius of the particles needed to reach a given row of cups was found using the iterative approach discussed in the previous chapter. As will be discussed later, the average velocity from the foam nozzle was approximately 5 m/s. Table 6.19 shows the radius the droplets would need to have in order to reach the given row of cups.

Table 6.19 Particle Radius Variation

Distance (m)	Radius (m)
0.9	0.00118
1.0	0.00141
1.1	0.00169
1.2	0.00202
1.3	0.00241
1.4	0.00290
1.5	0.00351
1.6	0.00431
1.7	0.00540
1.8	0.00700
1.9	0.00950
2.0	0.01370
2.1	0.02400
2.2	0.07000
2.3	Not Possible
2.4	Not Possible
2.5	Not Possible
2.6	Not Possible
2.7	Not Possible

Approximately 60% of the collected mass were in the rows that the radius of the droplets (based on the theory presented in table 6.19) were within half an order of magnitude as the assumed 0.01 m radius. Furthermore, there are no theoretical radii that would allow the particle to travel more than 2.26 m. This limit is the distance that an object would travel if the only force acting on it was gravity and had an initial v-velocity of 5.0 m/s, an initial w-velocity of 0 m/s, and an initial height of 1.0 m. This was approximately 14% of the collected mass.

Altering the radius to account for the different final y-positions cannot be used to accurately account for all of the found data. Furthermore, it does not correspond to the equivalent radius values found from the side and overhead cameras. While the theory has several approximations built into it, the trend from the predictions is not present in the observed data.

With the lack of a correlation from the observed data and the predicted data, as well as the failure of the theory to account for droplets traveling farther than 2.26 m, the subsequent discussion will only examine the effect of altering the initial velocity. As will be shown, altering the initial velocity agrees closer with the observed data and accounts for all possible locations that the foam particles reached in the mass distribution tests.

6.3.2 Trajectories

The approximate shape of the jet can be calculated from the paths of the particles as was discussed in the previous chapter. A general shape of the jet was determined by displaying the path of the extreme particles with respect to the y and z directions. Figures 6.7-6.9 show the trajectories for the 0º, -15º, and 15º cases respectively. The jets appear to follow parabolic paths.

Figure 6.7 Trajectory of 0º Jet

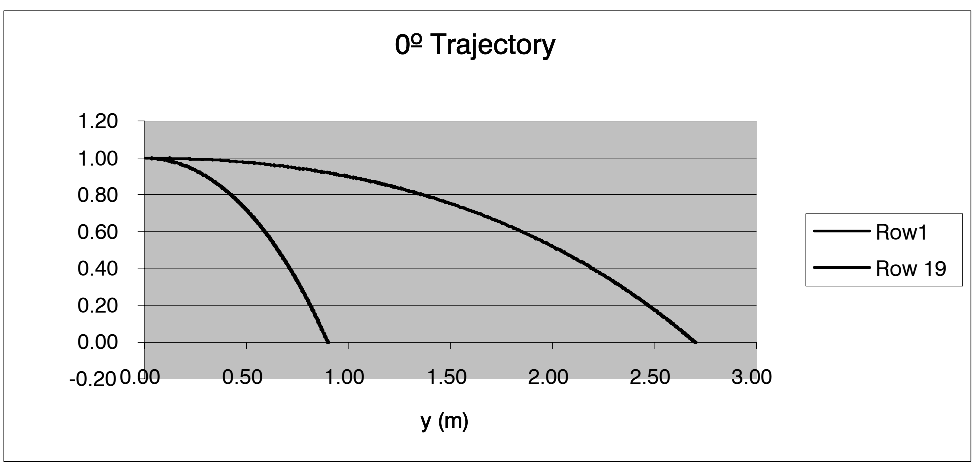


Figure 6.8 Trajectory of -15º Jet

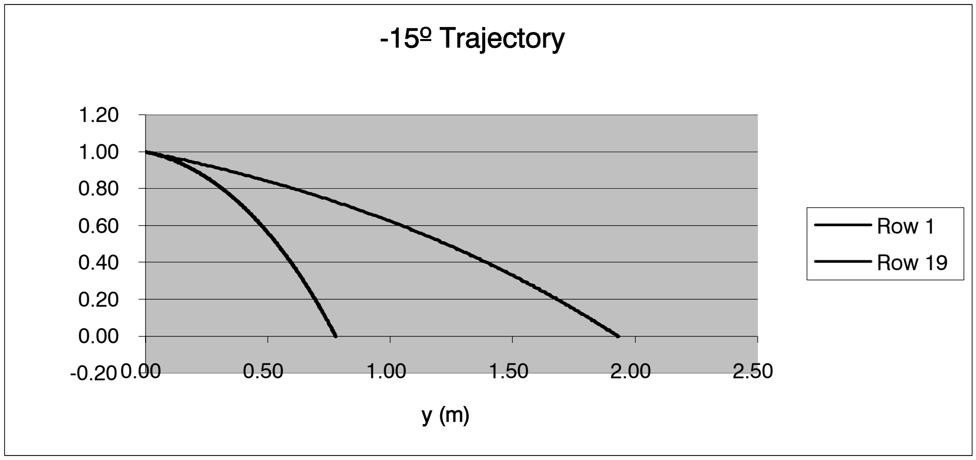
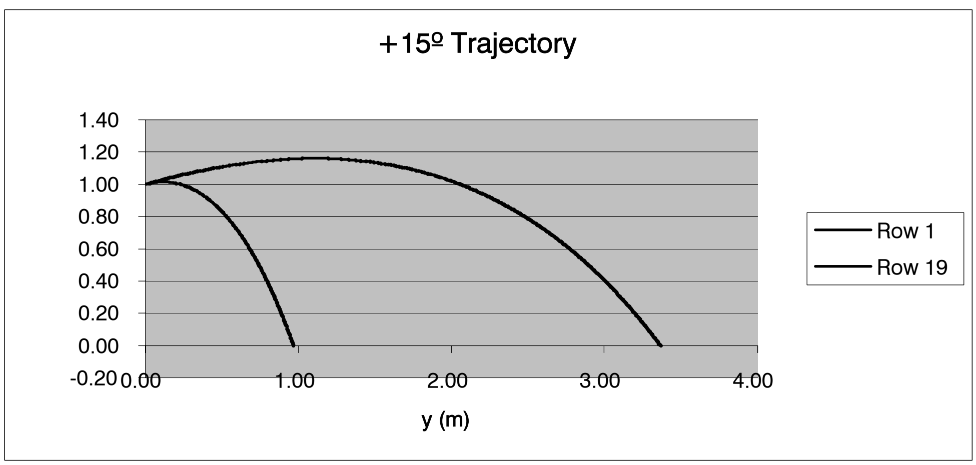


Figure 6.9 Trajectory of 15º Jet



6.3.3 Predicted Mass Distributions

Since the initial velocity required to reach a given cup was approximately constant across a row or column of cups, the percentage of the collected foam that fell in a given row or column were summed. These totals were then plotted to see if there were any trends in the data. The data is presented in Appendix AN and the graphs are presented there as well as in Figures 6.10 and 6.11.

Figure 6.10 U Velocity Mass Fractions at 0º

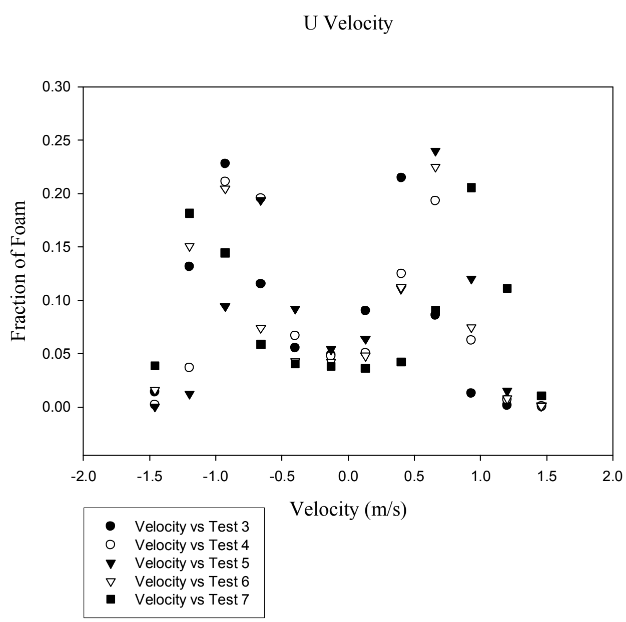
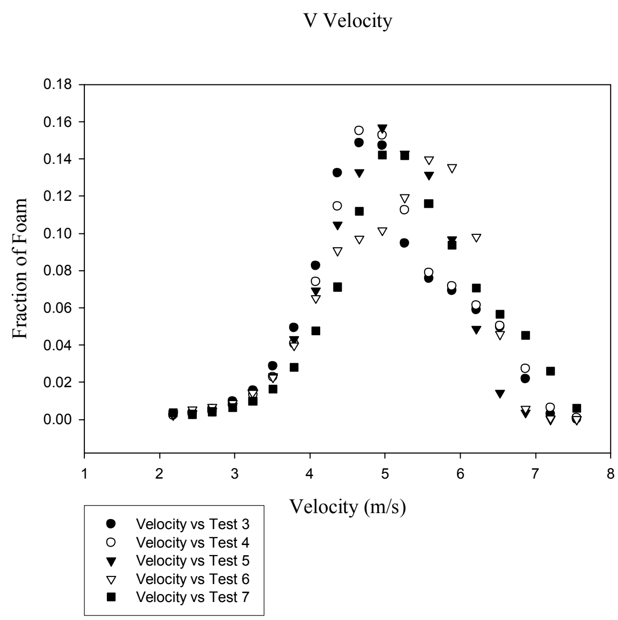


Figure 6.11 V Velocity Mass Fractions at 0º



The distribution appears to be a Gaussian distribution for the v-velocity and two Gaussian distributions for the u-velocity. By approximating the parameters, predicted distributions and a standard deviation above and below were added to the graphs in Figures 6.12 and 6.13.

Figure 6.12 Predicted U Velocity Mass Fractions at 0º

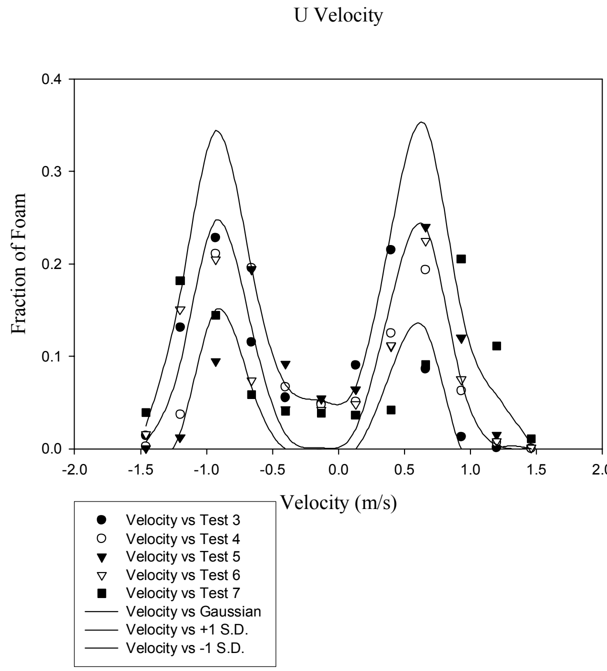
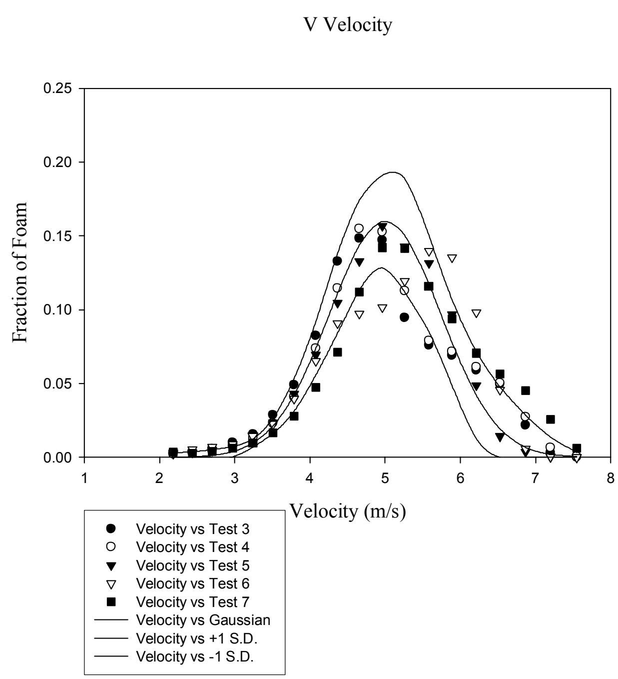


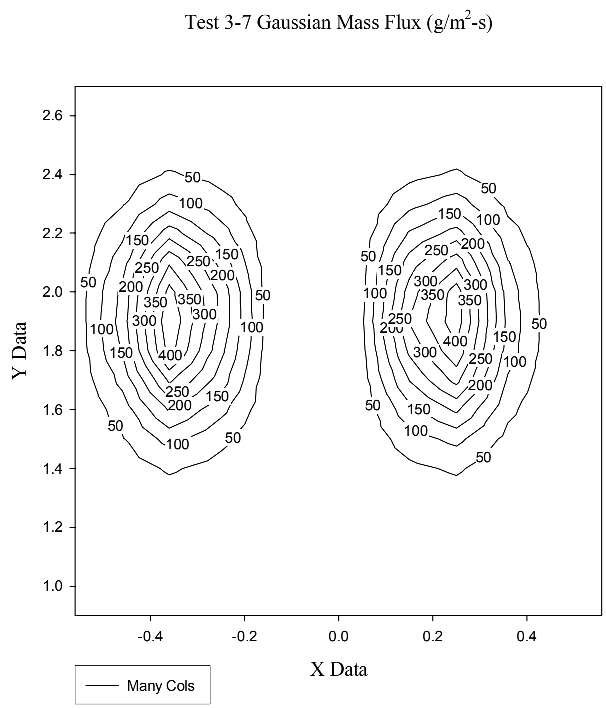
Figure 6.13 Predicted V Velocity Mass Fractions at 0º



The equation for the u-velocity profiles is $0.25 \cdot e^{\frac{-(-0.9-x)^2}{0.09}} + 0.25 \cdot e^{\frac{-(0.6-x)^2}{0.09}}$. For the v-velocity, it is $0.16 \cdot e^{\frac{-(5-x)^2}{1.1}}$. The standard deviations were found using $\left(\sum_{i=1}^{5} \frac{(\bar{y}-y_i)^2}{5-1}\right)^{0.5}$.

Using these initial velocity profiles, the acceleration formulas, and the flow rate from the nozzle, the footprint was calculated. The summary of this data is presented in Appendix AO. The corresponding graph is present there as well as in Figure 6.14.

Figure 6.14 Predicted Mass Flux at 0º



The calculated velocities for the other two cases are then used to find the final positions of particles with the given initial conditions. The Gaussian distribution value was applied to determine the percentage of mass that falls at each location. This value was multiplied by the flow rate and divided by the area of the location to get the mass flux. The raw data is available in Appendix AP for the -15º case and in Appendix AQ for the 15º case. The data is also shown in Figures 6.15 and 6.16. Also presented in Figures 6.15-6.16 are the average mass flux graphs for the respective cases.

Figure 6.15 Predicted and Average Mass Flux at -15º

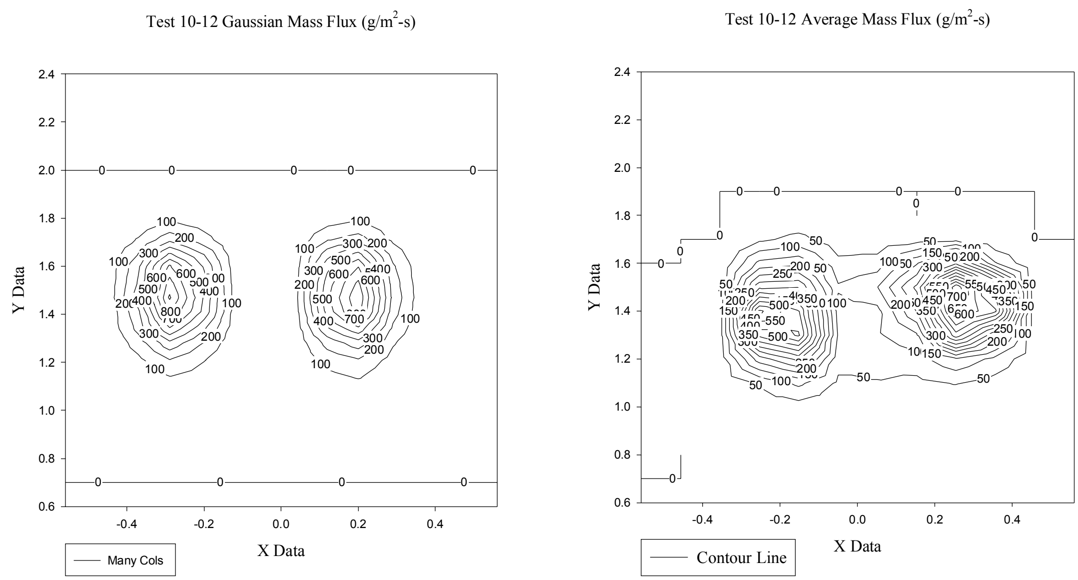
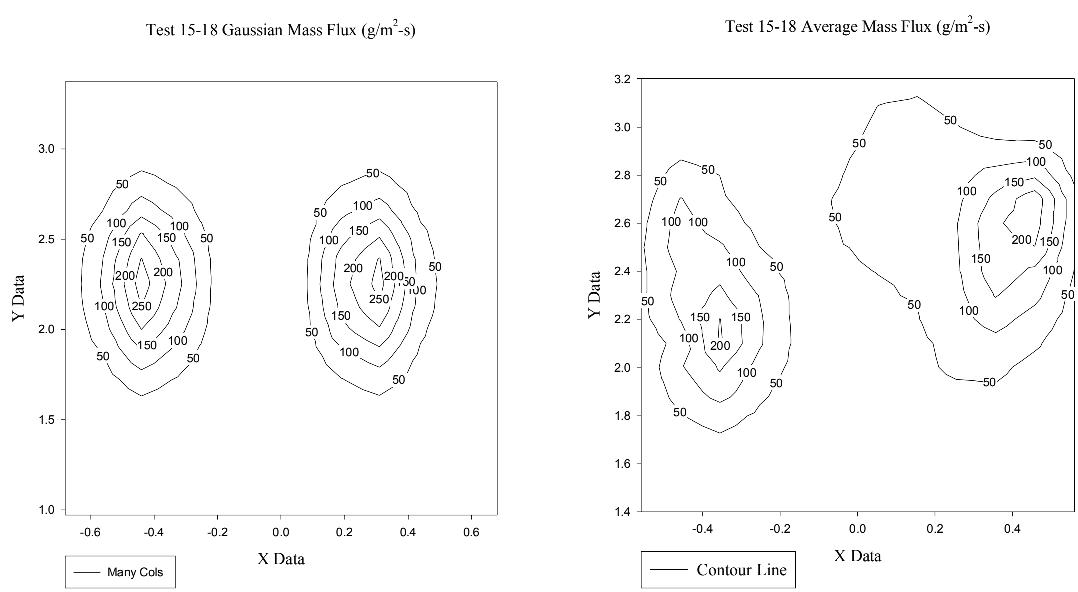


Figure 6.16 Predicted and Average Mass Flux at 15º



6.3.4 Initial Velocity

The average initial velocity was calculated using two different methods. The first method multiplied the flow rate (0.118 L/s) by the volume of a liter of water (0.001 m^3/L) and by the expansion ration of the foam (10.5) and then dividing by the area of nozzle opening (0.05 m by 0.005 m) yields an average velocity of 4.96 m/s. The second method used the initial velocities of the particles calculated previously and averaged the values for all particles. This gave a predicted average velocity of 4.95 m/s. This value also agrees with initial v-velocity of 5 m/s found to be the center of the Gaussian distribution.

6.4 Summary

Future testing will be able to add to the depth and breadth of the data collected in the course of the experiments described in this paper. While some limitations exist, the mass flux and momentum of the aspirated AFFF foam jet have been found for the nozzle at 0º and ±15º.

For the mass flux, two peak regions are visible and the peaks move away from the nozzle and spread out as the angle increases. The momentum was found to be approximately that of particles coming from a point source. Treating the foam jet from the nozzle and calculating the properties of a particle that went to the center of the concentrated area from the mass distribution tests, the expected values from the drag and gravitational forces was approximately the same as the values found using developed equations.

7 Conclusions

The research that has been presented in this paper was intended to develop a method for characterizing the flow from a particular type of spray nozzle. From here, future research can be done that will examine other types of foams and nozzles. However an understanding of which variables were unaccounted for and the full range have potential future applications has not been previously discussed.

7.1 Limitations

In individual sections throughout this paper, limitations with regard to the experimental set up and results were mentioned. This section will address some of these concerns as well as others that may have either affected the results or were beyond the scope of the investigation.

The environment in which the experiments were taking place was not strictly controlled. While being indoors helped limit many of the variabilities confronted by tests done in a natural environment, some possible errors were still introduced. Air currents, while slight, were present as they are in all buildings. The problem here would be most evident with the aspirated foam. Its small mass could lead to its velocity and momentum being easily affected by the air currents in the room. Also, with an evaporation rate of approximately 0.1 g/hr, small errors could exist in the measured mass of the foam collected.

Other limitations on measuring the foam collected include the circular cup openings, all measurements being to the nearest tenth of a gram, and foam splashing out of cups or falling outside of the grid. Also, errors in the expected mass flow could come from the density of the solution and the amount of actual flow time. While these factors by themselves would not greatly affect the mass distribution, and should vary randomly, the net result of all should be approximately zero when taken over all tests and data points. There does exist the possibility that the combination of these factors could lead the results away from the true values.

The nozzle and foam used raises some questions. The foam jet being pressurized as high as 1034 kPa then slowly dropping to 690 kPa before being allowed to spray onto the grid was not expected. It is unknown why this happened and what changes it caused to the footprint. Also, the fan tip nozzle is supposed to be symmetrical. With this symmetry, the mass flux field should be symmetric with respect to the y-axis. It is unknown if the nozzle in the actual MILSPEC test has the same nonsymmetrical profile. The cause of the nonsymmetric profile is unknown, but is most likely due to the manufacturing of the nozzle itself. Finally, to make the nonaspirated foam, the holes that allowed air to mix with the foam solution and water mixture were covered with metallic tape. The number of layers of metallic tape used changed the expansion ratio of the foam. Therefore, it is probable that the quality of the nonaspirated foam would be dependent on the person that applied the tape. If such a dependency exists, then the tests would not be easily repeatable.

Beyond the potential errors due to the environment, measurements, and equipment, the experiments were not accounting for all variables in the MILSPEC test. In the standard test, a person tries to extinguish a fire with the handheld nozzle. The position of this nozzle is rapidly changing and not limited to any bounding conditions. For the tests presented in this paper, the nozzle tip was maintained at 1 m above the ground and only changes in the nozzle angle were considered. Also, the tests were done without the effects of fire that are present in the standardized test.

Finally, nonaspirated foam was not examined for its velocity or momentum. In order to get an accurate mass flux, the grid would have needed to be resolved to an area less than 0.01 m^2. Approximately 1000 grid points would have been needed to accurately map the mass flux. Even with slender measuring devices, the trials would last for only a few seconds. At this small time scale, the error from manually timing the flow would have been on the same order as, if not greater than, the actual values. This would require mechanical control. Thus, new equipment and test procedures would need to be developed. The time and resources required for this level of sophistication were not within the scope of this project.

7.2 Conclusions

The foam jet from nozzles with throws of only a few meters has never been characterized. While there has been some effort to characterize other foam nozzles, these test methods are not well suited for a nozzle like the one used in the MILSPEC tests.

The history of fire fighting foam, 3M's withdrawal from the market, and the environmental concerns surrounding PFOS and PFOA all indicate that new foam concentrate formulations will be developed. Understanding how current nozzles apply foam to fuel surfaces can enable these new formulations to be made better.

Without a current test sequence to characterize nozzles like the one used in the MILSPEC tests and the need to test new foam concentrates, work needs to be done to develop a test procedure for characterizing the foam jets. These tests should be based on the current tests used to characterizing other suppression devices like sprinklers and other types of foam nozzles.

These other devices generally characterize the mass distribution, thrust, velocity, and delivered density. The first three measurements are all collected under ambient conditions. The delivered density, however, is determined when a fire is present. While this value should ultimately be examined, the ambient behavior must be understood before the turbulent fire conditions are introduced.

The work described in this document established methods for determining the mass distribution and momentum for the foam jet from nozzles with throws of only a few meters. These methods were applied to one particular nozzle (MILSPEC) and type of foam (aspirated AFFF).

For the MILSPEC nozzle and AFFF, foam was found to travel in a nearly parabolic path with a distribution that appeared to consist of two jets. Altering the initial velocity of the droplets, and approximating the initial velocities with two Gaussian equations, gave a reasonable prediction of the distribution for nozzle angles other than 0º.

Future work could build upon the data from these tests. Different nozzles and types of foam could be examined using the work presented here. Also, future tests could examine how fire alters the foam jet. Some possible areas of future research will now be discussed.

7.3 Future Research

First, as was mentioned previously, the nonaspirated foam tests could be performed using a finer grid size. This data could also be compared to the results using only water to see how different the nonaspirated properties are from water.

Second, as required in the MILSPEC standard, the properties could be determined for aged foam solution or mixtures with salt water. These conditions are commonly found in the actual use of AFFF. Knowing how this changes the properties of the footprint would be useful in determining what the characteristics will be like in actual use.

Third, tests should be done with a fire present. The fire will greatly change the momentum and velocity of the foam jet. Understanding these changes will enable agents to be designed that will be most effective in reaching the fire in order to extinguish it.

Fourth, a careful examination should be conducted of the operators of the foam nozzles in both the MILSPEC test and in practice. This would give a better understanding of the nozzle height, angle, and rotation commonly used. This information could then be used to examine more cases than were considered in this investigation.

Fifth, using similar methodology presented here, characterize different types of foam. AFFF is not the only foam product on the market nor, in all likelihood, will it always be an agent of choice. These other products should be characterized in a similar manner to see how the agents differ and to see if any combination of traits appears to be more significant.

Finally, more nozzles should be characterized. The MILSPEC nozzle is just one of many foam nozzles. The mass distribution, velocity, and momentum from these other nozzles are generally unknown. Tests based on the ones described here could be performed to characterize these nozzles.

The first step has been taken in characterizing nozzles like the one used in the MILSPEC tests. Future research can allow this process to evolve. The mass distribution and momentum have been determined using experiments that can be applied to similar nozzles or different foam formulations.

Appendix A- Blank Mass Distribution Data Sheet

Test #

	nozzle																							
Dist.(m)	1		2		3		4		5		6		7		8		9		10		11		12	

Pressure __psi
Angle __ ^{o}
Flow Type _____
time __s

The 1-12 are the numbers for the columns of cups. The grid spacing did not change. The center-to-center distance for each column was 0.102 m with the nozzle.

Appendix B- Aspirated 0º Raw Mass Distribution Data

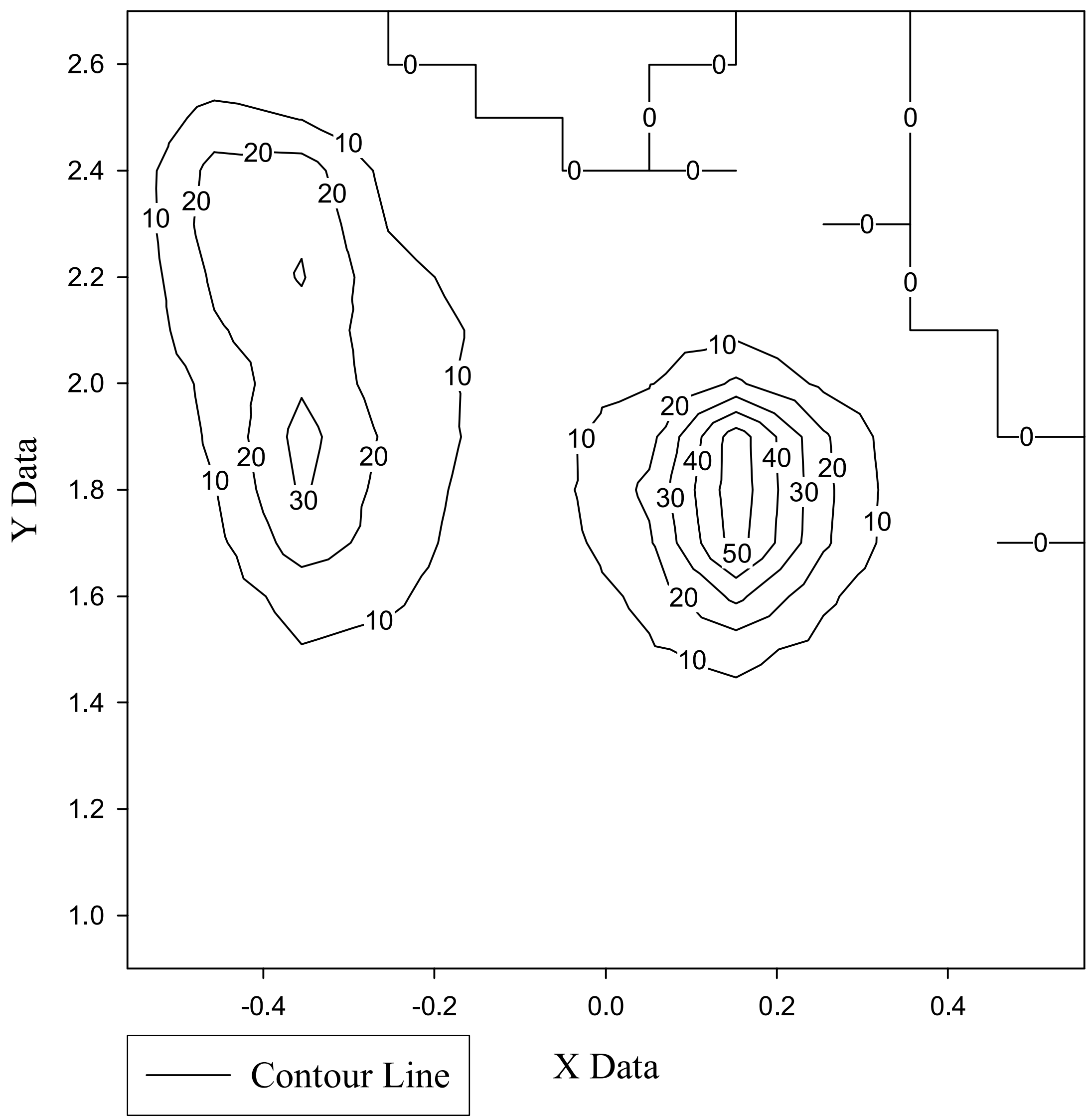
Test 3 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	tr	0.1	0.2	0.3	0.6	0.6	0.4	0.3	0.3	0.3	0.1	tr
1.00	0.1	0.2	0.2	0.5	0.6	0.7	0.7	0.5	0.5	0.2	0.1	0.1
1.10	tr	0.2	0.5	0.7	1.0	1.0	1.0	1.1	1.0	0.4	0.1	tr
1.20	0.1	0.3	1.2	1.1	1.1	2.2	2.1	1.4	1.6	0.6	0.1	tr
1.30	0.1	0.9	1.9	2.1	1.9	2.1	2.3	3.6	2.3	1.1	0.3	0.1
1.40	0.4	2.0	4.7	3.9	2.5	3.5	5.0	7.3	3.4	1.4	0.2	tr
1.50	0.4	2.8	9.6	7.5	3.9	3.5	9.0	13.1	6.8	2.0	0.2	0.1
1.60	0.5	4.6	13.7	11.7	4.6	4.6	12.3	32.6	11.8	2.1	0.3	0.1
1.70	0.4	7.3	25.3	15.9	5.6	6.7	18.5	54.7	21.7	2.6	tr	none
1.80	1.1	9.6	31.5	16.3	7.1	8.0	22.2	56.5	22.5	2.7	0.2	0.1
1.90	1.2	11.5	33.7	18.0	8.4	8.1	16.5	55.7	21.5	1.5	tr	tr
2.00	1.8	12.6	28.6	15.1	8.6	7.1	9.4	21.6	7.8	0.6	none	none
2.10	1.5	18.8	26.5	14.6	9.3	6.1	5.5	7.3	1.3	tr	none	none
2.20	2.0	21.9	30.7	13.2	7.2	3.6	2.8	1.3	0.1	none	none	none
2.30	2.8	25.3	28.7	9.5	2.9	0.7	0.6	0.2	tr	none	none	none
2.40	3.1	23.4	25.2	6.6	1.1	tr	tr	tr	0.1	none	none	none
2.50	1.7	13.7	9.5	1.2	tr	tr	tr	0.1	0.1	none	none	none
2.60	Tr	2.2	1.3	tr	tr	none	none	none	0.1	none	none	none
2.70	Tr	0.1	tr	tr	none	none	none	none	tr	none	none	none

Total: 1196.9g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 3 Mass Distribution (g)



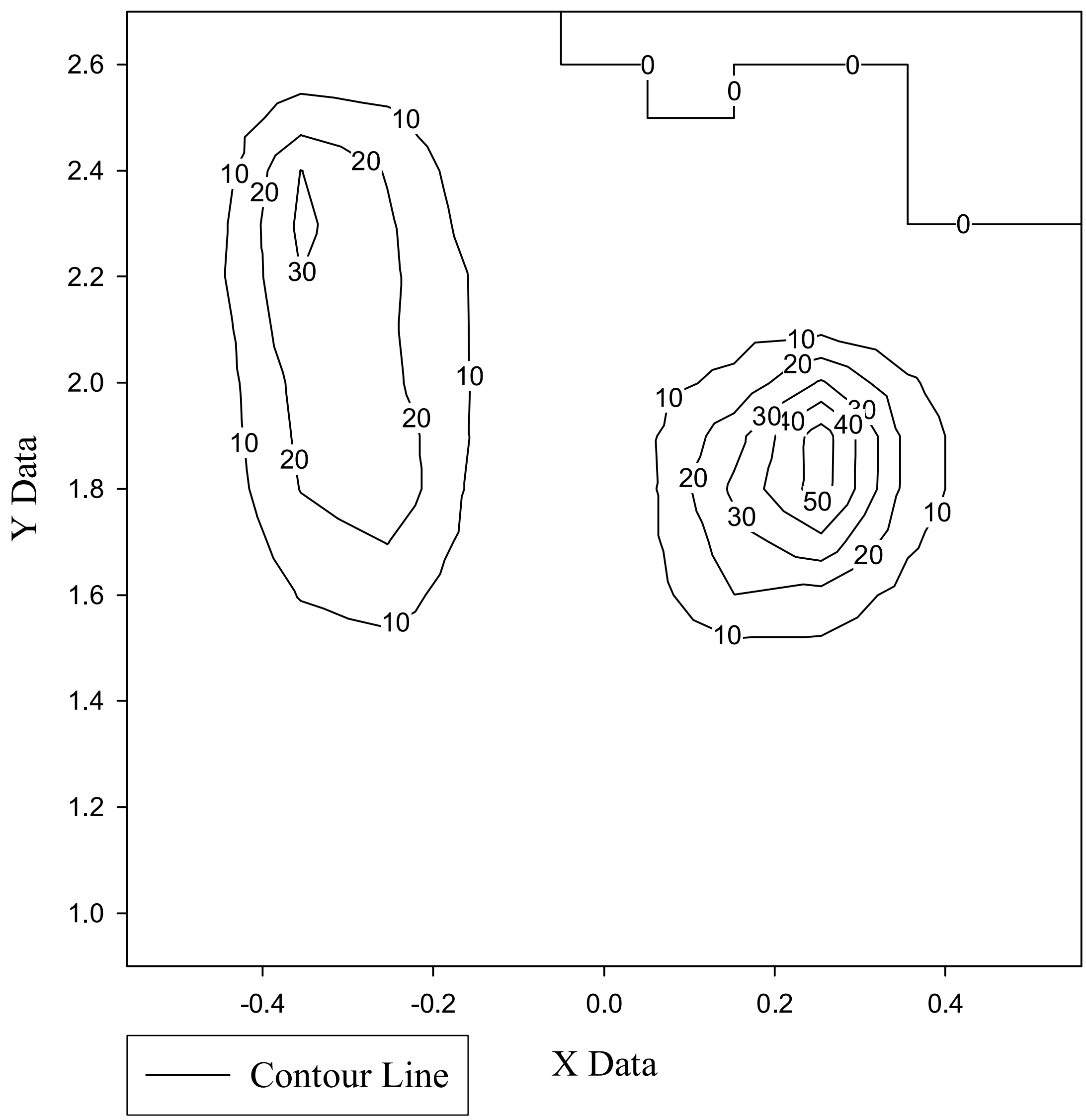
Test 4 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	tr	0.1	0.1	0.1	0.3	0.5	0.4	0.3	0.3	0.2	0.1	tr
1.00	tr	0.1	0.2	0.4	0.4	0.6	0.4	0.4	0.4	0.3	0.1	0.1
1.10	0.1	0.2	0.3	0.4	0.7	0.8	0.8	0.7	0.6	0.4	0.1	tr
1.20	0.1	0.2	0.5	0.6	0.8	1.3	1.4	1.5	1.1	0.6	0.6	0.1
1.30	0.1	0.3	1.5	1.9	1.4	1.9	2.1	2.5	2.3	0.8	0.3	0.1
1.40	0.1	0.6	3.3	3.3	2.6	2.5	3.2	4.5	3.9	1.6	0.5	0.2
1.50	0.3	1.3	6.1	7.4	4.0	3.0	4.2	7.8	8.0	3.7	0.7	0.3
1.60	0.2	1.1	10.5	14.2	4.6	4.4	5.8	19.9	16.8	6.4	1.0	0.1
1.70	0.1	2.4	14.8	20.3	6.7	4.7	7.3	25.3	37.2	11.6	1.3	tr
1.80	0.5	3.0	20.4	27.9	7.6	6.4	7.4	32.1	55.0	16.5	1.4	tr
1.90	0.4	4.0	22.0	26.4	9.0	6.5	8.0	25.8	55.5	16.6	1.3	tr
2.00	0.2	4.3	23.4	22.5	9.3	7.4	6.8	12.3	31.3	11.7	0.3	tr
2.10	0.1	4.9	27.8	21.6	9.2	5.9	5.7	6.0	7.8	1.6	0.2	tr
2.20	0.1	7.0	29.9	22.1	9.1	5.2	3.6	3.4	1.6	0.4	0.1	none
2.30	0.2	5.9	32.1	21.4	6.0	2.9	1.2	0.8	0.2	tr	none	none
2.40	tr	3.6	30.2	19.3	3.7	0.9	0.1	0.1	0.1	tr	none	none
2.50	tr	2.7	15.2	12.1	1.3	0.1	none	none	0.1	none	none	none
2.60	0.1	0.8	3.9	2.5	0.1	none	none	none	none	none	none	none
2.70	none	0.1	0.3	0.4	none	none	none	none	none	none	none	none

Total: 1149.6g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 4 Mass Distribution (g)



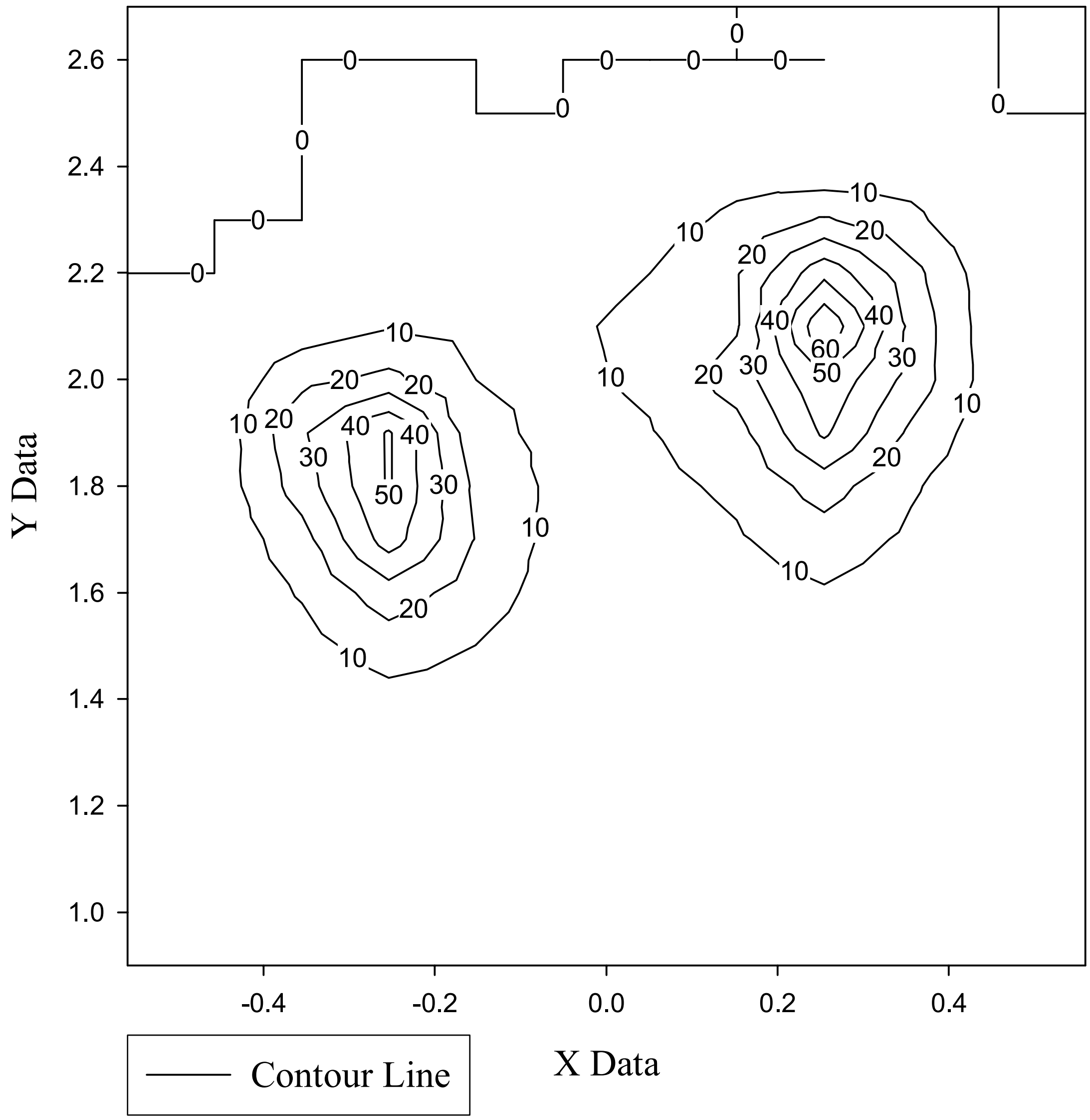
Test 5 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	tr	0.1	0.2	0.3	0.2	0.4	0.4	0.3	0.2	0.6	0.1	tr
1.00	tr	0.1	0.3	0.4	0.5	0.5	0.6	0.5	0.6	0.3	0.1	0.1
1.10	0.1	0.3	0.5	0.7	0.8	0.9	0.9	0.6	0.6	0.3	0.1	tr
1.20	0.1	0.2	0.8	1.2	1.6	1.5	1.1	1.0	1.1	0.4	0.1	tr
1.30	tr	0.5	2.0	3.4	3.6	2.1	1.7	1.6	1.7	1.0	0.3	tr
1.40	tr	0.7	2.7	6.9	5.8	2.6	2.3	2.2	2.8	2.0	0.3	0.1
1.50	0.1	1.1	6.4	14.8	9.9	3.8	3.2	3.4	5.7	3.1	0.7	0.1
1.60	0.1	2.3	10.9	25.6	14.8	5.0	4.2	6.1	9.0	5.0	1.2	0.2
1.70	0.1	2.2	16.2	45.0	19.4	5.6	5.0	9.0	15.5	8.2	1.2	tr
1.80	0.1	3.5	24.8	51.1	17.6	6.9	7.4	11.8	24.5	11.2	2.2	0.5
1.90	tr	2.7	28.5	51.3	12.9	7.0	9.5	16.2	41.7	18.0	2.7	0.3
2.00	none	1.3	17.2	22.8	10.0	8.4	11.3	24.5	48.2	26.3	3.4	0.2
2.10	none	0.3	4.5	9.3	7.2	8.9	11.7	19.0	69.5	27.2	2.3	0.2
2.20	none	none	0.2	2.9	5.2	7.4	10.0	19.2	47.2	23.4	2.3	tr
2.30	none	none	none	0.4	2.2	3.9	6.0	12.0	21.3	12.2	1.2	none
2.40	none	none	none	0.1	0.4	0.9	2.4	6.4	0.9	5.9	0.4	tr
2.50	none	none	none	0.1	none	none	0.3	1.3	1.7	1.0	tr	none
2.60	none	none	none	none	none	none	none	none	tr	0.1	none	none
2.70	none	none	none	none	none	none	none	none	0.1	tr	none	none

Total: 1217.2g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 5 Mass Distribution (g)



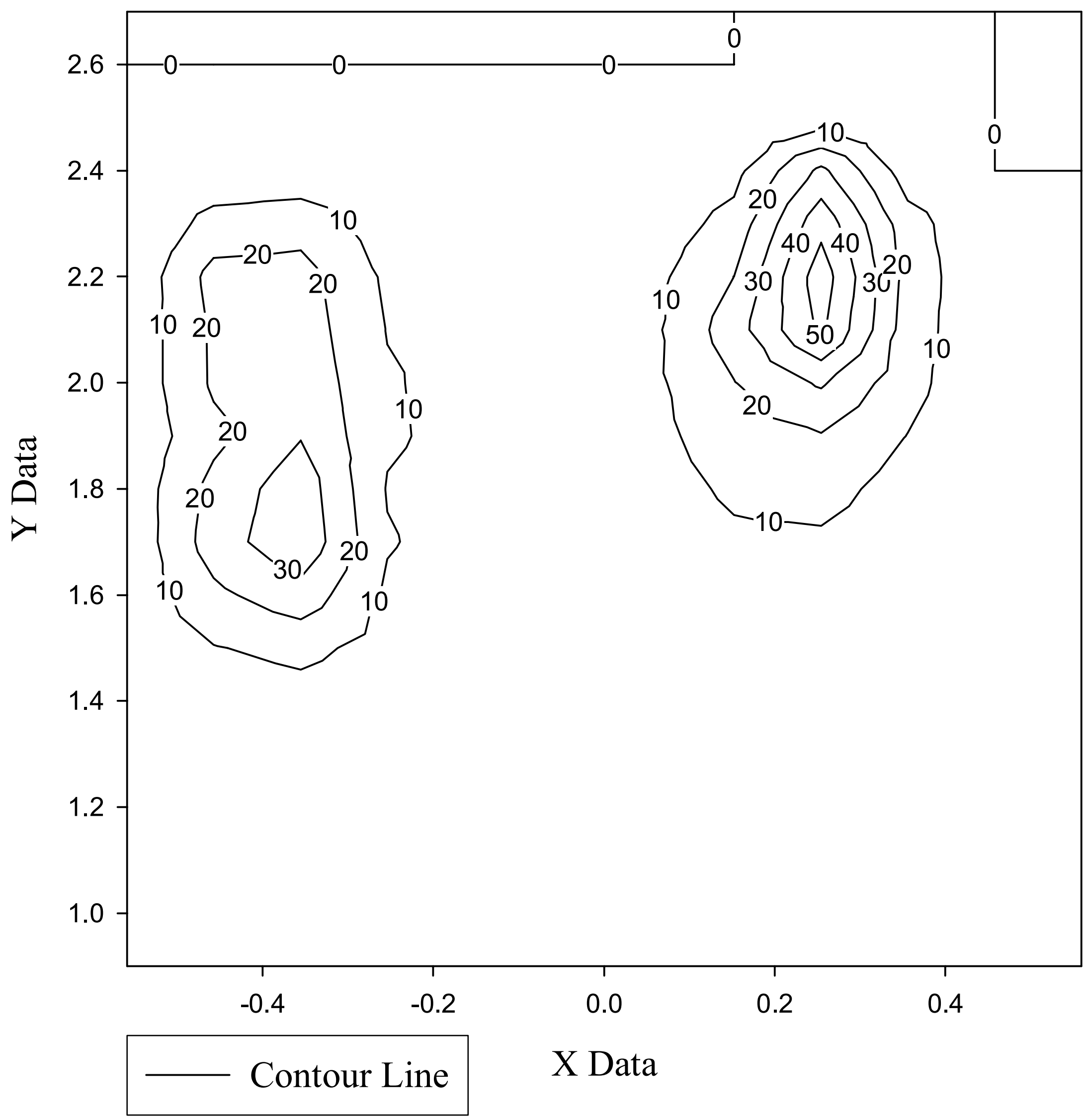
Test 6 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.1	0.2	0.4	0.4	0.3	0.9	0.7	0.4	0.2	0.2	0.1	tr
1.00	0.1	0.3	0.6	0.5	0.6	1.3	1.6	0.7	0.4	0.2	0.1	0.1
1.10	0.2	0.5	0.8	1.1	0.9	2.0	0.8	0.7	0.8	0.4	0.1	0.1
1.20	0.4	1.1	1.8	1.3	1.4	1.4	1.3	0.8	0.6	0.4	0.1	0.1
1.30	0.9	2.3	3.1	2.4	1.7	1.8	1.4	1.6	1.2	0.7	0.3	0.1
1.40	1.2	4.1	6.1	3.8	2.6	2.0	2.0	2.5	1.5	1.2	0.5	0.1
1.50	2.5	9.5	12.7	6.4	3.3	3.1	3.1	3.5	2.0	1.7	0.7	0.1
1.60	2.2	17.7	26.2	8.1	3.5	3.5	4.3	5.3	4.8	2.9	1.0	0.2
1.70	2.0	25.0	37.7	10.9	4.6	3.8	4.6	8.5	8.4	4.3	1.2	0.2
1.80	2.7	23.1	36.1	9.3	5.3	4.3	5.9	11.5	13.7	5.8	1.1	0.2
1.90	2.0	17.3	29.4	11.5	6.1	4.9	6.4	15.8	19.3	9.8	1.6	0.2
2.00	2.1	21.5	26.9	11.1	5.7	6.3	7.2	19.6	31.2	13.2	1.3	tr
2.10	1.9	21.7	25.3	9.6	6.7	5.7	6.8	25.3	52.1	14.9	1.1	tr
2.20	1.1	23.5	23.9	8.2	4.9	5.5	6.5	20.1	55.6	16.1	0.4	tr
2.30	0.1	13.7	16.1	4.7	3.6	3.4	4.0	13.3	46.9	14.2	0.2	tr
2.40	none	2.8	3.3	1.2	1.2	1.4	2.2	6.8	32.4	4.7	none	none
2.50	none	0.2	0.3	0.2	0.2	0.3	0.2	1.0	3.8	0.9	none	none
2.60	none	none	tr	none	none	none	none	none	0.5	0.1	none	none
2.70	none	none	none	none	none	none	none	none	tr	tr	none	none

Total: 1224.3 g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 6 Mass Distribution (g)



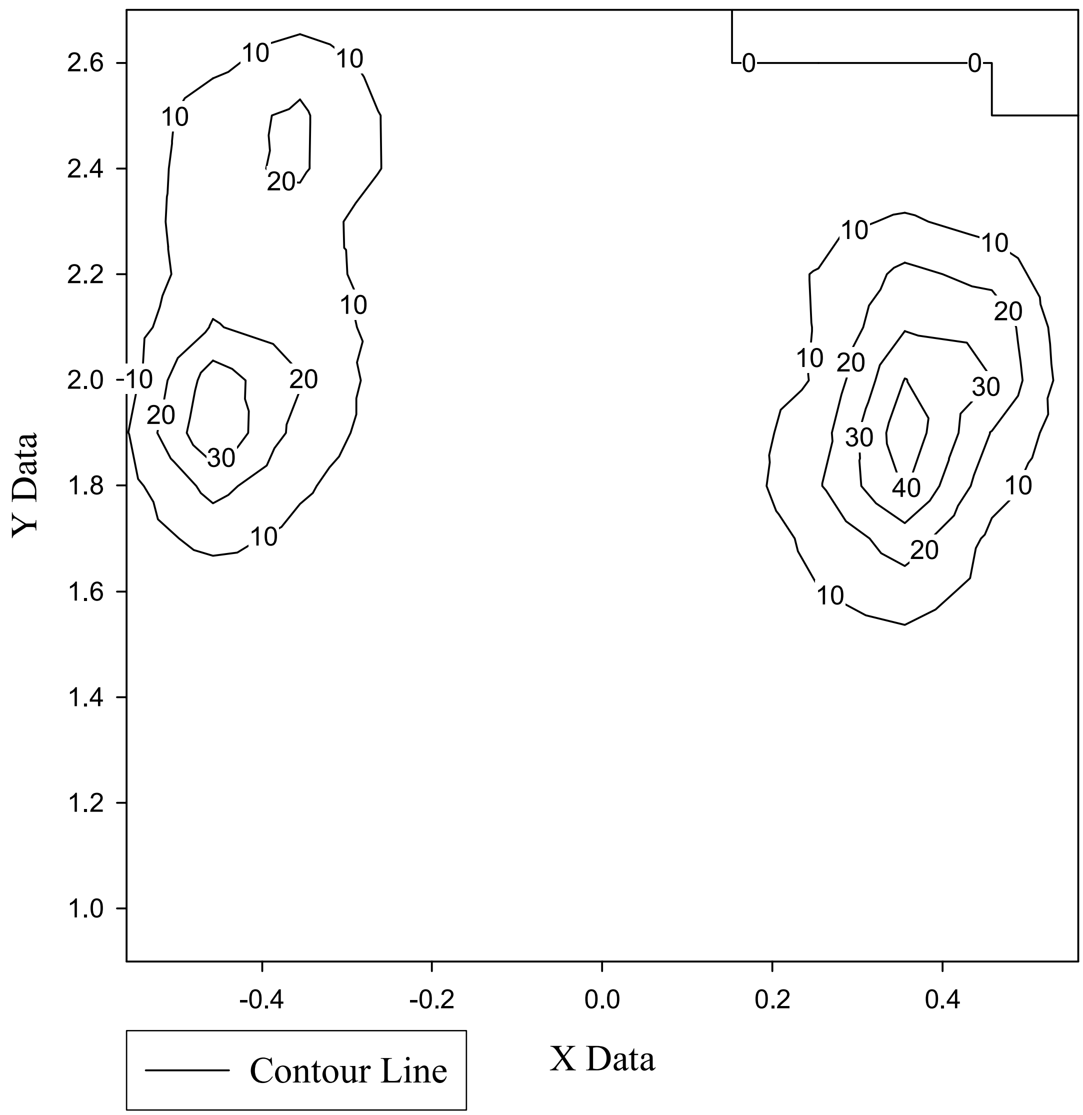
Test 7 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.1	0.1	0.2	0.1	0.3	2.6	0.2	0.2	0.2	0.2	0.1	0.1
1.00	tr	0.1	0.2	0.3	0.4	1.0	0.3	0.2	0.4	0.3	0.1	0.1
1.10	0.1	0.2	0.3	0.4	0.6	1.2	0.5	0.5	0.4	0.4	0.3	0.1
1.20	0.2	0.3	0.5	0.6	0.8	1.8	0.9	0.8	0.6	0.6	0.4	0.2
1.30	0.2	0.7	0.9	0.8	0.9	1.4	1.3	0.9	1.7	1.9	0.7	0.4
1.40	0.6	1.4	1.8	1.4	1.4	1.5	1.3	1.6	3.0	3.5	2.0	0.4
1.50	1.2	3.4	2.3	1.7	1.9	1.9	2.0	2.5	5.9	7.1	2.8	1.2
1.60	2.1	2.9	5.2	2.5	2.4	3.3	2.8	3.9	9.8	15.1	6.4	1.1
1.70	4.8	13.4	7.1	3.3	2.7	0.9	3.1	3.9	12.3	25.3	7.9	1.4
1.80	6.7	23.3	11.5	3.8	3.3	3.3	3.5	4.0	19.0	41.2	13.3	2.5
1.90	9.5	39.1	16.4	5.5	4.0	3.9	4.4	5.1	15.1	46.9	19.6	2.4
2.00	6.1	35.4	20.8	5.4	4.5	5.0	5.3	6.1	10.5	40.3	30.1	1.9
2.10	5.4	20.7	15.1	7.4	5.7	5.7	5.6	6.5	10.3	29.2	27.6	0.9
2.20	3.3	16.3	12.2	8.2	6.5	5.1	5.3	6.5	10.4	22.5	16.8	0.3
2.30	3.0	18.7	16.4	3.7	5.5	4.5	4.5	4.7	6.9	11.5	6.0	tr
2.40	2.4	18.0	21.3	9.3	4.8	2.4	2.1	2.9	2.7	2.4	0.2	none
2.50	1.5	16.9	21.5	9.2	2.6	0.8	0.7	0.8	0.6	0.1	tr	none
2.60	none	7.1	16.6	6.3	1.0	0.2	0.1	none	none	none	none	none
2.70	tr	1.6	4.4	1.3	0.1	none	none	none	none	none	none	none

Total: 1209.2g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 7 Mass Distribution (g)

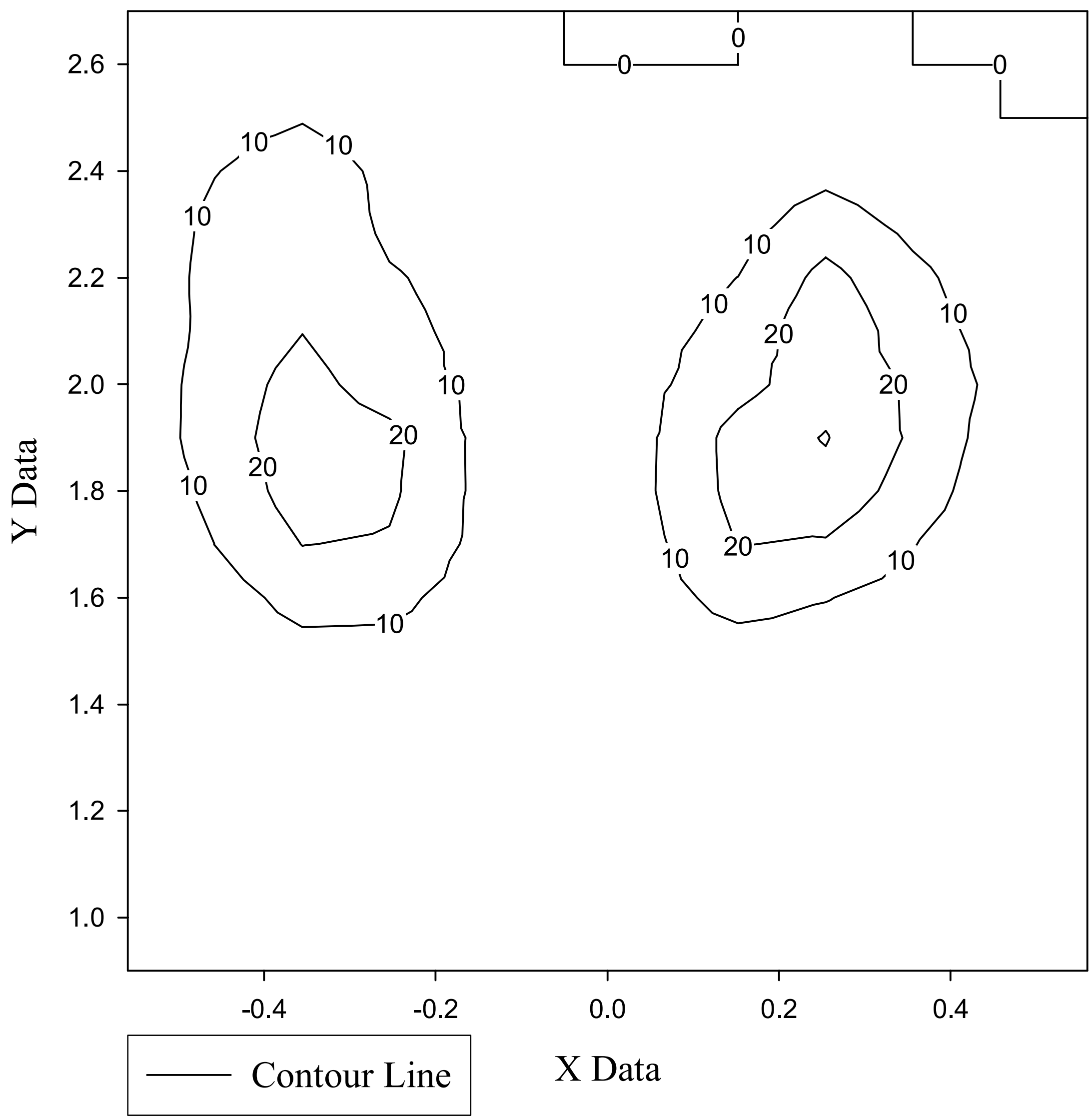


Avg 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.1	0.2	0.2	0.3	1.0	0.4	0.3	0.2	0.3	0.1	0.0
1.00	0.0	0.2	0.3	0.4	0.5	0.8	0.7	0.5	0.5	0.3	0.1	0.1
1.10	0.1	0.3	0.5	0.7	0.8	1.2	0.8	0.7	0.7	0.4	0.1	0.0
1.20	0.2	0.4	1.0	1.0	1.1	1.6	1.4	1.1	1.0	0.5	0.3	0.1
1.30	0.3	0.9	1.9	2.1	1.9	1.9	1.8	2.0	1.8	1.1	0.4	0.1
1.40	0.5	1.8	3.7	3.9	3.0	2.4	2.8	3.6	2.9	1.9	0.7	0.2
1.50	0.9	3.6	7.4	7.6	4.6	3.1	4.3	6.1	5.7	3.5	1.0	0.4
1.60	1.0	5.7	13.3	12.4	6.0	4.2	5.9	13.6	10.4	6.3	2.0	0.3
1.70	1.5	10.1	20.2	19.1	7.8	4.3	7.7	20.3	19.0	10.4	2.3	0.3
1.80	2.2	12.5	24.9	21.7	8.2	5.8	9.3	23.2	26.9	15.5	3.6	0.7
1.90	2.6	14.9	26.0	22.5	8.1	6.1	9.0	23.7	30.6	18.6	5.0	0.6
2.00	2.0	15.0	23.4	15.4	7.6	6.8	8.0	16.8	25.8	18.4	7.0	0.4
2.10	1.8	13.3	19.8	12.5	7.6	6.5	7.1	12.8	28.2	14.6	6.2	0.2
2.20	1.3	13.7	19.4	10.9	6.6	5.4	5.6	10.1	23.0	12.5	3.9	0.1
2.30	1.2	12.7	18.7	7.9	4.0	3.1	3.3	6.2	15.1	7.6	1.5	0.0
2.40	1.1	9.6	16.0	7.3	2.2	1.1	1.4	3.2	7.2	2.6	0.1	0.0
2.50	0.6	6.7	9.3	4.6	0.8	0.2	0.2	0.6	1.3	0.4	0.0	0.0
2.60	0.0	2.0	4.4	1.8	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0
2.70	0.0	0.4	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in grams

Test 3-7 Average Mass Distribution (g)



Appendix C- Aspirated -15º Raw Mass Distribution Data

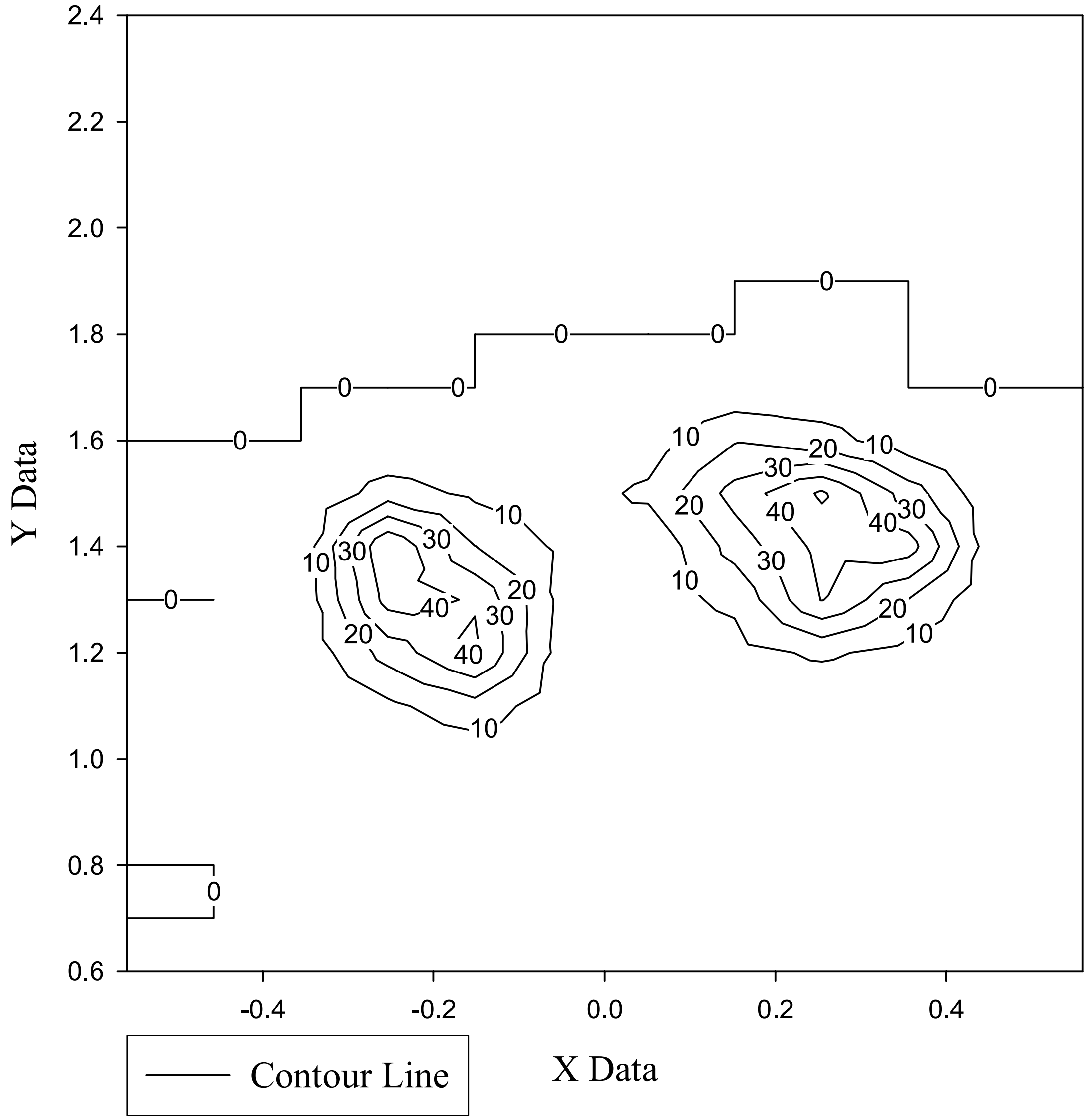
Test 10 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	tr	0.1	0.1	0.1	0.1	0.2	0.7	0.3	0.1	0.1	0.1	tr
0.70	none	tr	0.1	0.2	0.2	0.6	0.7	0.4	0.3	0.2	0.1	tr
0.80	none	tr	0.2	0.8	0.6	0.6	1.3	0.5	0.5	0.3	0.1	0.1
0.90	none	0.1	0.4	0.8	1.2	1.4	2.7	0.9	0.9	0.4	tr	0.1
1.00	0.1	0.1	0.5	3.2	3.4	2.1	4.3	1.4	1.1	1.1	0.3	0.1
1.10	none	0.1	1	7.8	16.1	3.3	5.2	3	2.0	2.2	0.4	0.1
1.20	none	0.1	1.8	24	42	5.4	4.7	6.6	11.6	6.7	0.8	0.1
1.30	none	tr	2.3	44.0	39.1	6.9	6.5	11.9	40.5	19.8	1.1	0.1
1.40	none	0.1	2.7	49.8	20.2	7.9	1.3	24.0	43.4	45.2	1.7	tr
1.50	none	0.1	0.4	14.7	7.9	5.1	12	33.7	51.6	25.3	1.0	none
1.60	none	none	none	0.6	0.6	1.7	4.5	19.0	14.4	3.5	0.1	tr
1.70	none	none	tr	tr	tr	0.1	0.5	2.1	1.5	tr	none	none
1.80	none	none	none	none	none	none	none	tr	0.1	tr	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none
2.30	none	none	none	none	none	none	none	none	none	none	none	none
2.40	none	none	none	none	none	none	none	none	none	none	none	none

Total: 750.3 g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 10 Mass Distribution (g)



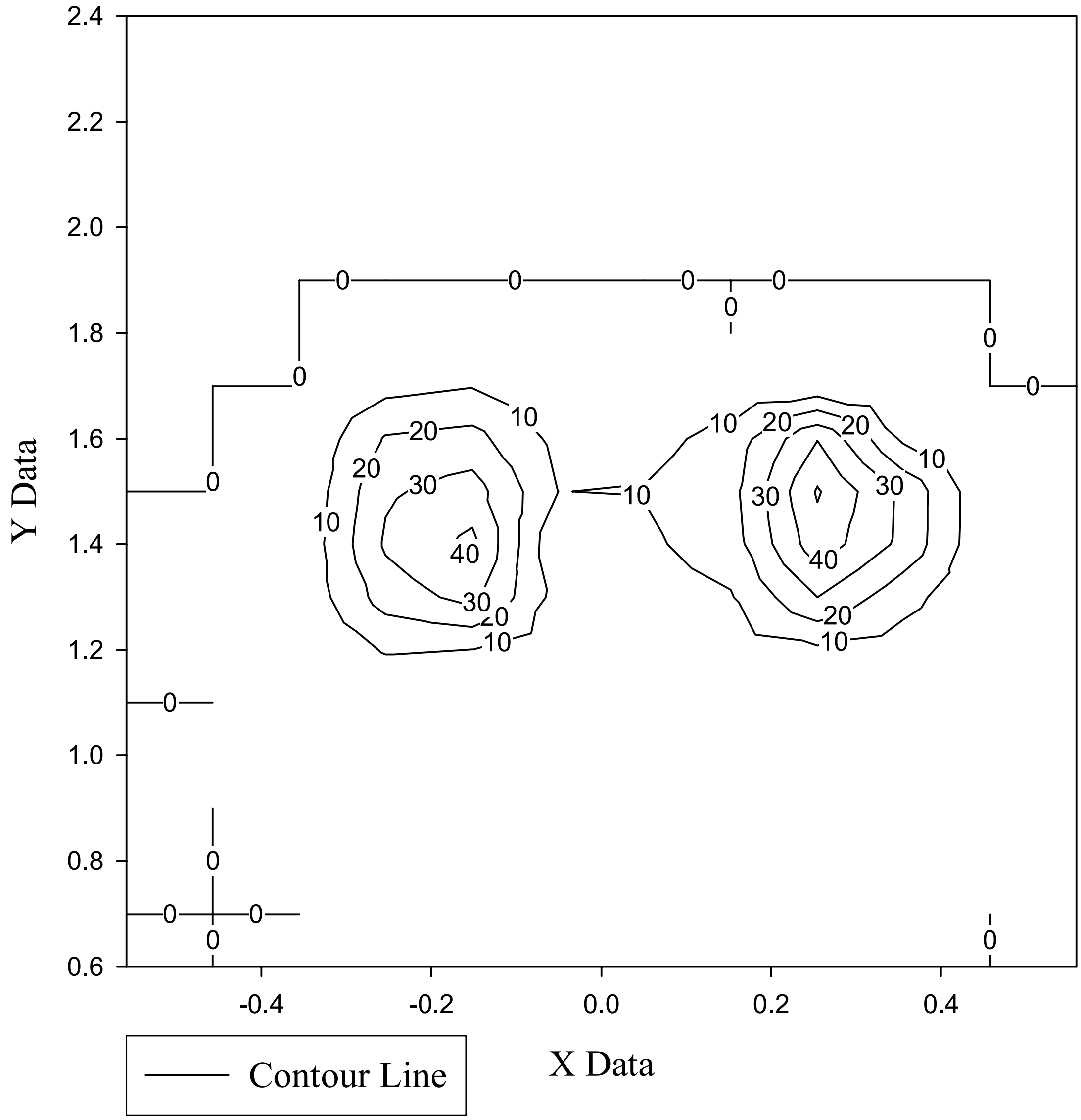
Test 11 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	tr	tr	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	tr	tr
0.70	tr	tr	tr	0.2	0.1	0.3	0.2	0.2	0.2	0.1	tr	0.1
0.80	0.1	tr	0.1	0.3	0.4	0.3	0.5	0.4	0.4	0.2	0.1	tr
0.90	0.1	tr	0.1	0.3	0.5	0.6	0.8	0.7	0.6	0.2	0.1	tr
1.00	none	0.1	0.3	1.0	1.1	1.3	1.4	1.4	1.2	0.6	0.2	0.1
1.10	none	tr	0.7	1.8	3.4	2.2	1.9	2.6	3.4	2.2	0.3	tr
1.20	none	0.1	1.3	10.8	9.9	4.2	3.5	5.7	8.2	5.5	0.8	0.2
1.30	none	0.1	1.9	24.5	33.3	6.1	5.6	9.2	30.0	13.4	1.3	0.1
1.40	none	0.1	1.5	31.5	42.5	1.0	8.2	15.0	46.1	27.3	0.6	tr
1.50	none	tr	0.8	28.5	34.5	9.9	10.5	16.5	51.0	27.8	0.6	tr
1.60	none	tr	0.4	20.9	23.5	6.9	6.5	13.6	39.5	8.0	0.1	none
1.70	none	none	tr	6.6	9.5	3.0	2.2	2.1	3.0	0.5	tr	none
1.80	none	none	tr	0.5	1.2	0.4	0.1	tr	0.1	0.1	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none
2.30	none	none	none	none	none	none	none	none	none	none	none	none
2.40	none	none	none	none	none	none	none	none	none	none	none	none

Total: 714.8g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 11 Mass Distribution (g)



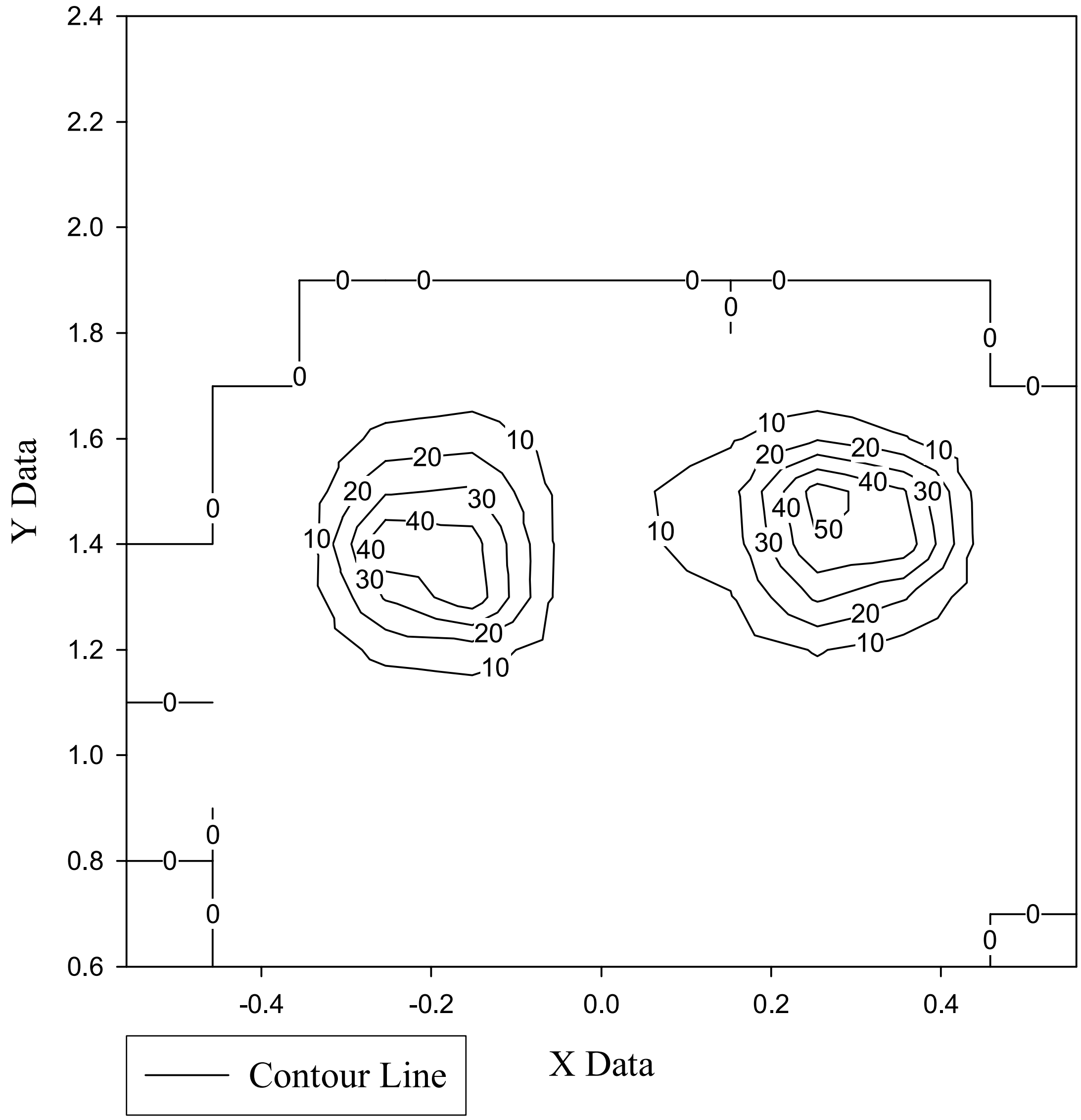
Test 12 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	none	tr	0.1	0.1	0.1	0.2	0.5	0.3	0.1	0.1	tr	0.1
0.70	tr	tr	0.1	0.2	0.2	0.2	1.1	0.5	0.2	0.2	tr	tr
0.80	tr	tr	0.1	0.3	0.3	0.4	0.5	0.6	0.3	0.1	0.1	tr
0.90	0.1	tr	0.2	0.5	0.6	0.7	1.0	0.8	0.5	0.4	0.2	tr
1.00	tr	0.1	0.3	1.0	1.4	2.2	1.7	1.5	1.6	0.8	0.4	0.1
1.10	none	tr	0.7	2.2	4.3	3.2	3.2	2.4	5.8	2.4	0.5	tr
1.20	none	0.2	1.4	13.3	15.2	5.0	4.5	4.8	10.6	5.7	1.1	tr
1.30	none	0.1	1.9	31.2	46.9	7.3	7.4	9.4	32.0	21.0	1.2	0.1
1.40	none	tr	1.5	49.2	44.3	8.1	8.7	14.7	49.6	46.9	1.4	tr
1.50	none	tr	1.1	28.8	31.4	7.8	9.2	16.2	55.0	41.1	1.1	0.1
1.60	tr	tr	0.3	13.4	15.8	4.9	4.2	8.7	18.9	10.7	0.1	none
1.70	none	none	tr	1.9	4.4	1.1	1.0	1.6	2.0	0.2	tr	none
1.80	none	none	tr	0.2	0.3	0.1	0.1	tr	0.1	0.1	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none
2.30	none	none	none	none	none	none	none	none	none	none	none	none
2.40	none	none	none	none	none	none	none	none	none	none	none	none

Total: 774.4g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 12 Mass Distribution (g)

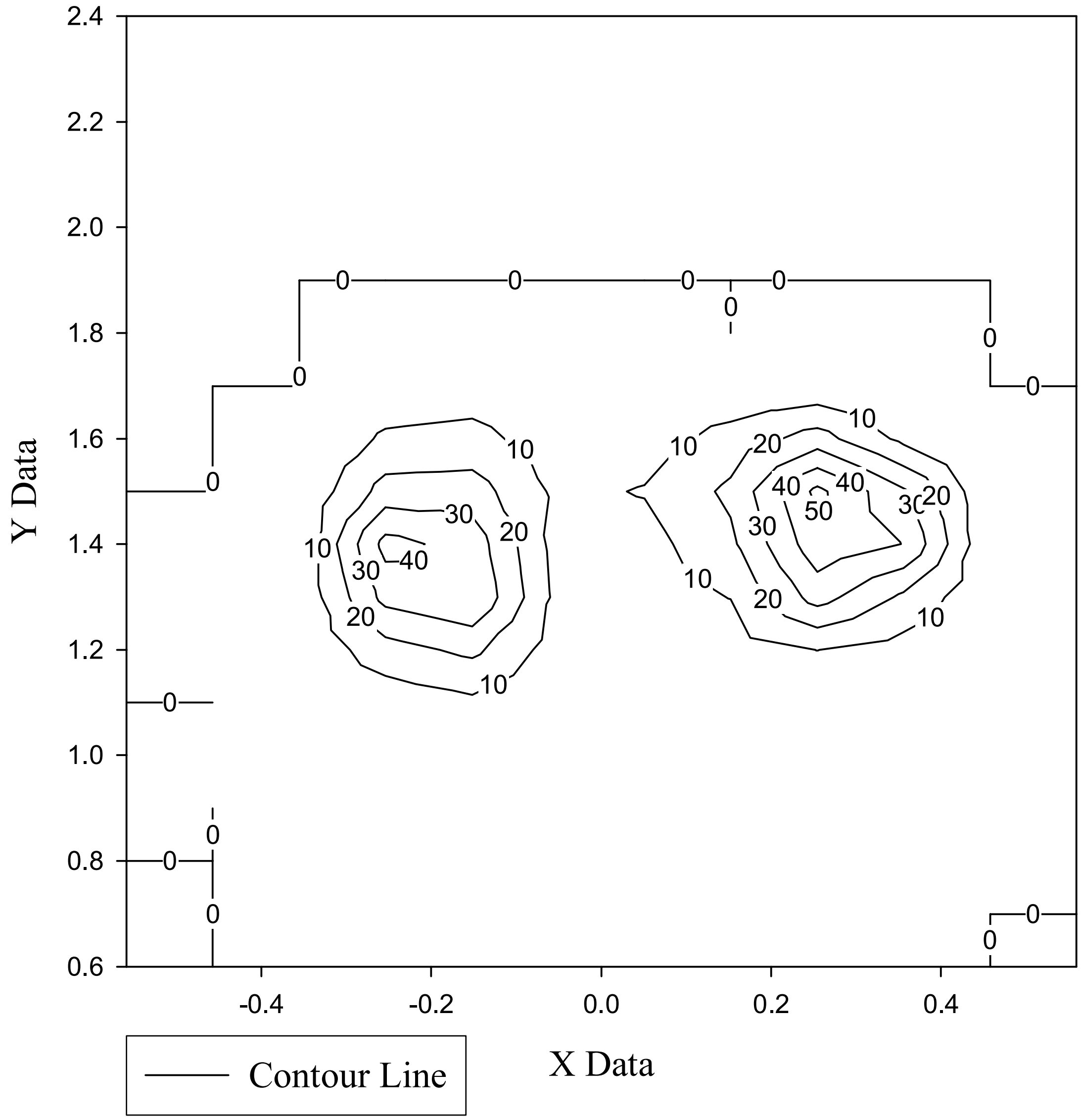


Avg -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	0.1	0.1	0.1	0.2	0.5	0.2	0.1	0.1	0.0	0.0
0.70	0.0	0.0	0.1	0.2	0.2	0.4	0.7	0.4	0.2	0.2	0.0	0.0
0.80	0.0	0.0	0.1	0.5	0.4	0.4	0.8	0.5	0.4	0.2	0.1	0.0
0.90	0.1	0.0	0.2	0.5	0.8	0.9	1.5	0.8	0.7	0.3	0.1	0.0
1.00	0.0	0.1	0.4	1.7	2.0	1.9	2.5	1.4	1.3	0.8	0.3	0.1
1.10	0.0	0.0	0.8	3.9	7.9	2.9	3.4	2.7	3.7	2.3	0.4	0.0
1.20	0.0	0.1	1.5	16.0	22.4	4.9	4.2	5.7	10.1	6.0	0.9	0.1
1.30	0.0	0.1	2.0	33.2	39.8	6.8	6.5	10.2	34.2	18.1	1.2	0.1
1.40	0.0	0.1	1.9	43.5	35.7	5.7	6.1	17.9	46.4	39.8	1.2	0.0
1.50	0.0	0.0	0.8	24.0	24.6	7.6	10.6	22.1	52.5	31.4	0.9	0.0
1.60	0.0	0.0	0.2	11.6	13.3	4.5	5.1	13.8	24.3	7.4	0.1	0.0
1.70	0.0	0.0	0.0	2.8	4.6	1.4	1.2	1.9	2.2	0.2	0.0	0.0
1.80	0.0	0.0	0.0	0.2	0.5	0.2	0.1	0.0	0.1	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 746.5g
All measurements in grams

Test 10-12 Average Mass Distribution (g)



Appendix D- Aspirated 15º Raw Mass Distribution Data

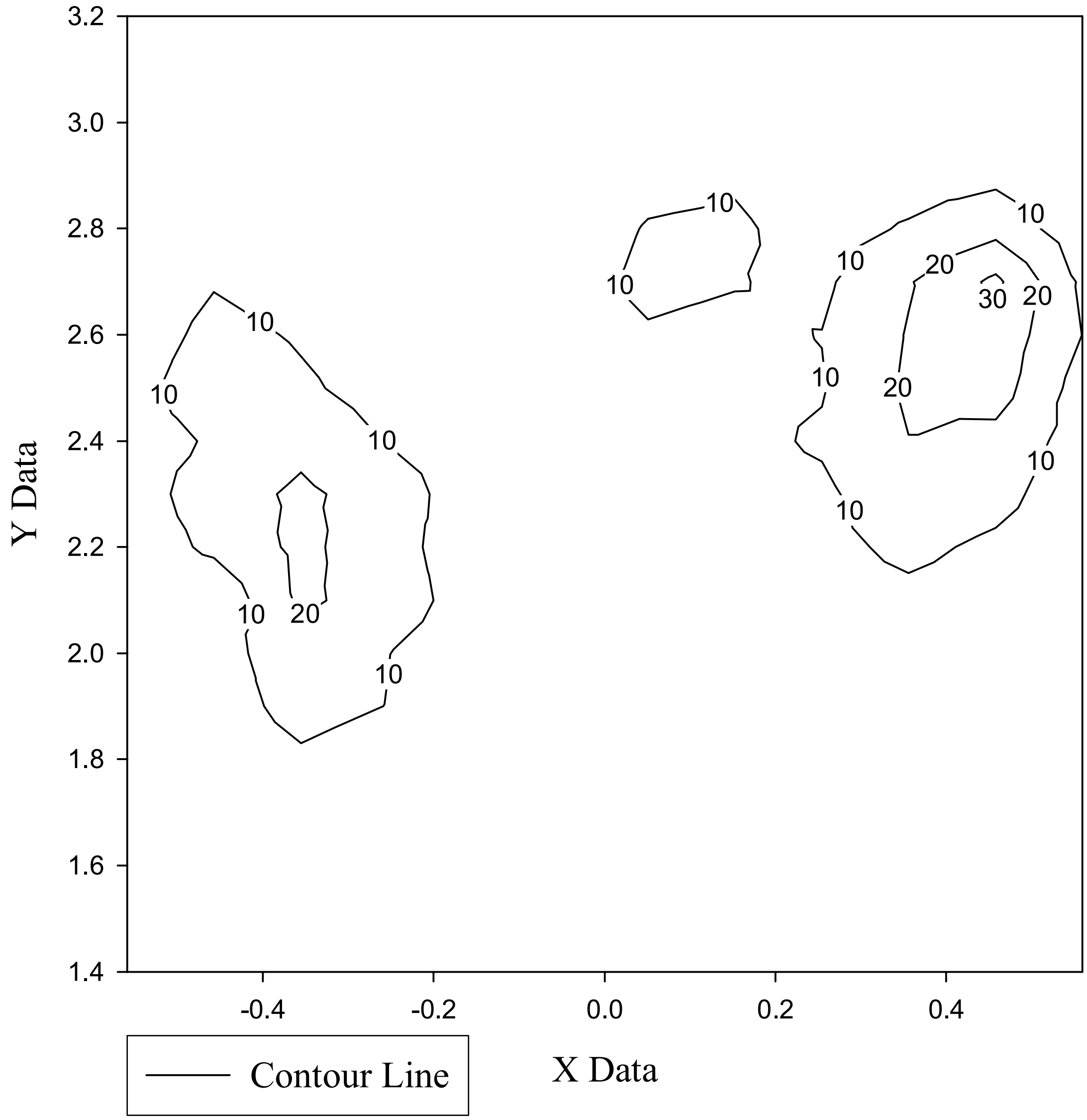
Test 15 15º 100 psi asp 15 s

Dist. (m)	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.1	0.2	0.3	0.4	0.5	0.6
1.40	0.1	0.4	0.5	0.5	0.7	1.5	1.5	0.9	0.6	0.6	0.3	0.2
1.50	0.3	0.6	0.9	1.2	1.0	1.8	1.4	1.0	0.9	0.6	0.3	0.2
1.60	0.4	1.3	2.0	2.2	1.2	2.8	1.6	1.6	1.4	1.1	0.5	0.4
1.70	0.6	2.6	4.2	3.2	2.7	1.9	2.8	1.9	1.9	1.9	1.3	0.5
1.80	1.1	3.2	8.4	4.5	2.9	2.4	2.9	3.1	3.3	3.0	1.5	0.6
1.90	1.1	5.2	13.6	9.8	2.9	2.6	3.3	3.3	4.0	3.3	2.6	0.4
2.00	1.6	6.3	15.7	10.2	4.0	3.2	3.5	4.4	6.5	6.1	3.1	0.9
2.10	1.8	1.9	21.9	15.4	5.1	3.8	3.9	4.6	6.1	7.9	6.2	2.1
2.20	3.8	12.0	22.5	13.6	4.6	3.6	4.3	5.3	7.5	12.0	8.3	3.5
2.30	4.4	15.6	21.7	15.9	3.6	4.5	5.9	6.8	8.3	16.2	13.1	4.0
2.40	5.0	11.2	17.5	9.5	3.8	5.5	6.5	7.5	11.1	19.8	16.9	5.6
2.50	5.1	17.9	11.6	5.8	4.2	6.0	7.1	8.3	9.4	21.5	24.5	5.7
2.60	3.1	13.3	8.9	4.3	4.3	6.5	9.4	8.2	10.2	20.6	26.5	9.9
2.70	1.7	9.2	5.0	3.2	3.3	7.2	11.5	10.4	8.2	19.2	32.1	8.2
2.80	1.0	5.3	4.1	0.8	2.5	5.7	10.5	11.3	6.5	10.9	16.9	3.8
2.90	0.8	2.1	1.8	0.9	1.6	3.8	7.8	9.0	4.6	6.0	7.6	1.8
3.00	0.1	0.1	0.4	0.5	1.1	2.6	6.1	7.1	2.9	2.4	2.4	0.3
3.10	tr	0.2	0.2	0.1	0.4	1.2	4.2	3.1	1.2	0.3	0.2	tr
3.20	tr	tr	tr	tr	tr	0.1	1.5	1.1	tr	tr	tr	tr

Total: 1174.5g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 15 Mass Distribution (g)



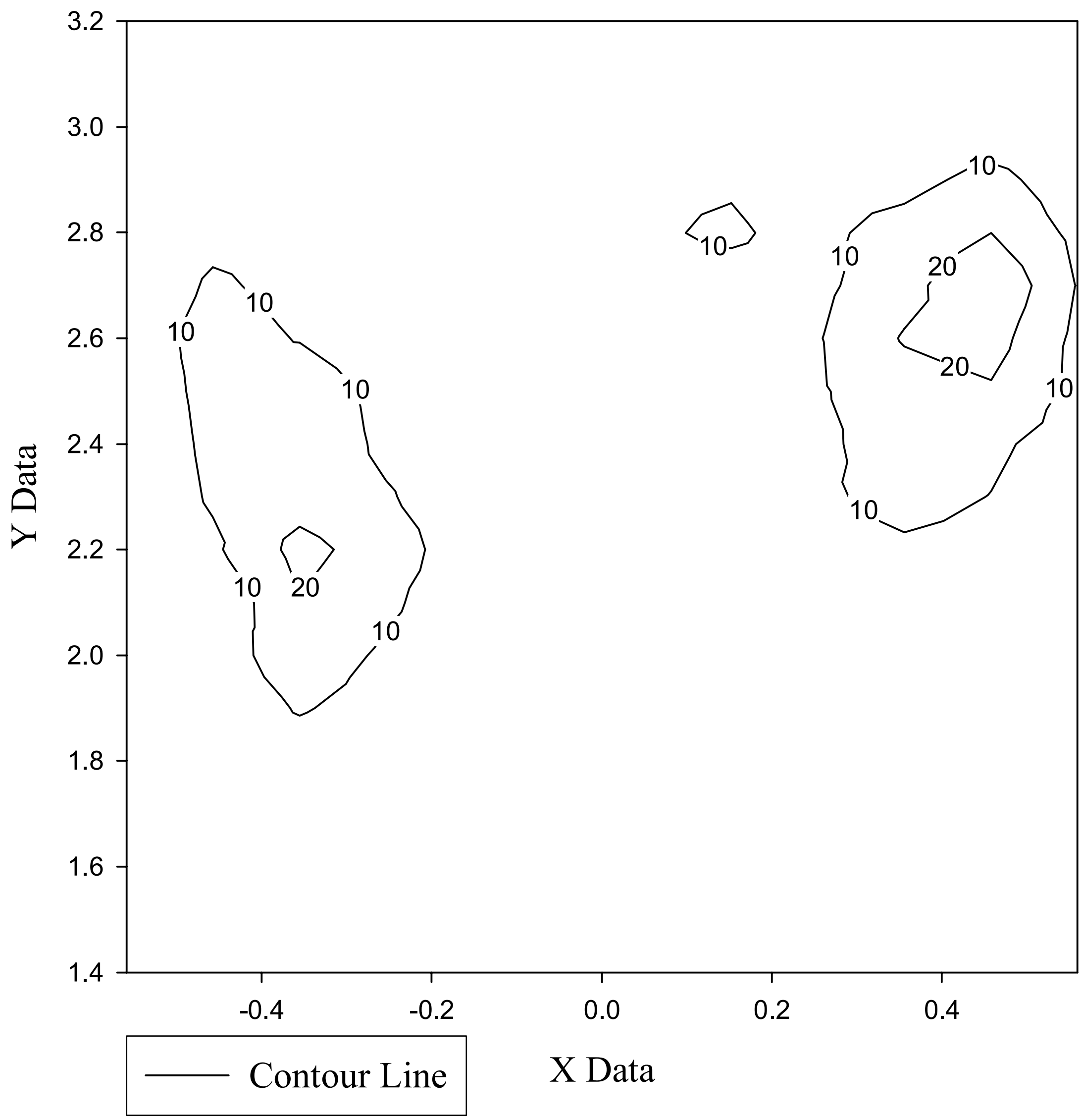
Test 16 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.2	0.4	0.5	0.4	0.9	0.8	0.8	0.7	0.5	0.4	0.2	0.1
1.50	0.3	0.6	1.0	1.0	1.1	1.4	1.0	0.8	0.6	0.6	0.3	0.2
1.60	0.4	0.9	1.9	1.5	1.2	1.4	1.1	1.2	1.0	1.1	0.5	0.2
1.70	1.0	1.6	3.4	2.1	1.5	1.7	1.8	1.4	1.6	1.3	0.9	0.3
1.80	0.8	4.1	5.8	3.4	2.2	2.0	1.8	2.5	2.5	2.5	1.3	0.5
1.90	1.1	4.5	10.7	6.7	2.7	2.8	2.5	2.5	2.4	3.4	2.0	0.7
2.00	1.5	5.6	15.1	8.6	4.1	2.9	3.1	3.4	4.3	4.0	2.3	1.4
2.10	1.4	1.6	19.4	11.6	4.1	3.6	3.6	3.8	4.9	5.6	4.7	1.5
2.20	2.4	8.3	23.3	14.9	4.0	3.5	3.9	4.6	6.7	8.6	7.7	2.9
2.30	2.7	11.1	15.8	10.9	3.9	4.2	4.8	5.1	8.4	12.9	9.8	4.4
2.40	3.0	12.0	17.2	8.0	3.7	5.7	5.4	5.0	7.2	16.6	11.6	6.1
2.50	4.1	12.7	15.7	7.1	4.7	5.7	6.8	6.8	9.0	15.7	18.9	7.4
2.60	4.0	13.9	9.5	4.0	4.4	6.0	8.1	7.5	9.4	20.8	24.2	7.7
2.70	3.2	11.3	7.4	3.0	4.4	6.7	8.5	7.8	7.7	16.5	29.4	9.6
2.80	2.8	7.6	6.6	0.7	3.2	6.0	9.2	10.9	7.7	13.9	20.0	7.4
2.90	2.0	6.2	4.1	2.1	2.5	5.7	9.0	9.3	6.2	6.8	13.2	4.0
3.00	0.1	2.8	1.9	1.5	1.5	3.5	8.6	8.7	4.7	2.4	2.9	1.3
3.10	0.2	0.9	0.5	0.5	1.2	1.6	7.4	6.0	2.8	1.6	0.4	0.2
3.20	tr	0.1	tr	tr	0.2	0.8	2.2	3.8	0.8	0.1	0.1	0.1

Total: 1113.7g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 16 Mass Distribution (g)



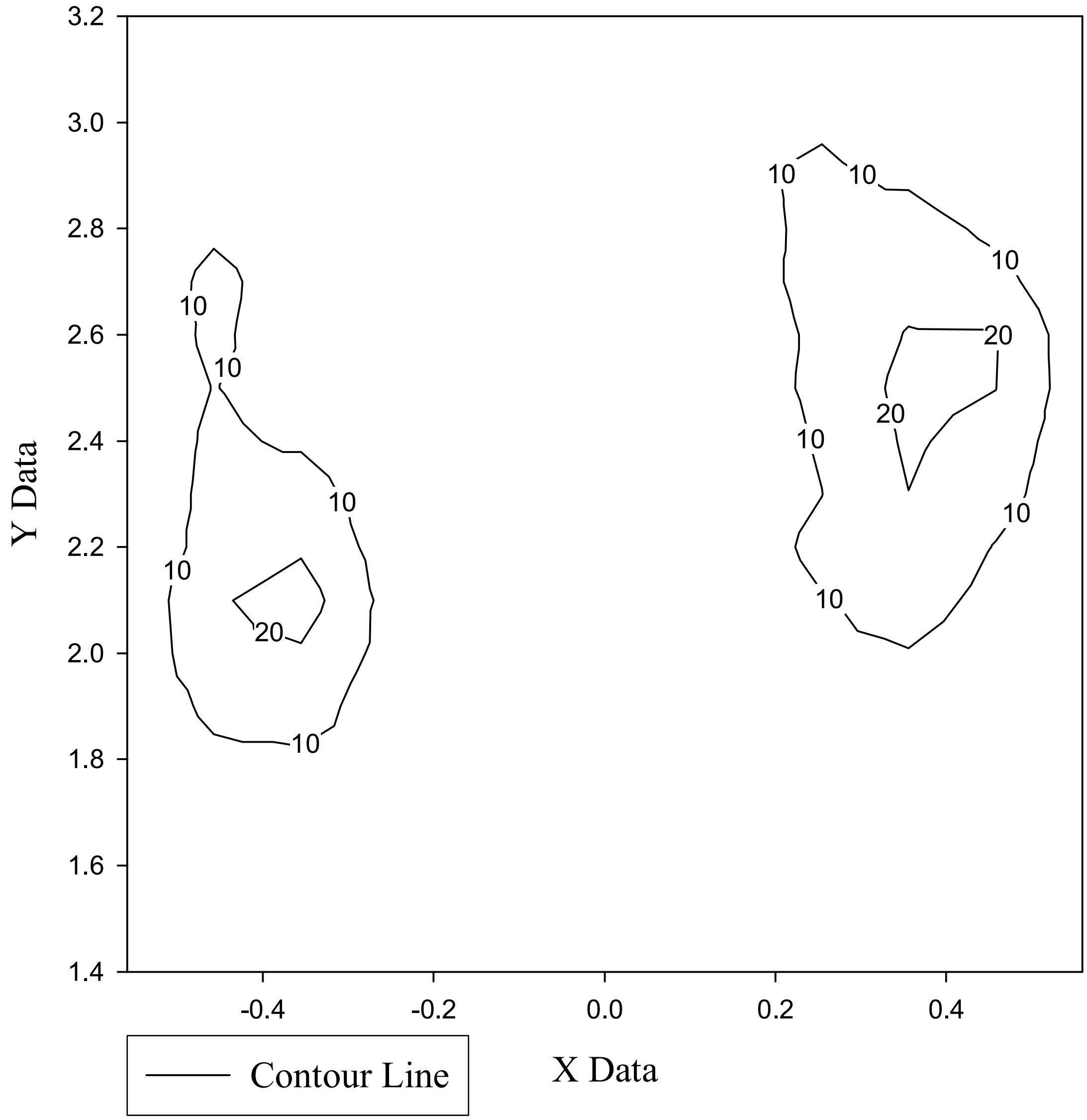
Test 18 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.4	0.7	0.8	0.7	0.9	0.9	0.8	0.9	0.8	0.8	0.4	0.2
1.50	0.8	1.2	1.3	1.5	1.3	1.4	1.2	1.3	1.4	1.3	0.6	0.2
1.60	0.8	2.7	3.3	2.2	1.6	1.6	1.7	1.6	1.9	1.6	0.9	0.4
1.70	2.3	5.1	6.2	3.0	1.6	2.0	1.7	1.9	2.5	3.0	2.1	0.5
1.80	2.7	8.1	8.1	5.4	2.0	1.9	2.3	3.1	4.7	5.0	2.5	0.9
1.90	3.3	12.1	15.9	2.9	2.1	2.1	2.2	3.3	6.2	7.2	2.9	0.5
2.00	0.9	18.3	18.9	6.9	2.3	2.1	2.6	4.1	8.4	9.6	5.8	2.3
2.10	2.1	18.7	24.7	7.1	2.4	2.6	3.3	4.4	9.6	13.7	7.4	1.8
2.20	4.7	12.5	18.7	5.7	2.1	2.4	3.3	5.2	12.1	17.7	9.6	2.2
2.30	5.4	11.7	14.0	4.6	3.0	3.5	4.0	5.0	9.9	19.9	13.5	3.4
2.40	4.7	11.3	8.9	3.7	2.5	3.1	4.3	4.6	10.8	21.4	15.9	3.9
2.50	5.0	10.2	7.0	3.2	2.9	3.4	4.4	6.3	11.6	23.1	20.2	3.9
2.60	4.9	11.4	5.6	3.1	2.7	3.7	6.1	6.6	11.2	20.7	20.6	3.3
2.70	3.8	12.2	5.4	2.7	2.2	3.3	6.0	7.7	11.8	16.4	12.8	3.1
2.80	3.7	8.7	5.2	2.0	1.9	2.9	6.9	8.1	11.3	13.8	8.2	1.0
2.90	2.0	4.6	3.2	1.5	1.2	2.5	4.6	8.6	11.3	8.6	2.5	tr
3.00	0.1	1.5	1.9	0.6	0.5	1.5	4.6	7.5	9.1	5.5	0.9	tr
3.10	none	0.4	0.6	0.4	0.4	1.0	3.9	8.6	6.9	3.2	0.2	none
3.20	none	none	none	none	tr	0.3	2.8	6.4	5.9	1.3	tr	none

Total: 1139.4g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 18 Mass Distribution (g)

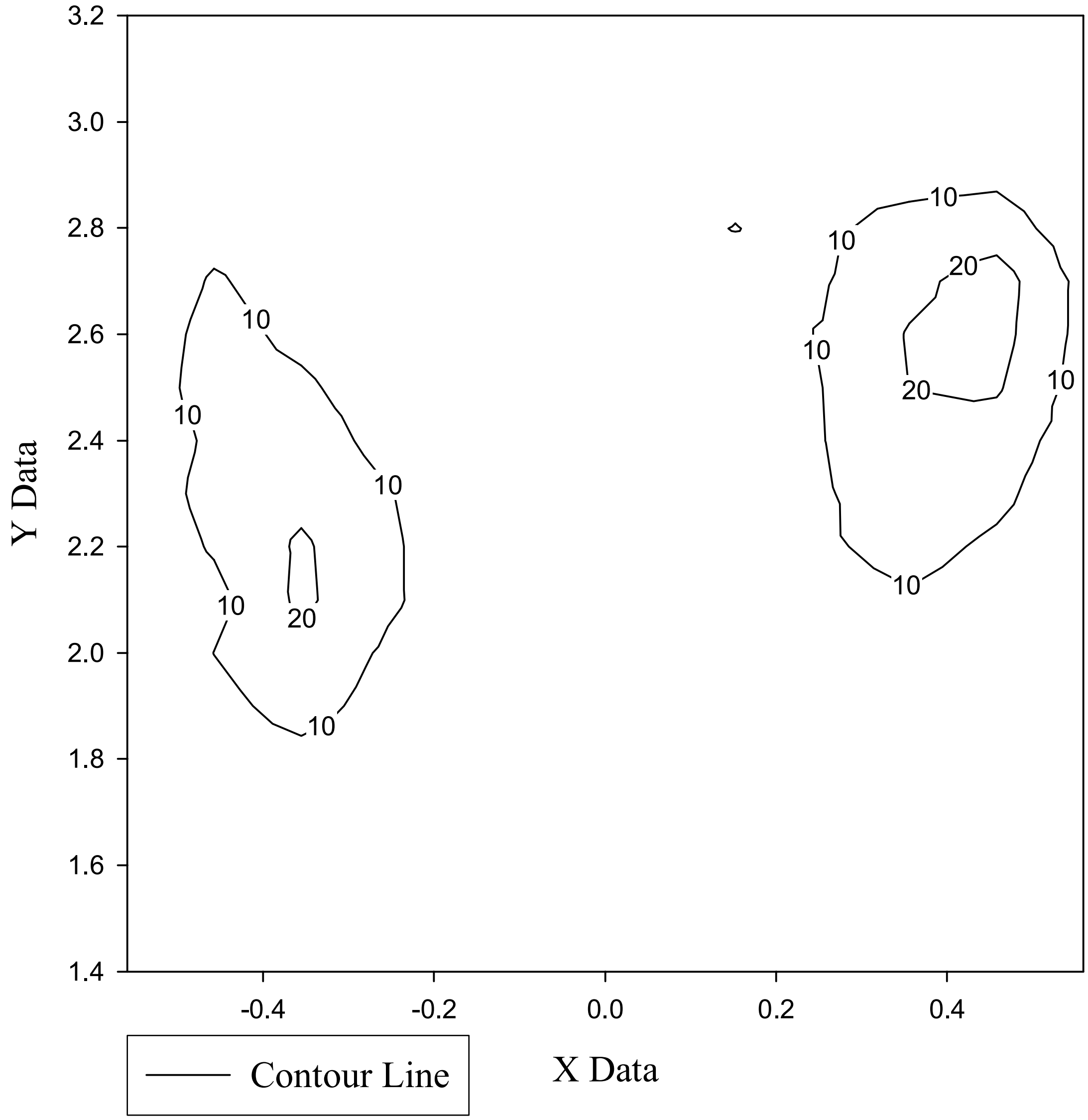


Avg 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.2	0.5	0.6	0.5	0.8	1.1	1.0	0.8	0.6	0.6	0.3	0.2
1.50	0.5	0.8	1.1	1.2	1.1	1.5	1.2	1.0	1.0	0.8	0.4	0.2
1.60	0.5	1.6	2.4	2.0	1.3	1.9	1.5	1.5	1.4	1.3	0.6	0.3
1.70	1.3	3.1	4.6	2.8	1.9	1.9	2.1	1.7	2.0	2.1	1.4	0.4
1.80	1.5	5.1	7.4	4.4	2.4	2.1	2.3	2.9	3.5	3.5	1.8	0.7
1.90	1.8	7.3	13.4	6.5	2.6	2.5	2.7	3.0	4.2	4.6	2.5	0.5
2.00	1.3	10.1	16.6	8.6	3.5	2.7	3.1	4.0	6.4	6.6	3.7	1.5
2.10	1.8	7.4	22.0	11.4	3.9	3.3	3.6	4.3	6.9	9.1	6.1	1.8
2.20	3.6	10.9	21.5	11.4	3.6	3.2	3.8	5.0	8.8	12.8	8.5	2.9
2.30	4.2	12.8	17.2	10.5	3.5	4.1	4.9	5.6	8.9	16.3	12.1	3.9
2.40	4.2	11.5	14.5	7.1	3.3	4.8	5.4	5.7	9.7	19.3	14.8	5.2
2.50	4.7	13.6	11.4	5.4	3.9	5.0	6.1	7.1	10.0	20.1	21.2	5.7
2.60	4.0	12.9	8.0	3.8	3.8	5.4	7.9	7.4	10.3	20.7	23.8	7.0
2.70	2.9	10.9	5.9	3.0	3.3	5.7	8.7	8.6	9.2	17.4	24.8	7.0
2.80	2.5	7.2	5.3	1.2	2.5	4.9	8.9	10.1	8.5	12.9	15.0	4.1
2.90	1.6	4.3	3.0	1.5	1.8	4.0	7.1	9.0	7.4	7.1	7.8	1.9
3.00	0.1	1.5	1.4	0.9	1.0	2.5	6.4	7.8	5.6	3.4	2.1	0.5
3.10	0.1	0.5	0.4	0.3	0.7	1.3	5.2	5.9	3.6	1.7	0.3	0.1
3.20	0.0	0.0	0.0	0.0	0.1	0.4	2.2	3.8	2.2	0.5	0.0	0.0

Total: 1142.5g
All measurements in grams

Test 15-18 Average Mass Distribution (g)



Appendix E- Nonaspirated 0º Raw Mass Distribution Data

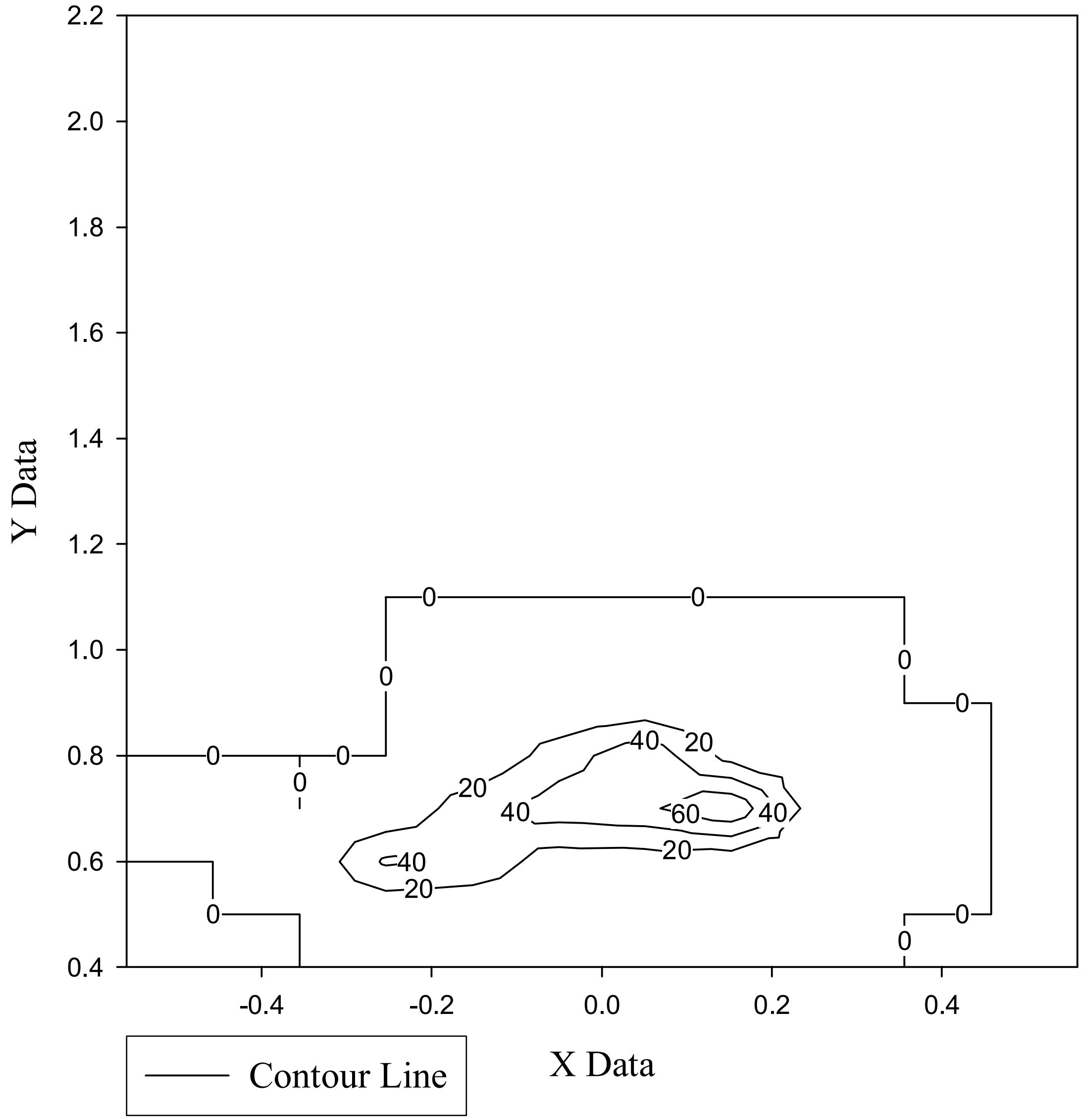
Test 23 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	none	0.1	0.8	0.3	0.2	0.1	0.1	none	none	none
0.50	none	none	none	1.8	1.6	2.0	1.8	0.9	0.1	none	none	none
0.60	none	none	0.1	43.3	34.7	8.9	8.7	5.0	0.3	0.1	none	none
0.70	none	0.1	tr	1.9	31.7	50.9	56.0	78.5	5.2	0.1	none	none
0.80	none	none	none	tr	1.3	29.6	55.3	12.1	0.2	0.1	none	none
0.90	none	none	none	tr	0.1	1.3	2.6	0.5	0.2	tr	none	none
1.00	none	none	none	none	0.1	0.1	0.2	0.1	0.1	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 439.2g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 23 Mass Distribution (g)



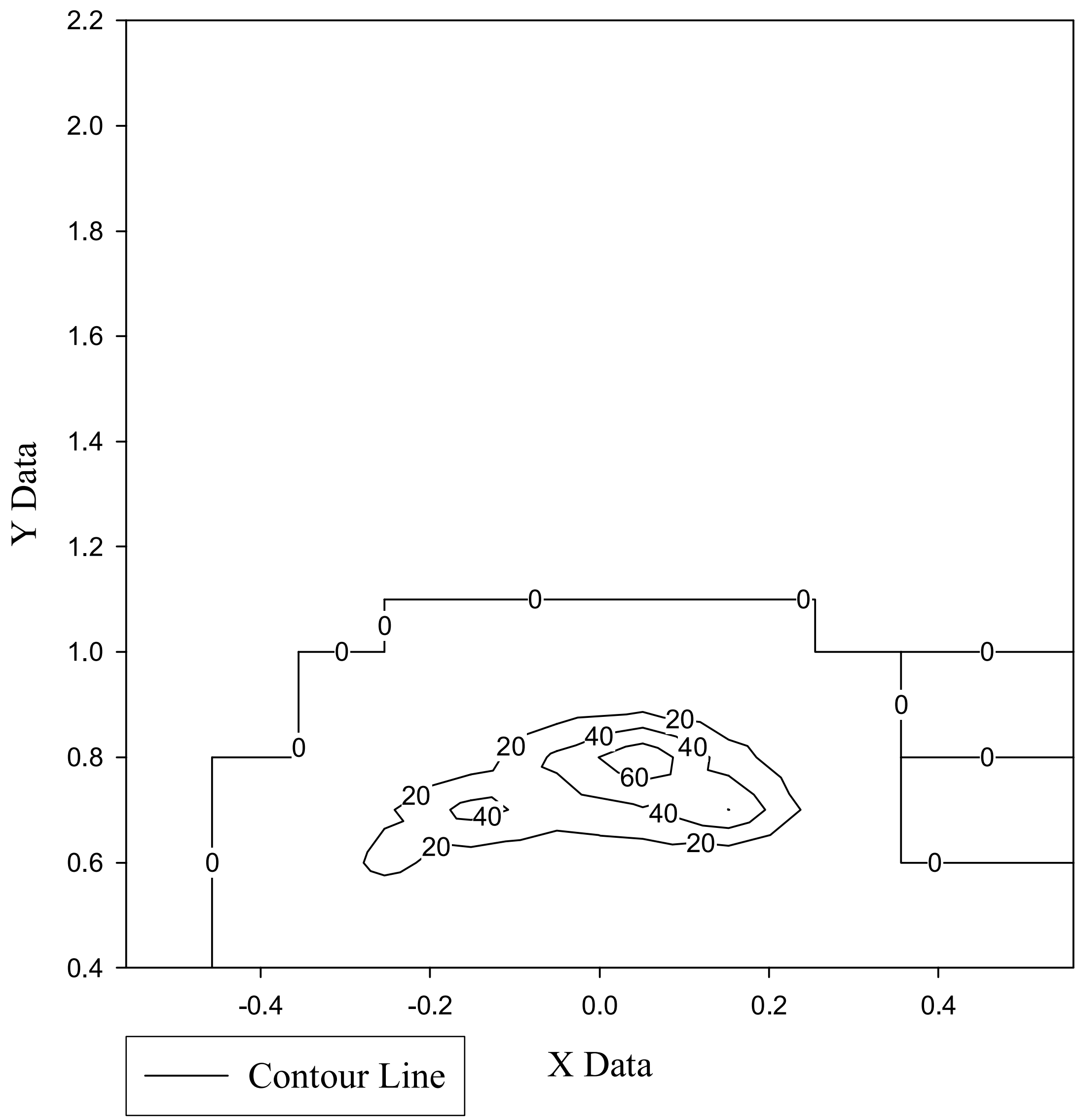
Test 24 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	0.1	0.1	0.1	0.4	0.2	0.1	0.1	none	none	none
0.50	none	none	0.1	0.2	0.2	0.7	0.9	0.4	0.3	0.1	0.1	none
0.60	none	none	0.1	26.4	8.7	4.4	5.7	1.2	0.5	none	none	none
0.70	none	none	0.1	16.4	47.5	30.3	37.9	60.2	12.1	tr	none	none
0.80	none	none	tr	0.3	6.9	44.3	76.9	29.3	0.2	tr	none	none
0.90	none	none	none	0.1	0.3	6.2	11	1.4	0.1	tr	0.1	tr
1.00	none	none	none	none	0.1	0.4	0.5	0.2	tr	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 433.9g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 24 Mass Distribution (g)



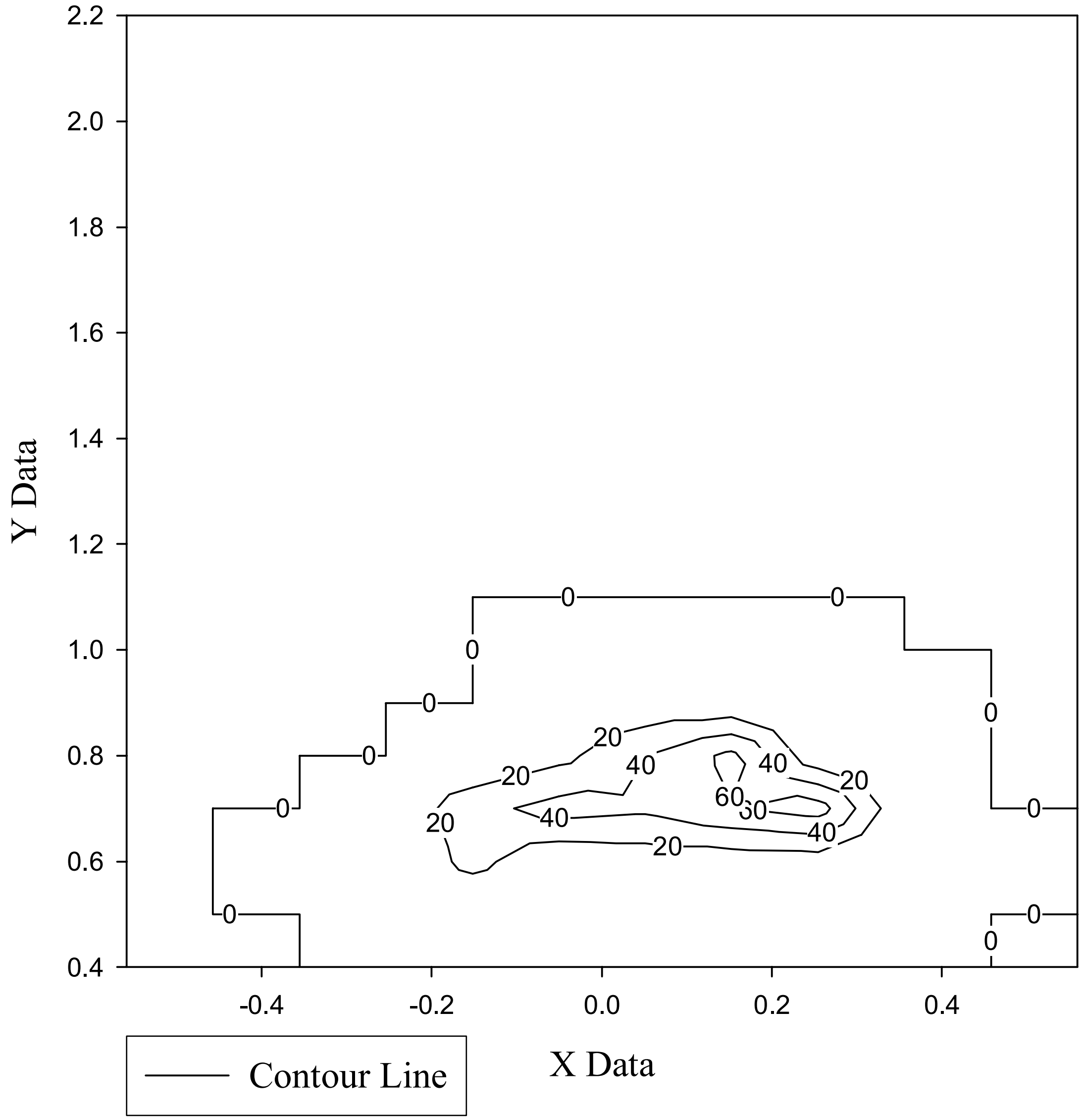
Test 25 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	none	none	0.1	0.3	0.6	0.3	0.2	0.1	tr	tr
0.50	none	none	none	0.1	0.3	0.7	1.4	1.4	0.4	0.1	tr	none
0.60	none	none	0.1	0.4	26.2	3.7	7.7	7.9	9.5	0.1	0.1	none
0.70	none	none	tr	1.2	33.0	47.7	43.9	59.1	69.6	1.2	tr	none
0.80	none	none	tr	tr	0.5	13.6	39.8	65.0	4.1	0.1	tr	none
0.90	none	none	none	none	tr	0.7	3.6	3.7	0.3	0.1	none	none
1.00	none	none	none	none	tr	0.1	0.3	0.4	0.1	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 449.8g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 25 Mass Distribution (g)



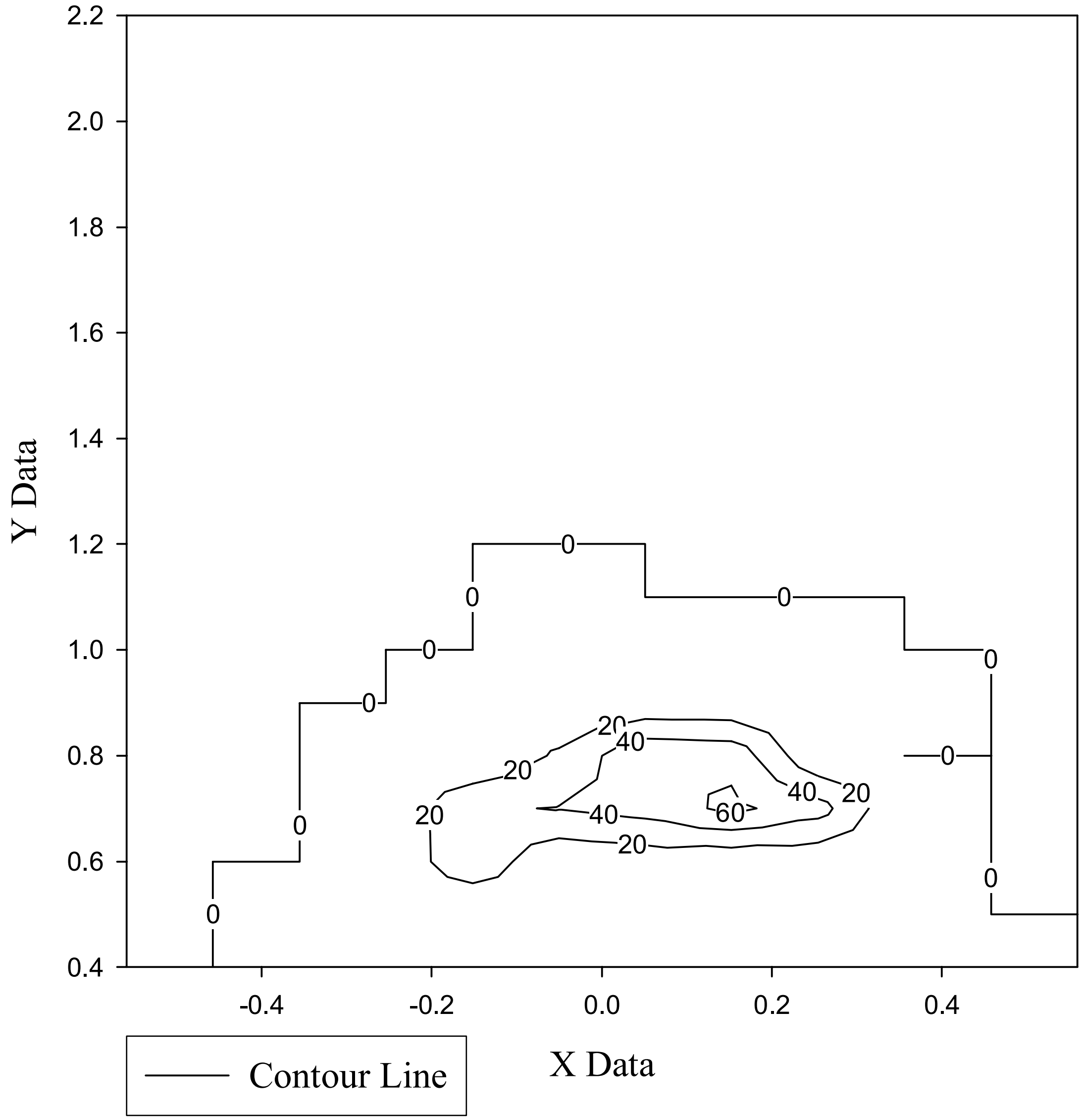
Test 26 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	0.1	tr	0.2	0.3	0.8	0.1	tr	tr	0.1	none
0.50	none	none	0.1	0.1	0.1	0.8	1.4	0.9	0.2	0.1	none	none
0.60	none	none	none	4.4	34.4	3.5	7.8	4.3	4.6	0.3	tr	tr
0.70	none	none	none	2.7	37.4	40.9	47.8	64.8	48.2	0.3	tr	tr
0.80	none	none	none	0.1	0.6	23.2	56.8	53.8	2.0	tr	tr	none
0.90	none	none	none	none	0.1	0.8	4.2	3.4	0.4	0.1	none	none
1.00	none	none	none	none	none	0.1	0.3	0.3	0.2	none	none	none
1.10	none	none	none	none	none	0.1	tr	tr	tr	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 453.2g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 26 Mass Distribution (g)



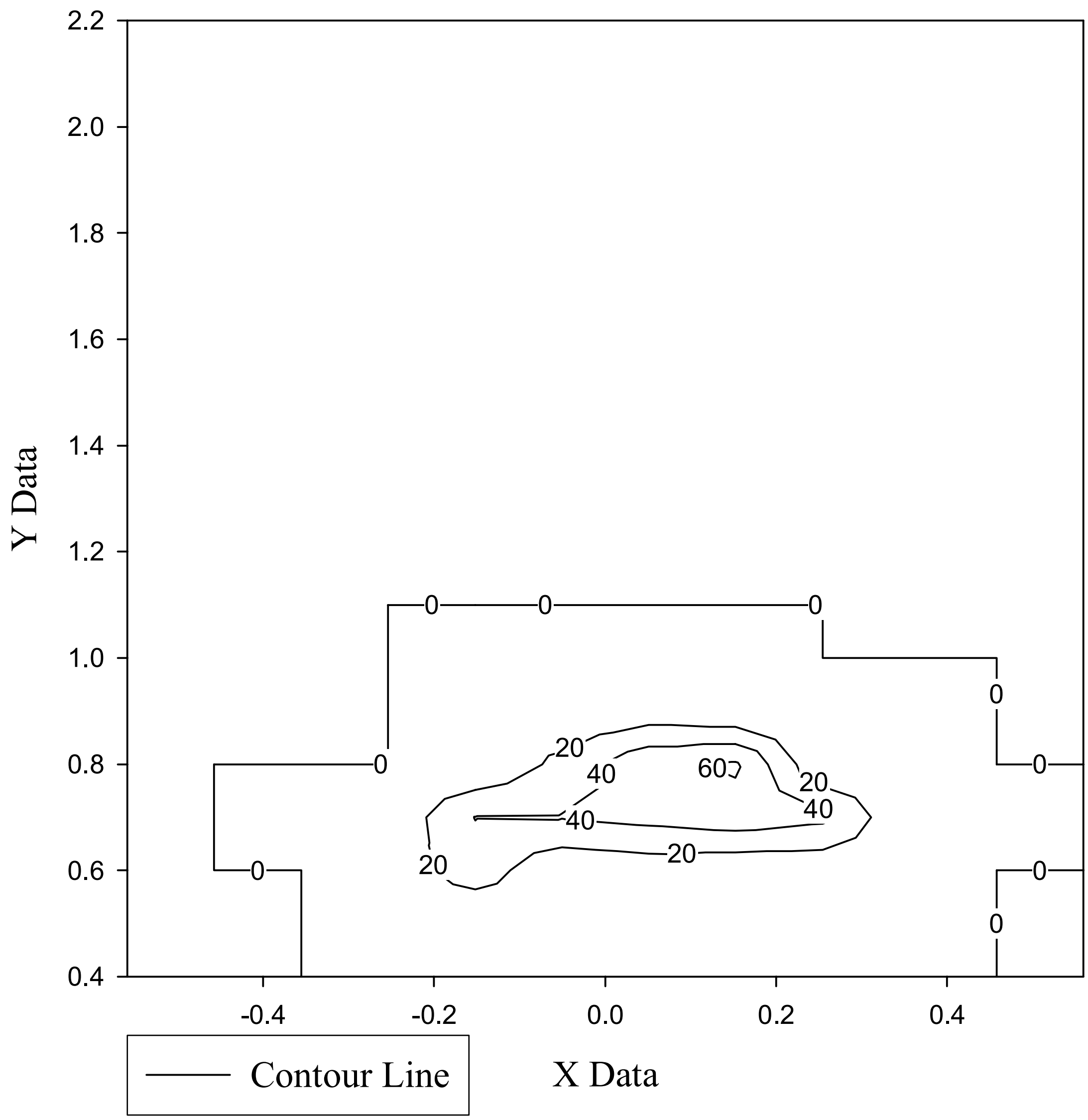
Test 27 0 deg 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	none	tr	0.1	0.1	0.2	tr	tr	tr	tr	tr
0.50	none	none	none	0.1	0.1	1.1	0.9	0.6	0.2	0.1	tr	tr
0.60	none	tr	tr	7.4	31.1	3.4	8.1	3.6	4.2	0.1	tr	none
0.70	none	none	0.1	4.2	40.6	41.1	46.0	52.3	45.0	0.2	0.1	none
0.80	none	none	none	tr	0.5	25.8	55.8	62.6	1.7	0.1	tr	none
0.90	none	none	none	none	0.1	1.8	7.5	2.5	0.2	0.1	none	none
1.00	none	none	none	none	0.1	0.2	0.5	0.3	tr	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 450.8 g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 27 Mass Distribution (g)



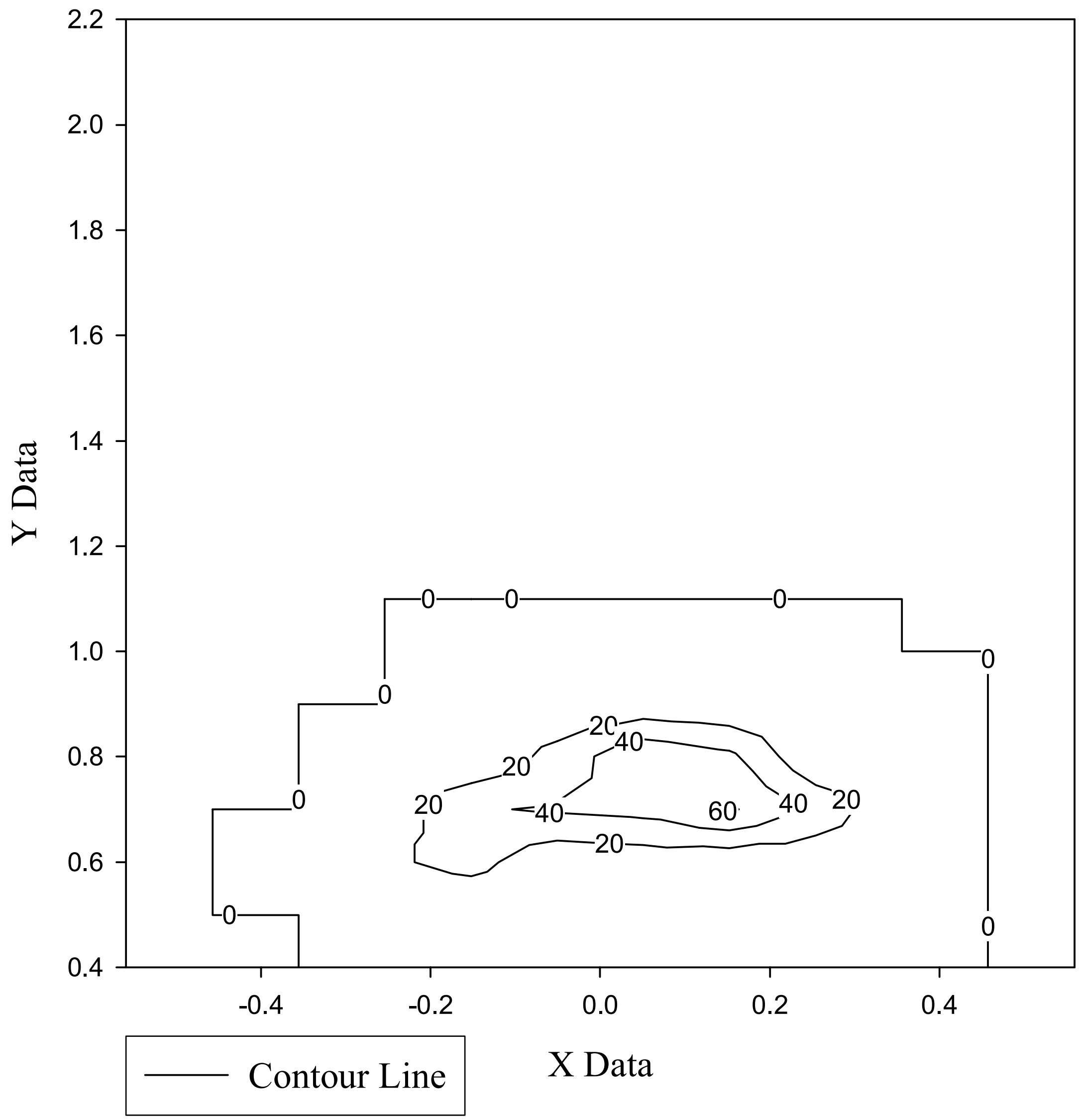
Avg 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.3	0.3	0.4	0.1	0.1	0.0	0.0	0.0
0.50	0.0	0.0	0.0	0.5	0.5	1.1	1.3	0.8	0.2	0.1	0.0	0.0
0.60	0.0	0.0	0.1	16.4	27.0	4.8	7.6	4.4	3.8	0.1	0.0	0.0
0.70	0.0	0.0	0.0	5.3	38.0	42.2	46.3	63.0	36.0	0.4	0.0	0.0
0.80	0.0	0.0	0.0	0.1	2.0	27.3	56.9	44.6	1.6	0.1	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.1	2.2	5.8	2.3	0.2	0.1	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.3	0.1	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 445.4g

All measurements in grams

Tests 23-27 Average Mass Distribution (g)



Appendix F- Nonaspirated -15º Raw Mass Distribution Data

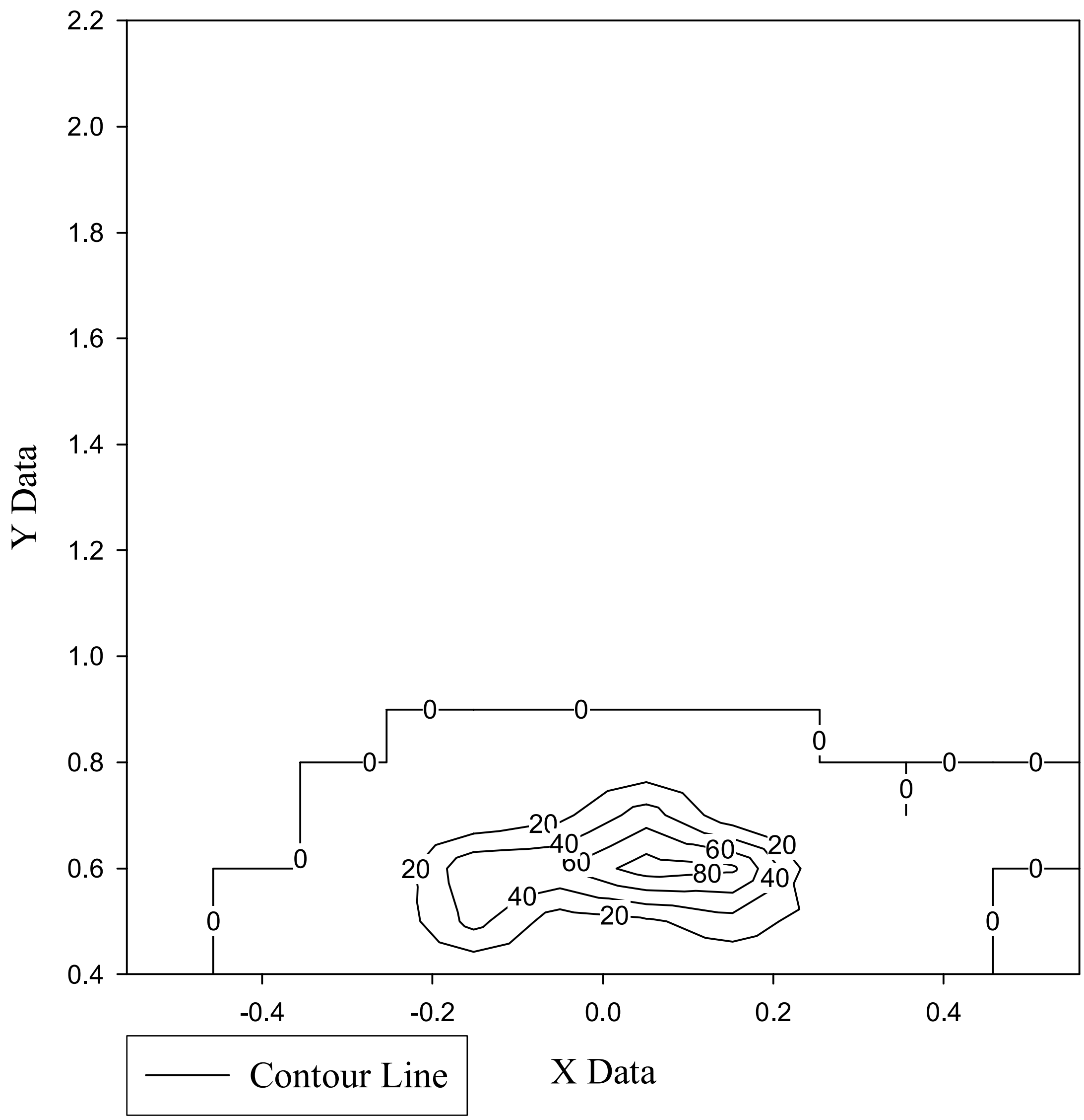
Test 28 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	none	tr	0.3	1.2	2.4	0.7	0.5	0.1	none	none
0.50	none	none	0.1	2.8	47.2	8.6	16.3	32.0	9.6	0.1	none	none
0.60	none	none	none	1.9	56.8	59.1	91.0	84.2	2.3	0.1	none	none
0.70	none	none	none	0.1	0.6	14.3	50.1	5.0	0.2	tr	0.1	none
0.80	none	none	none	none	0.2	0.5	2.0	0.4	tr	none	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 490.8g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 28 Mass Distribution (g)



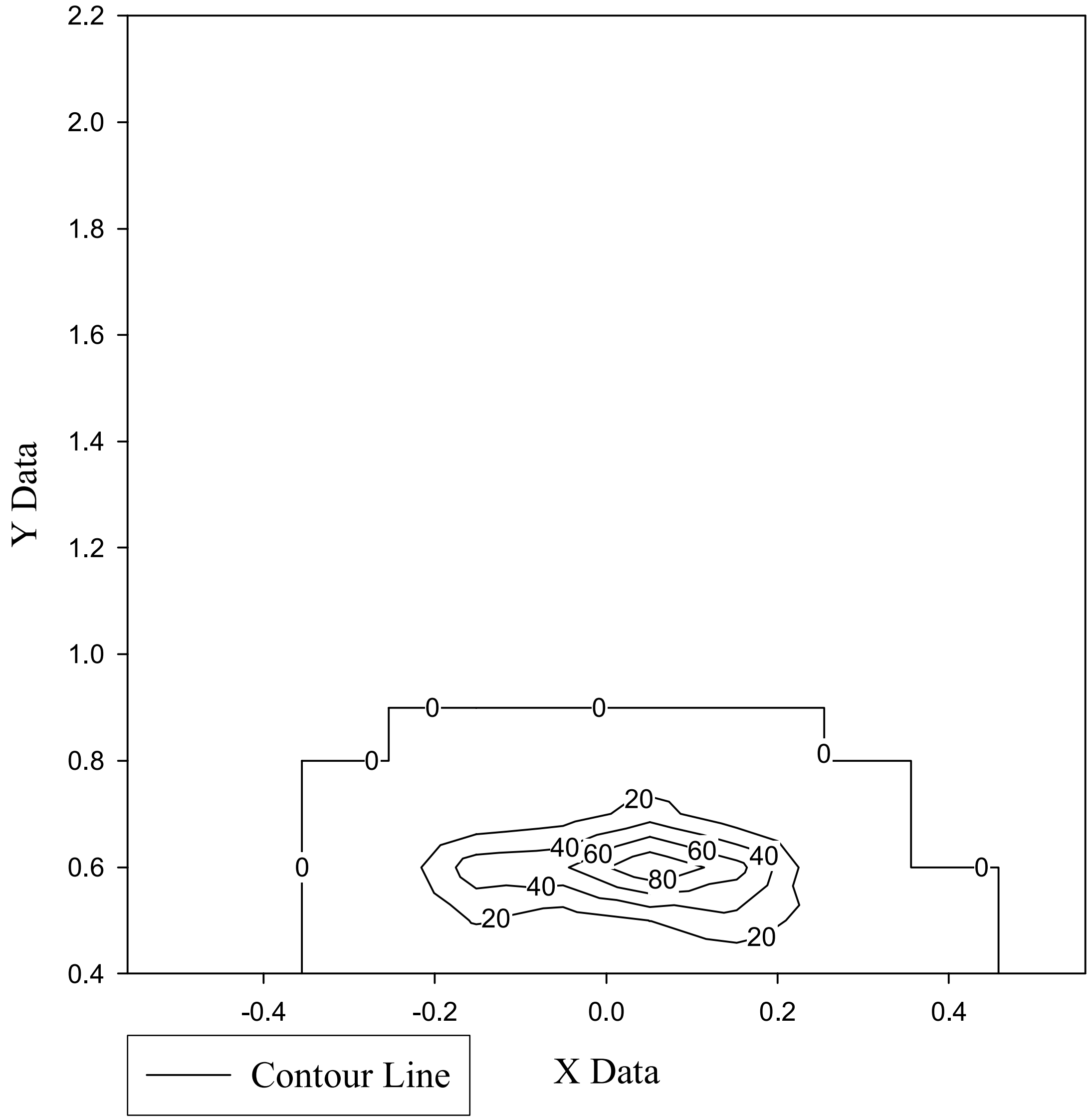
Test 29 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	tr	tr	tr	tr	0.1	1.2	2.5	1.1	0.1	tr	tr	none
0.50	none	none	tr	0.8	21.7	7.7	20.2	33.7	9.5	0.1	none	none
0.60	none	none	none	1.0	52.0	57.3	99.9	67.9	0.6	none	none	none
0.70	none	none	none	0.1	0.3	8.7	29.3	3.2	0.2	tr	none	none
0.80	none	none	none	tr	0.1	0.5	1.2	0.3	tr	none	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 421.3g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 29 Mass Distribution (g)



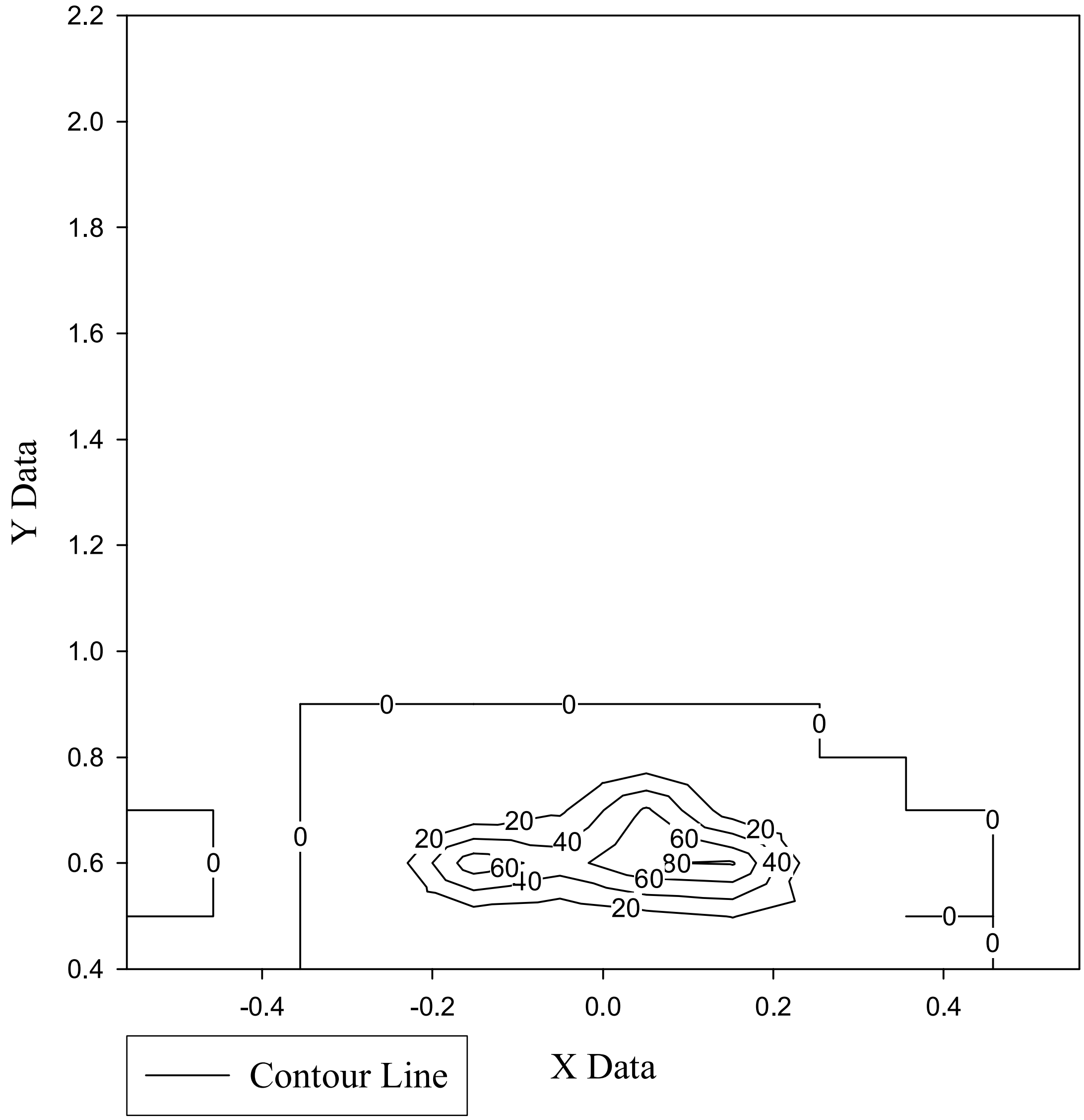
Test 30 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	none	tr	0.1	0.7	0.9	0.7	0.1	0.1	none	none
0.50	none	none	tr	1.0	9.0	4.6	13.5	20.5	9.4	tr	none	none
0.60	0.1	none	tr	3.0	73.1	50.6	79.1	81.9	1.4	0.1	none	none
0.70	none	none	none	0.1	1.0	16.2	63.1	7.1	0.1	tr	none	none
0.80	none	none	none	0.1	0.1	0.6	1.3	0.4	tr	tr	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 440.0g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 30 Mass Distribution (g)



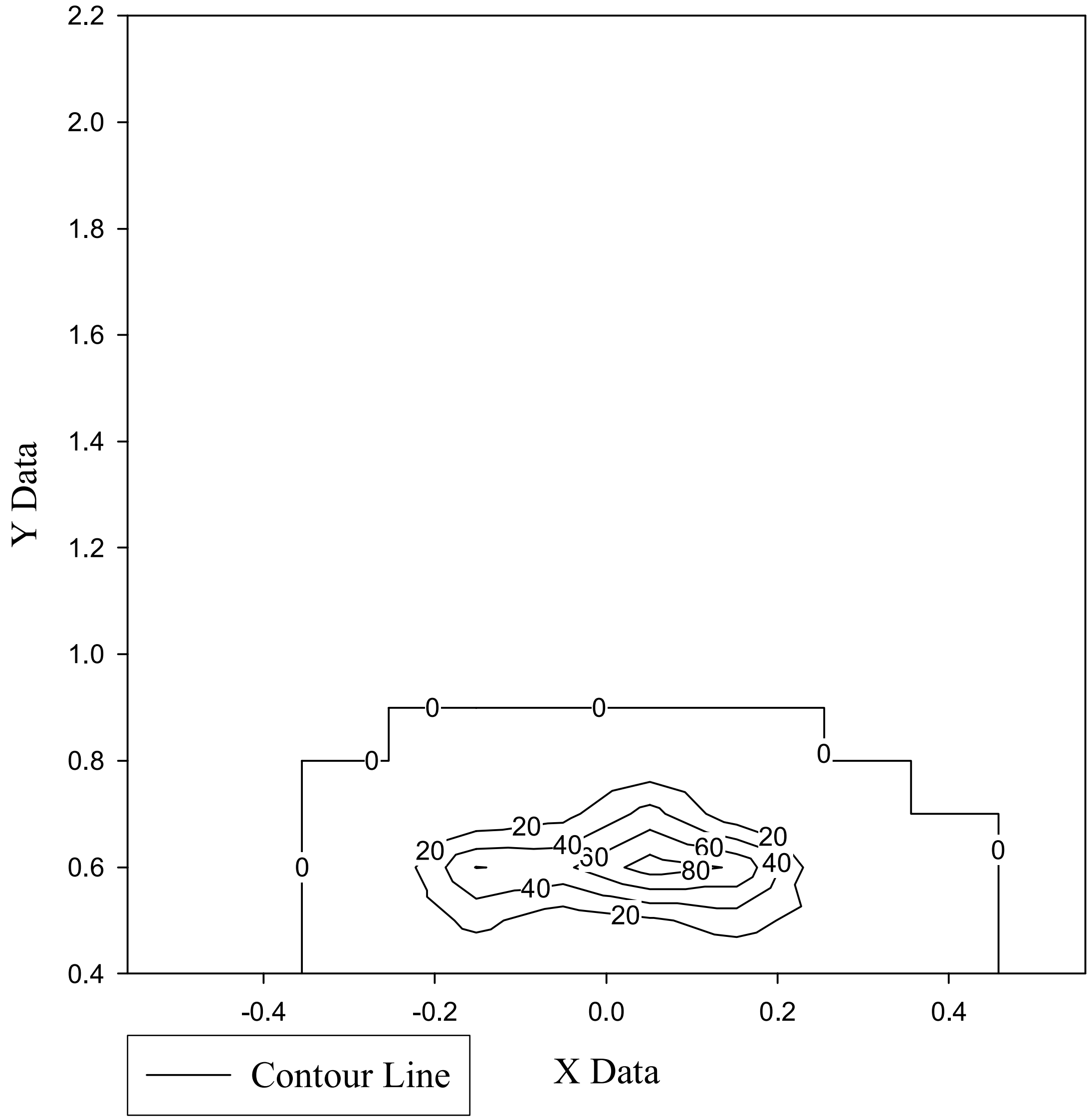
Avg -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.2	1.0	1.9	0.8	0.2	0.1	0.0	0.0
0.50	0.0	0.0	0.0	1.5	26.0	7.0	16.7	28.7	9.5	0.1	0.0	0.0
0.60	0.0	0.0	0.0	2.0	60.6	55.7	90.0	78.0	1.4	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.1	0.6	13.1	47.5	5.1	0.2	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.1	0.5	1.5	0.4	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 450.7g

All measurements in grams

Test 28-30 Average Mass Distribution (g)



Appendix G- Nonaspirated 15º Raw Mass Distribution Data

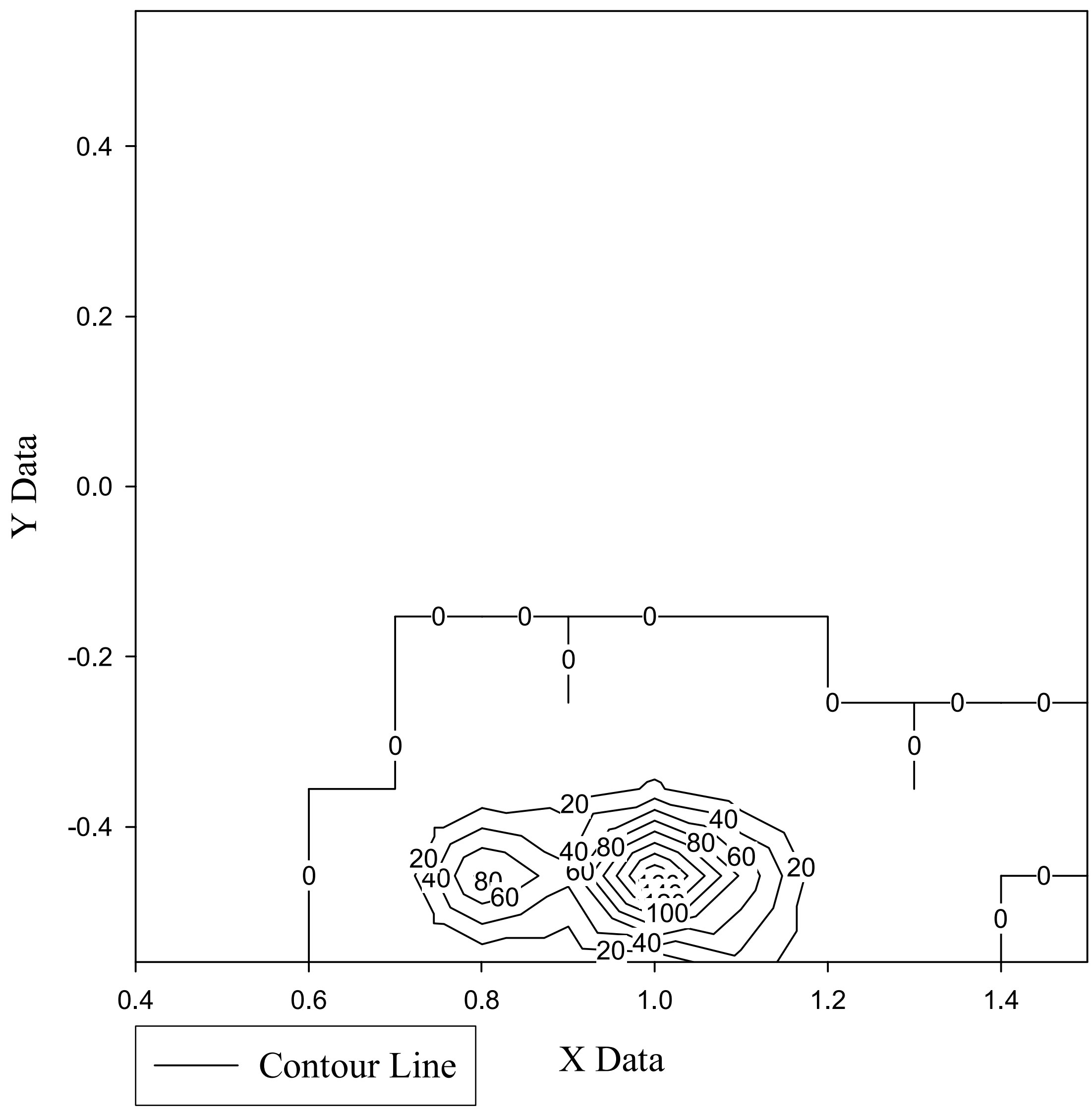
Test 31 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	tr	tr	2.1	2.1	8.2	33.9	0.3	0.1	none	none
0.50	none	none	none	0.1	87.7	45.5	179.4	76.5	0.3	0.1	tr	none
0.60	none	none	none	none	0.8	8.0	22.5	1.1	0.1	tr	0.2	none
0.70	none	none	none	none	0.1	tr	0.1	0.1	none	none	none	none
0.80	none	none	none	none	none	none	none	none	none	none	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 469.3 g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 31 Mass Distribution (g)



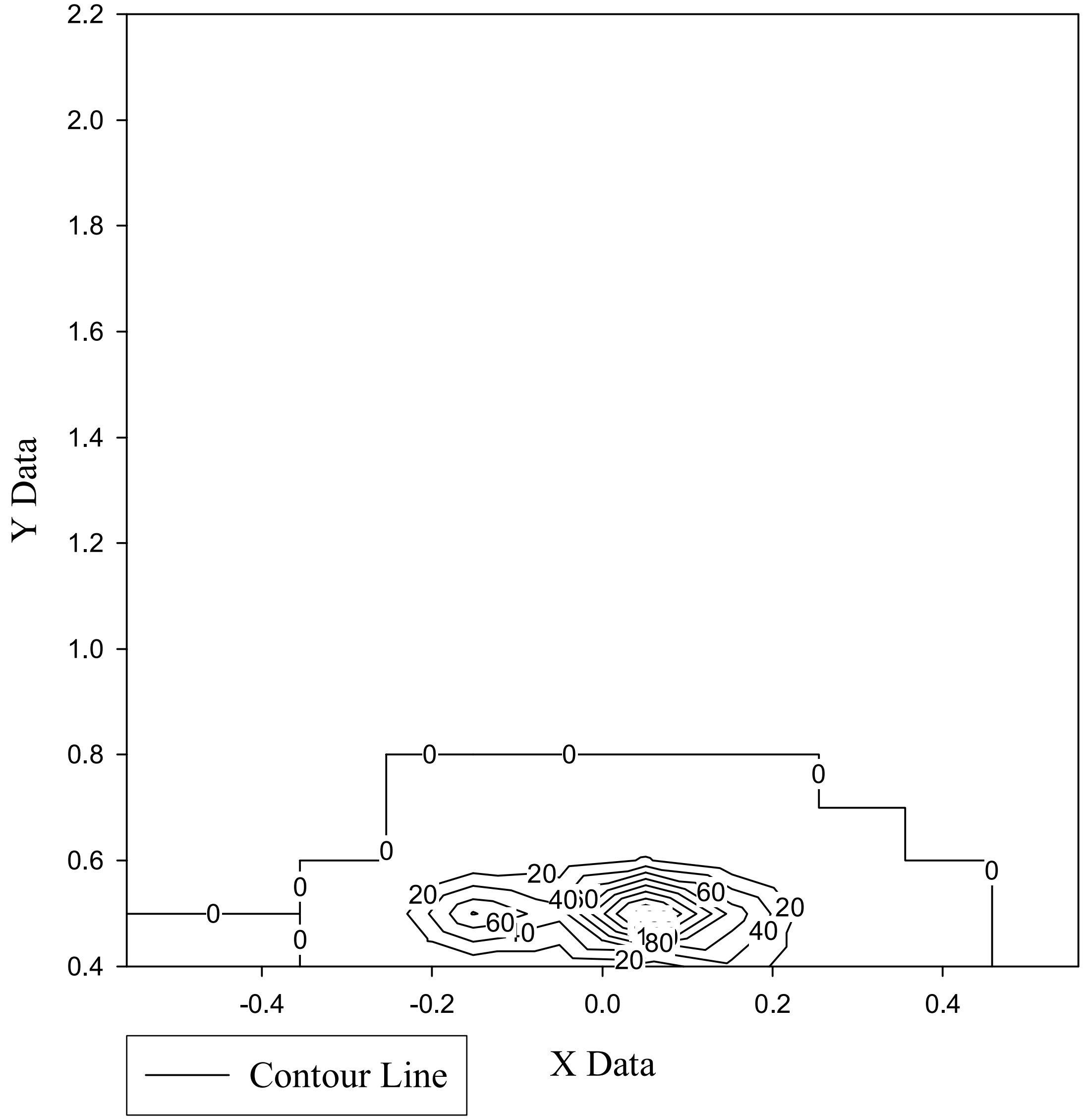
Test 32 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.1	0.1	tr	tr	2.8	1.8	7.1	35.2	0.2	0.1	tr	tr
0.50	none	tr	tr	0.1	81.9	47.0	187.4	72.6	0.2	0.1	none	none
0.60	none	none	none	none	0.6	6.9	21.7	0.9	0.1	none	none	none
0.70	none	none	none	none	0.1	0.1	0.1	0.1	none	none	none	none
0.80	none	none	none	none	none	none	none	none	none	none	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 467.3g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 32 Mass Distribution (g)



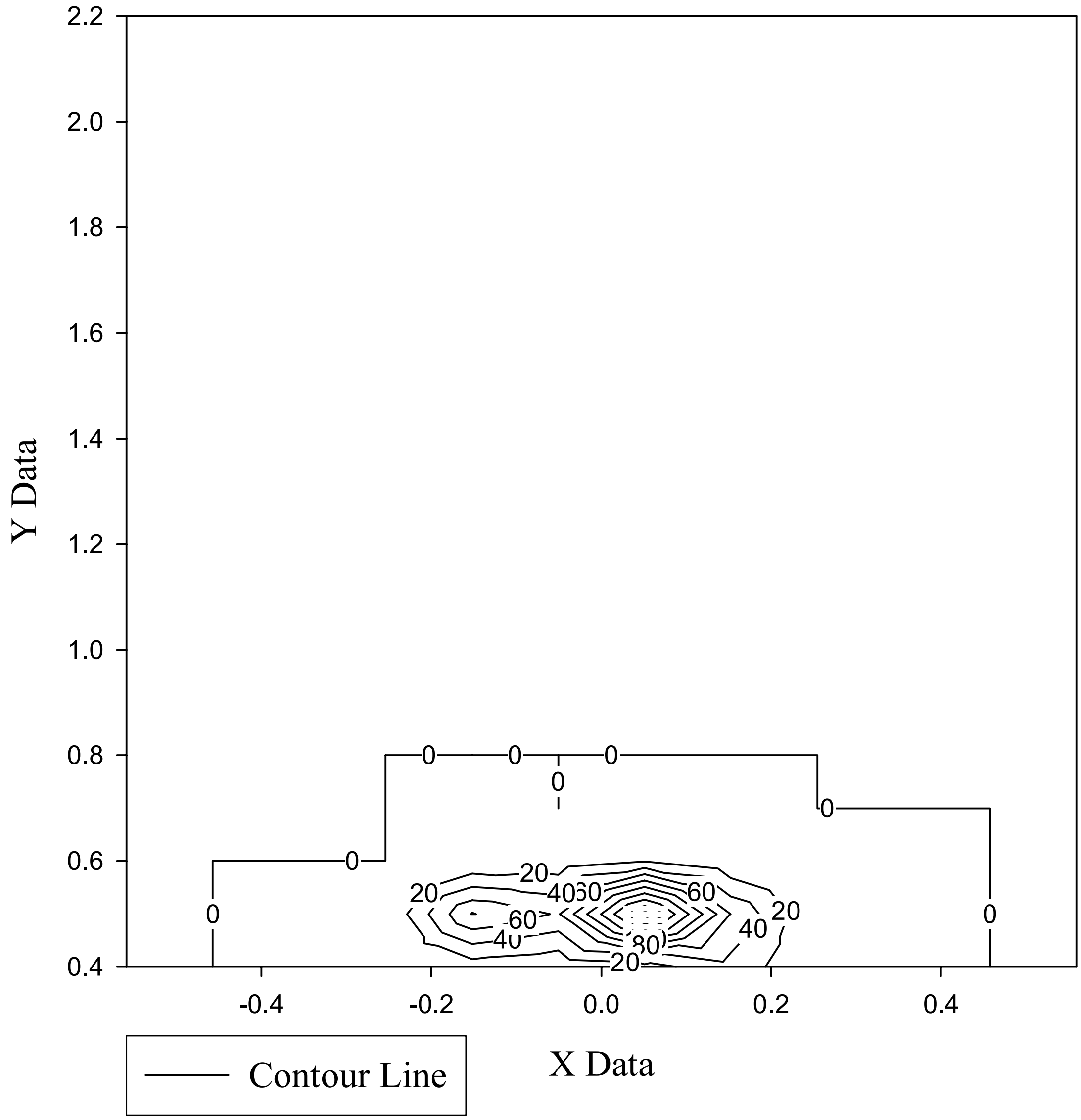
Test 33 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	none	none	tr	tr	9.6	3.6	11.7	33.1	0.2	0.1	none	none
0.50	none	tr	0.1	0.1	81.0	57.8	184.1	59.6	0.2	0.1	none	none
0.60	none	none	none	none	0.4	6.4	18.8	0.7	0.1	0.1	none	none
0.70	none	none	none	none	0.1	tr	0.1	0.1	none	none	none	none
0.80	none	none	none	none	none	none	none	none	none	none	none	none
0.90	none	none	none	none	none	none	none	none	none	none	none	none
1.00	none	none	none	none	none	none	none	none	none	none	none	none
1.10	none	none	none	none	none	none	none	none	none	none	none	none
1.20	none	none	none	none	none	none	none	none	none	none	none	none
1.30	none	none	none	none	none	none	none	none	none	none	none	none
1.40	none	none	none	none	none	none	none	none	none	none	none	none
1.50	none	none	none	none	none	none	none	none	none	none	none	none
1.60	none	none	none	none	none	none	none	none	none	none	none	none
1.70	none	none	none	none	none	none	none	none	none	none	none	none
1.80	none	none	none	none	none	none	none	none	none	none	none	none
1.90	none	none	none	none	none	none	none	none	none	none	none	none
2.00	none	none	none	none	none	none	none	none	none	none	none	none
2.10	none	none	none	none	none	none	none	none	none	none	none	none
2.20	none	none	none	none	none	none	none	none	none	none	none	none

Total: 468.1g

All measurements in grams tr=visible foam, mass<0.1 g none=no change in mass or visible foam

Test 33 Mass Distribution (g)

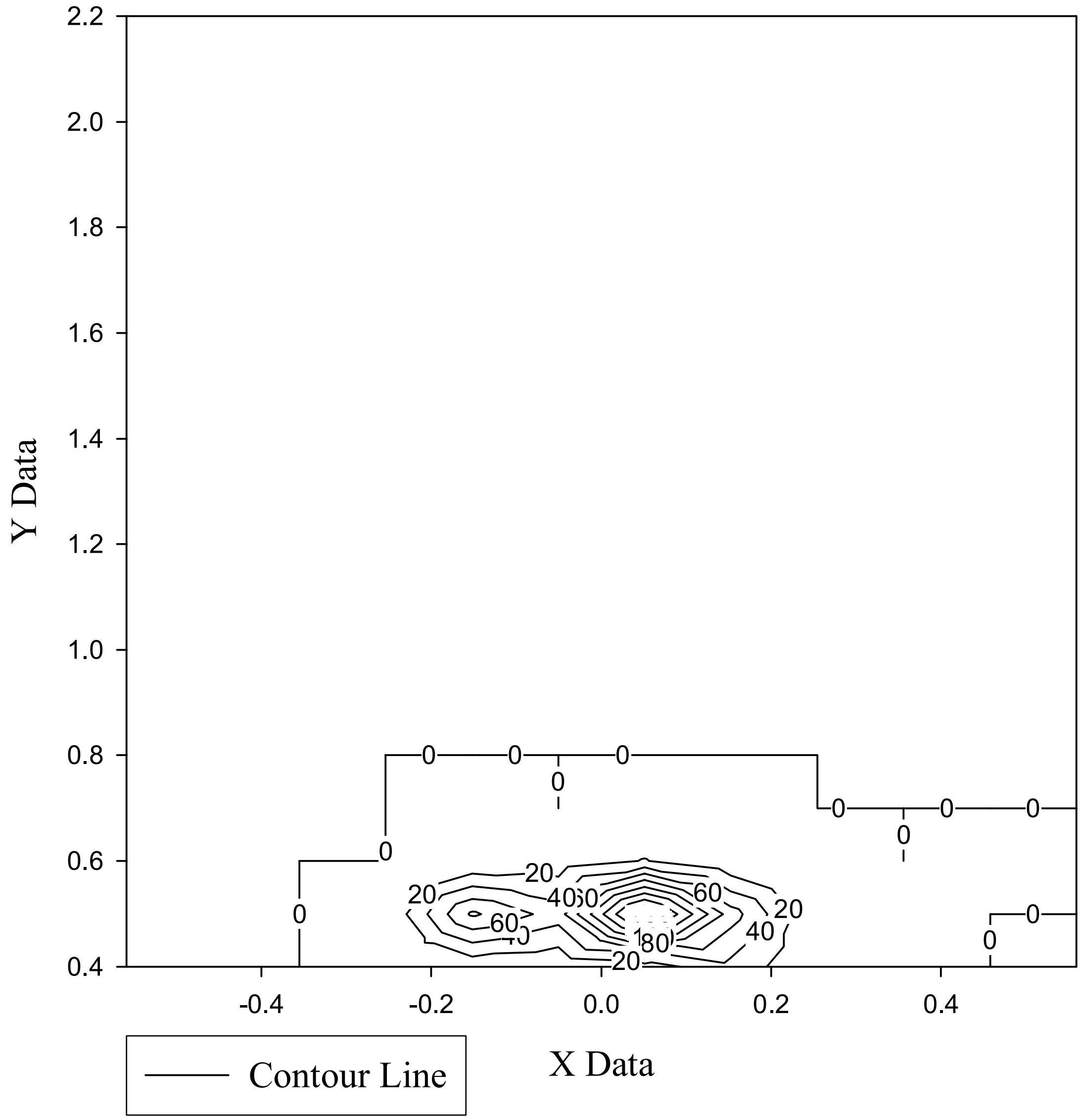


Avg 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	4.8	2.5	9.0	34.1	0.2	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	83.5	50.1	183.6	69.6	0.2	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	0.6	7.1	21.0	0.9	0.1	0.0	0.1	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 468.2g
All measurements in grams

Test 31-33 Average Mass Distribution (g)



Appendix H- Early Flow Overhead Camera Data

0 m, 0.2 m, 2m time step =1/30 s

0º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.04	0.00			
	-0.08	0.08	0.18	-0.9	1.2	5.4
Pulse 2	-0.05	0.01	0.10			
	-0.09	0.08	0.25	-1.2	2.1	4.5
Pulse 3	-0.04	0.06	0.16			
	-0.11	0.10	0.30	-2.1	1.2	4.2
Pulse 4	-0.06	0.04	0.01			
	-0.12	0.09	0.19	-1.8	1.5	5.4
Pulse 5	-0.06	0.08	0.11			
	-0.10	0.13	0.28	-1.2	1.5	5.1

-15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.02	0.09			
	-0.07	0.08	0.25	-0.6	1.8	4.8
Pulse 2	-0.10	0.05	0.14			
	-0.14	0.08	0.31	-1.2	0.9	5.1
Pulse 3	-0.07	0.04	0.10			
	-0.12	0.09	0.24	-1.5	1.5	4.2
Pulse 4	-0.07	0.01	0.00			
	-0.11	0.08	0.16	-1.2	2.1	4.8
Pulse 5	-0.06	0.03	0.10			
	-0.14	0.06	0.26	-2.4	0.9	4.8

15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.05	0.03	0.04			
	-0.11	0.06	0.23	-1.8	0.9	5.7
Pulse 2	-0.07	0.07	0.05			
	-0.10	0.11	0.22	-0.9	1.2	5.1
Pulse 3	-0.07	0.04	0.01			
	-0.13	0.09	0.14	-1.8	1.5	3.9
Pulse 4	-0.04	0.08	0.09			
	-0.10	0.11	0.24	-1.8	0.9	4.5
Pulse 5	-0.08	0.06	0.00			
	-0.13	0.16	0.14	-1.5	3.0	4.2

Appendix I- Late Flow Overhead Camera Data

0 m, 1.0 m, 2m time step =1/30 s

0^o	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.21	0.22	0.90			
	-0.25	0.25	1.02	-1.2	0.9	3.6
	-0.29	0.29	1.17	-1.2	1.2	4.5
Pulse 2	-0.18	0.20	0.82			
	-0.24	0.23	0.95	-1.8	0.9	3.9
	-0.28	0.27	1.09	-1.2	1.2	4.2
Pulse 3	-0.18	0.15	0.91			
	-0.21	0.21	1.00	-0.9	1.8	2.7
	-0.24	0.24	1.13	-0.9	0.9	3.9
	-0.29	0.26	1.24	-1.5	0.6	3.3
Pulse 4	-0.20	0.19	0.87			
	-0.22	0.21	1.03	-0.6	0.6	4.8
	-0.23	0.25	1.14	-0.3	1.2	3.3
Pulse 5	-0.21	0.20	0.92			
	-0.24	0.22	1.06	-0.9	0.6	4.2
	-0.28	0.27	1.19	-1.2	1.5	3.9

-15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.14	0.19	0.93			
	-0.17	0.20	1.03	-0.9	0.3	3.0
	-0.20	0.22	1.14	-0.9	0.6	3.3
	-0.22	0.23	1.23	-0.6	0.3	2.7
Pulse 2	-0.14	0.16	0.85			
	-0.16	0.19	0.96	-0.6	0.9	3.3
	-0.19	0.24	1.05	-0.9	1.5	2.7
	-0.24	0.27	1.14	-1.5	0.9	2.7
Pulse 3	-0.14	0.17	0.95			
	-0.16	0.19	1.03	-0.6	0.6	2.4
	-0.19	0.23	1.13	-0.9	1.2	3.0
	-0.25	0.26	1.22	-1.8	0.9	2.7
Pulse 4	-0.17	0.18	0.99			
	-0.20	0.22	1.08	-0.9	1.2	2.7
	-0.25	0.25	1.18	-1.5	0.9	3.0
	-0.27	0.29	1.27	-0.6	1.2	2.7
Pulse 5	-0.16	0.17	0.89			
	-0.19	0.19	0.98	-0.9	0.6	2.7
	-0.23	0.22	1.05	-1.2	0.9	2.1
	-0.26	0.26	1.14	-0.9	1.2	2.7
	-0.29	0.28	1.22	-0.9	0.6	2.4

15º	x_l (m)	x_r (m)	y (m)	u_l (m/s)	u_r (m/s)	v (m/s)
Pulse 1	-0.28	0.28	0.95			
	-0.32	0.31	1.08	-1.2	0.9	3.9
Pulse 2	-0.29	0.29	0.99			
	-0.32	0.31	1.13	-0.9	0.6	4.2
Pulse 3	-0.27	0.28	0.97			
	-0.32	0.32	1.09	-1.5	1.2	3.6
Pulse 4	-0.27	0.24	0.98			
	-0.31	0.29	1.14	-1.2	1.5	4.8
Pulse 5	-0.28	0.26	1.02			
	-0.33	0.29	1.12	-1.5	0.9	3.0

Appendix J- Early Flow Side Camera Data

2 m, 0.3 m, 0.5 m time step =1/60 s

0º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.25	0.99		
	0.33	0.98	4.8	-0.6
Pulse 2	0.26	1.00		
	0.33	0.99	4.2	-0.6
Pulse 3	0.25	0.99		
	0.34	0.99	5.4	0.0
Pulse 4	0.27	1.00		
	0.34	0.99	4.2	-0.6
Pulse 5	0.28	0.99		
	0.36	0.99	4.8	0.0

-15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.25	0.81		
	0.33	0.78	4.8	-1.8
	0.40	0.76	4.2	-1.2
	0.48	0.73	4.8	-1.8
	0.55	0.71	4.2	-1.2
Pulse 2	0.28	0.82		
	0.35	0.80	4.2	-1.2
	0.43	0.76	4.8	-2.4
	0.52	0.73	5.4	-1.8
Pulse 3	0.24	0.85		
	0.33	0.81	5.4	-2.4
	0.41	0.79	4.8	-1.2
	0.49	0.76	4.8	-1.8
	0.55	0.74	3.6	-1.2
Pulse 4	0.28	0.82		
	0.34	0.79	3.6	-1.8
	0.42	0.77	4.8	-1.2
	0.51	0.75	5.4	-1.2
	0.58	0.71	4.2	-2.4
Pulse 5	0.23	0.86		
	0.30	0.83	4.2	-1.8
	0.39	0.79	5.4	-2.4
	0.47	0.77	4.8	-1.2
	0.54	0.75	4.2	-1.2

15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	0.29	1.05		
	0.36	1.06	4.2	0.6
Pulse 2	0.31	1.06		
	0.39	1.07	4.8	0.6
Pulse 3	0.29	1.07		
	0.36	1.07	4.2	0.0
Pulse 4	0.29	1.07		
	0.37	1.07	4.8	0.0
Pulse 5	0.28	1.05		
	0.36	1.06	4.8	0.6

Appendix K- Late Flow Side Camera Data

2 m, 1.1 m, 0.5 m   time step =1/60 s

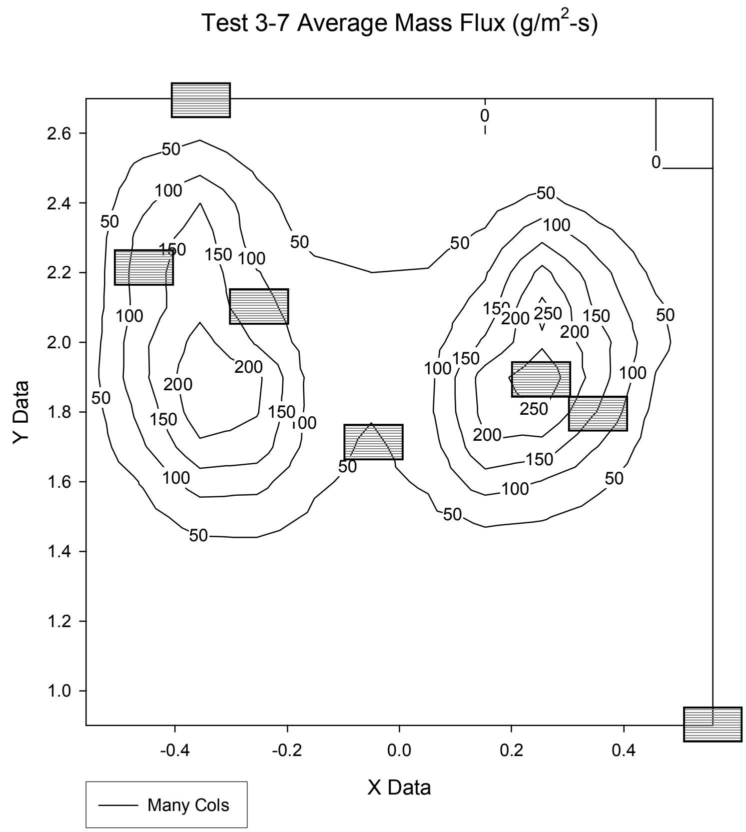
0º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.05	0.77		
	1.11	0.73	3.6	-2.4
	1.16	0.70	3.0	-1.8
	1.22	0.66	3.6	-2.4
	1.28	0.63	3.6	-1.8
Pulse 2	1.04	0.75		
	1.09	0.72	3.0	-1.8
	1.16	0.68	4.2	-2.4
	1.21	0.66	3.0	-1.2
	1.27	0.63	3.6	-1.8
Pulse 3	1.05	0.76		
	1.10	0.74	3.0	-1.2
	1.17	0.71	4.2	-1.8
	1.23	0.68	3.6	-1.8
	1.30	0.65	4.2	-1.8
Pulse 4	1.07	0.75		
	1.15	0.72	4.8	-1.8
	1.21	0.70	3.6	-1.2
	1.26	0.67	3.0	-1.8
	1.33	0.64	4.2	-1.8
Pulse 5	1.06	0.72		
	1.12	0.68	3.6	-2.4
	1.19	0.66	4.2	-1.2
	1.26	0.63	4.2	-1.8

-15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.08	0.31		
	1.14	0.26	3.6	-3.0
Pulse 2	1.07	0.30		
	1.12	0.26	3.0	-2.4
Pulse 3	1.09	0.29		
	1.16	0.23	4.2	-3.6
Pulse 4	1.08	0.28		
	1.13	0.23	3.0	-3.0
Pulse 5	1.09	0.30		
	1.15	0.26	3.6	-2.4

15º	y (m)	z (m)	v (m/s)	w (m/s)
Pulse 1	1.01	1.02		
	1.06	0.99	3.0	-1.8
	1.12	0.95	3.6	-2.4
	1.18	0.93	3.6	-1.2
	1.22	0.90	2.4	-1.8
Pulse 2	1.03	1.00		
	1.07	0.98	2.4	-1.2
	1.14	0.96	4.2	-1.2
	1.20	0.93	3.6	-1.8
	1.25	0.91	3.0	-1.2
Pulse 3	1.03	0.99		
	1.08	0.97	3.0	-1.2
	1.14	0.94	3.6	-1.8
	1.19	0.93	3.0	-0.6
Pulse 4	1.04	1.00		
	1.10	0.99	3.6	-0.6
	1.15	0.96	3.0	-1.8
	1.21	0.93	3.6	-1.8
Pulse 5	1.02	0.99		
	1.07	0.97	3.0	-1.2
	1.14	0.95	4.2	-1.2
	1.18	0.92	2.4	-1.8
	1.23	0.90	3.0	-1.2

Appendix L- Aspirated 0º Cup Level Camera Positions

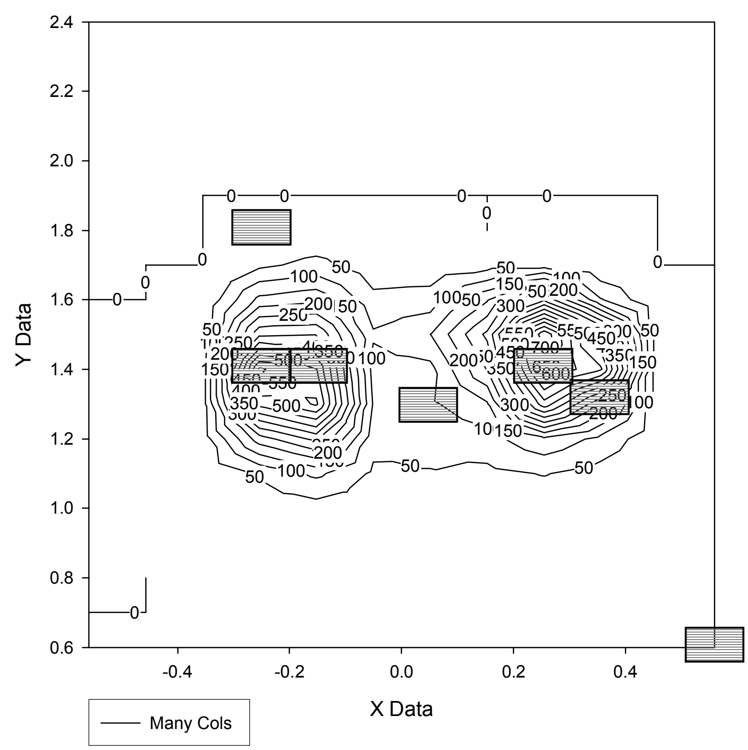
0º	Aspirated	
Test #	x (m)	y (m)
1	0.56	0.9
2	0.36	1.8
3	0.25	1.9
4	-0.05	1.7
5	-0.25	2.1
6	-0.46	2.2
7	-0.36	2.7



Appendix M- Aspirated -15º Cup Level Camera Positions

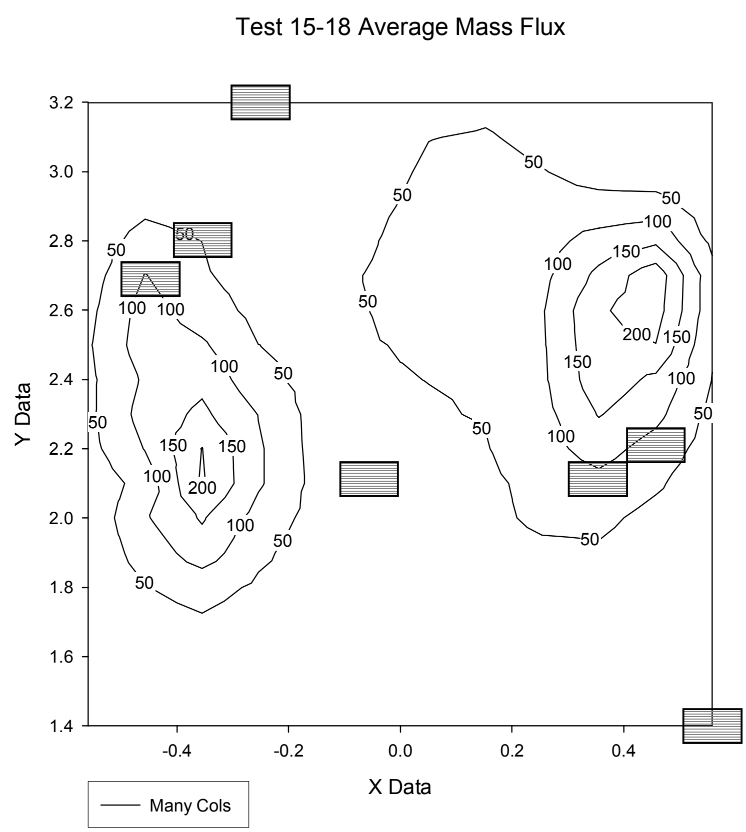
-15º	Aspirated	
Test #	x (m)	y (m)
8	0.56	0.6
9	0.36	1.3
10	0.25	1.4
11	-0.05	1.3
12	-0.15	1.4
13	-0.25	1.4
14	-0.25	1.3

Test 10-12 Average Mass Flux (g/m^2-s)



Appendix N- Aspirated 15º Cup Level Camera Positions

15º	Aspirated	
Test #	x (m)	y (m)
15	0.56	1.4
16	0.46	2.2
17	0.36	2.1
18	-0.05	2.1
19	-0.36	2.8
20	-0.46	2.7
21	-0.25	3.2



Appendix O- Blank Particle Size and Velocity Data Sheet

Test	º	Loc	R1	L1	1yi	1zi	1yf	1zf	R2	L2	2yi	2zi	2yf	2zf	R3	L3	3yi	3zi	3yf	3zf
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				

Test	º	Loc	R4	L4	4yi	4zi	4yf	4zf	R5	L5	5yi	5zi	5yf	5zf
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														

Appendix P- Aspirated 0º Particle Trajectory and Size Data

Test 1	Angle= 0º		x= 0.56 m		y= 0.9 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	0.4	-6.3	1.6	-10.1	-3.2	2.4	1.2	4.3	1.05
B	5.6	-3.8	8.4	-11.0	-2.6	4.6	0.9	2.0	0.67
C	-2.3	-5.4	0.2	-10.9	-2.2	3.6	0.7	5.1	0.78
D	1.9	0.0	2.6	-6.4	-9.1	3.9	0.7	3.5	0.69
E	3.3	-0.5	5.7	-7.1	-2.8	4.2	0.5	3.3	0.54
Predict					-2.5	4.3			

Test 2	Angle= 0º		x= 0.36 m		y= 1.8 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	3.8	-2.3	5.4	-6.2	-2.4	2.5	0.5	3.8	0.56
B	-4.5	0.0	1.3	-6.1	-1.1	5.1	1.2	4.7	1.08
C	5.1	0.0	7.9	-7.2	-2.6	4.6	0.9	6.2	0.98
D	-5.5	-0.9	-3.4	-5.8	-2.3	3.2	1.2	4.4	1.06
E	4.8	-3.3	7.2	-8.8	-2.3	3.6	0.9	5.6	0.95
Predict					-1.3	4.8			

Test 3	Angle= 0º		x= 0.25 m		y= 1.9 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	1.4	-3.8	4.1	-8.6	-1.8	3.3	0.7	3.7	0.70
B	-4.6	-1.7	-1.0	-7.3	-1.6	4.0	0.8	6.1	0.90
C	5.1	-3.7	7.7	-7.8	-1.6	2.9	0.8	7.8	0.98
D	1.3	-1.9	2.8	-6.9	-3.3	3.1	0.5	5.3	0.63
E	2.3	-3.1	4.4	-7.2	-2.0	2.8	0.6	6.1	0.74
Predict					-1.2	4.8			

Test 4	Angle= 0º		x= -0.05 m		y= 1.7 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	1.6	-3.4	3.5	-7.4	-2.1	2.7	0.6	5.1	0.70
B	1.4	-4.3	2.7	-6.8	-1.9	1.7	0.6	3.5	0.62
C	-2.6	-0.5	0.6	-5.4	-1.5	3.5	0.3	3.7	0.40
D	2.5	-5.4	5.4	-11.2	-2.0	3.9	0.5	4.1	0.58
E	0.1	-4.9	3.8	-10.9	-1.6	4.2	0.7	4.2	0.73
Predict					-1.4	4.7			

Test 5	Angle= 0º		x= -0.25 m		y= 2.1 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	-4.3	0.8	-0.7	-5.2	-1.7	4.2	0.7	4.4	0.74
B	-2.0	0.2	2.1	-6.1	-1.5	4.5	1.1	4.8	1.03
C	-6.2	-3.8	-2.7	-8.1	-1.2	3.3	0.7	4.1	0.72
D	-6.2	-3.8	-3.9	-7.8	-1.7	2.8	0.8	2.5	0.67
E	-3.1	0.2	0.4	-5.1	-1.5	3.8	1.1	2.1	0.78
Predict					-1.2	5.0			

Test 6	Angle= 0º		x= -0.46 m		y= 2.2 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	0.0	-1.1	1.9	-5.4	-2.3	2.8	0.8	3.1	0.72
B	-5.4	-2.8	-1.4	-5.3	-0.6	2.8	0.4	6.9	0.59
C	-2.3	0.0	0.9	-5.7	-1.8	3.9	0.5	5.2	0.62
D	0.6	-2.8	2.7	-7.2	-2.1	2.9	0.5	4.8	0.61
E	1.0	-0.8	4.6	-5.8	-1.4	3.7	0.9	3.8	0.83
Predict					-1.1	5.1			

Test 7	Angle= 0º		x= -0.36 m		y= 2.7 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	-1.1	-3.7	3.6	-8.1	-0.9	3.9	0.9	5.2	0.92
B	-2.8	-2.1	4.1	-7.9	-0.8	5.4	0.7	2.1	0.58
C	-1.2	-2.9	6.4	-10.9	-1.1	6.6	0.7	4.2	0.73
D	4.7	-3.3	8.4	-7.7	-1.2	3.4	0.4	5.6	0.55
E	0.2	-1.4	3.9	-3.8	-0.6	2.6	0.3	4.4	0.42
Predict					-0.9	5.4			

Appendix Q- Aspirated -15º Particle Trajectory and Size Data

Test 8	Angle= -15º		x= 0.56 m		y= 0.6 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	1.3	-0.8	3.5	-6.5	-2.6	3.7	0.8	5.3	0.86
B	-6.5	0.2	-4.8	-6.3	-3.8	4.0	1.3	3.7	1.05
C	-2.3	-3.4	-0.7	-9.1	-3.6	3.6	0.4	4.9	0.53
D	4.9	-1.7	6.7	-6.9	-2.9	3.3	0.7	6.1	0.82
E	-0.1	-0.9	1.0	-4.7	-3.5	2.4	0.9	4.8	0.90
Predict					-2.5	4.3			

Test 9	Angle= -15º		x= 0.36 m		y= 1.3 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	5.6	-2.3	8.7	-8.3	-1.9	4.1	0.7	4.6	0.75
B	0.9	-3.0	2.1	-7.4	-3.7	2.7	0.3	5.1	0.44
C	4.6	-2.3	6.9	-8.4	-2.7	3.9	0.6	2.8	0.57
D	3.7	-3.1	6.9	-8.7	-1.8	3.9	0.7	4.3	0.73
E	0.3	-1.2	2.4	-8.8	-3.6	4.7	0.4	6.3	0.57
Predict					-1.4	4.8			

Test 10	Angle= -15º		x= 0.25 m		y= 1.4 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	1.2	-1.7	3.2	-6.8	-2.6	3.3	0.4	4.7	0.52
B	3.2	-3.6	5.8	-7.9	-1.7	3.0	0.9	3.7	0.83
C	1.8	-4.1	5.4	-10.3	-1.7	4.3	0.4	4.6	0.52
D	4.6	-3.9	7.6	-8.9	-1.7	3.5	1.2	3.9	1.02
E	4.3	-3.4	6.6	-7.8	-1.9	3.0	0.6	5.4	0.71
Predict					-1.4	4.8			

Test 11	Angle= -15º		x= -0.05 m		y= 1.3 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	0.0	-3.3	2.9	-7.7	-1.5	3.2	0.6	4.1	0.65
B	-2.7	-0.8	1.3	-7.6	-1.7	4.7	0.3	2.8	0.36
C	-3.7	-2.9	0.4	-6.9	-1.0	3.4	0.4	3.4	0.47
D	1.2	-3.1	3.4	-7.8	-2.1	3.1	0.6	3.2	0.60
E	0.9	-2.2	2.9	-6.4	-2.1	2.8	0.4	1.4	0.35
Predict					-1.4	4.7			

Test 12	Angle= -15º		x= -0.15 m		y= 1.4 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	0.1	-1.5	3.7	-6.1	-1.3	3.5	0.6	3.2	0.60
B	-2.4	-0.7	2.8	-8.6	-1.5	5.7	0.7	5.1	0.78
C	-0.8	-2.0	4.1	-8.3	-1.3	4.8	0.5	2.7	0.50
D	-4.7	-2.4	-2.6	-6.9	-2.1	3.0	0.4	2.8	0.44
E	-2.4	-0.7	3.8	-7.1	-1.0	5.3	0.6	3.9	0.64
Predict					-1.4	4.8			

Test 13	Angle= -15º		x= -0.25 m		y= 1.4 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	-2.2	-5.1	0.4	-8.3	-1.2	2.5	0.7	4.1	0.72
B	-6.1	-0.5	-1.9	-3.4	-0.7	3.1	0.6	1.8	0.50
C	0.0	-2.0	4.1	-6.9	-1.2	3.8	0.7	2.5	0.61
D	1.1	-2.2	4.3	-6.1	-1.2	3.0	1.1	6.4	1.13
E	0.0	-3.3	3.9	-6.7	-0.9	3.1	0.9	3.1	0.78
Predict					-1.4	4.8			

Test 14	Angle= -15º		x= -0.25 m		y= 1.3 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	2.6	-3.4	4.4	-7.3	-2.2	2.6	0.6	3.3	0.61
B	-1.7	-2.4	2.1	-6.9	-1.2	3.5	1.1	5.1	1.05
C	-2.7	-2.3	0.3	-7.2	-1.6	3.4	1.3	3.4	1.03
D	-5.4	-3.7	-2.1	-6.4	-0.8	2.6	0.7	2.8	0.64
E	-3.4	-3.6	-1.9	-6.2	-1.7	1.8	0.6	2.9	0.58
Predict					-1.4	4.8			

Appendix R- Aspirated 15º Particle Trajectory and Size Data

Test 15	Angle= 15º		x= 0.56 m		y= 1.4 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	-1.0	1.0	1.2	-4.4	-2.5	3.5	1.1	5.1	1.05
B	0.0	-2.1	1.2	-7.1	-4.2	3.1	0.8	5.8	0.89
C	3.9	-1.8	5.1	-6.4	-3.8	2.9	0.7	2.2	0.59
D	-3.3	-3.3	-2.1	-7.6	-3.6	2.7	0.3	4.1	0.41
E	-5.4	-2.9	-3.6	-8.1	-2.9	3.3	0.3	2.8	0.36
Predict					-2.7	4.3			

Test 16	Angle= 15º		x= 0.46 m		y= 2.2 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	4.4	-3.4	6.9	-9.1	-2.3	3.7	0.7	3.1	0.66
B	0.9	-1.1	2.3	-6.8	-4.1	3.5	0.9	4.6	0.89
C	3.8	-3.6	5.2	-7.1	-2.5	2.3	0.6	3.8	0.64
D	0.1	-3.0	2.2	-6.8	-1.8	2.6	0.7	5.2	0.78
E	-2.4	-1.6	-0.5	-4.9	-1.7	2.3	0.4	4.8	0.52
Predict					-1.5	4.7			

Test 17	Angle= 15º		x= 0.36 m		y= 2.1 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	0.1	-3.3	2.2	-8.8	-2.6	3.5	0.8	3.6	0.76
B	-0.3	-3.4	1.2	-8.7	-3.5	3.3	0.6	3.6	0.62
C	0.0	-1.2	1.9	-5.2	-2.1	2.7	0.4	3.2	0.46
D	-0.7	-0.8	1.1	-5.7	-2.7	3.1	0.4	2.4	0.42
E	3.4	-2.8	4.1	-5.3	-3.6	1.6	0.5	2.8	0.51
Predict					-1.6	4.6			

Test 18	Angle= 15º		x= -0.05 m		y= 2.1 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	-5.4	-4.3	-2.9	-9.1	-1.9	3.2	0.5	3.8	0.56
B	0.8	-3.1	3.3	-6.1	-1.2	2.3	0.4	2.7	0.43
C	-2.3	-2.4	0.4	-7.3	-1.8	3.4	0.8	4.1	0.79
D	0.2	-3.4	4.9	-10.5	-1.5	5.1	0.6	5.2	0.71
E	-2.3	-4.4	-0.6	-8.9	-2.6	2.9	0.7	4.2	0.73
Predict					-1.6	4.6			

Test 19	Angle= 15º		x= -0.36 m		y= 2.8 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad (cm)
A	3.7	-4.2	7.7	-8.9	-1.2	3.7	0.4	4.9	0.53
B	3.9	-4.4	5.5	-6.9	-1.6	1.8	0.6	4.6	0.68
C	-3.3	-1.4	-0.7	-4.8	-1.3	2.6	0.7	2.9	0.64
D	2.9	-3.2	5.1	-6.2	-1.4	2.2	0.8	3.3	0.73
E	1.7	-2.4	4.9	-4.1	-0.5	2.2	0.3	3.2	0.38
Predict					-1.3	5.0			

Test 20	Angle= 15º		x= -0.46 m		y= 2.7 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	4.8	0.9	8.5	-5.7	-1.8	4.5	0.6	3.7	0.63
B	4.3	-2.4	7.4	-8.5	-2.0	4.1	0.7	3.1	0.66
C	-3.2	-2.3	1.2	-8.5	-1.4	4.6	1.1	3.6	0.93
D	-4.6	-2.7	-1.4	-8.8	-1.9	4.1	1.2	4.1	1.03
E	-5.9	-0.8	-1.4	-6.7	-1.3	4.5	1.1	2.0	0.77
Predict					-1.4	4.9			

Test 21	Angle= 15º		x= -0.25 m		y= 3.2 m				
Particle	y_i (cm)	z_i (cm)	y_f (cm)	z_f (cm)	Slope	Speed (m/s)	Height (cm)	Length (cm)	Eq Rad. (cm)
A	1.4	-2.1	4.7	-8.5	-1.9	4.3	1.3	4.7	1.14
B	1.7	-1.8	4.8	-8.2	-2.1	4.3	0.8	6.4	0.92
C	-0.6	-0.3	2.1	-6.4	-2.3	4.0	0.9	5.8	0.96
D	3.2	-3.5	5.2	-9.9	-3.2	4.0	1.4	3.9	1.13
E	-0.9	-0.1	2.9	-6.7	-1.7	4.6	0.6	4.6	0.68
Predict					-1.6	4.6			

Appendix S- Aspirated 0º Test 2 Particle Size Distribution Data

Test 2	Height (cm)	Length (cm)	Equivalent Radius (cm)
Particle 1	1.3	4.5	1.13
Particle 2	0.6	3.8	0.64
Particle 3	0.6	4.8	0.69
Particle 4	1.2	4.7	1.08
Particle 5	0.9	6.2	0.98
Particle 6	1.2	4.4	1.06
Particle 7	0.9	5.6	0.95
Particle 8	0.6	4.1	0.65
Particle 9	1.2	6.0	1.17
Particle 10	1.6	8.2	1.58
Particle 11	1.2	5.8	1.16
Particle 12	1.4	7.2	1.38
Particle 13	0.8	3.7	0.76
Particle 14	0.9	5.5	0.94
Particle 15	0.6	5.1	0.70
Particle 16	0.8	4.3	0.80
Particle 17	0.4	6.3	0.57
Particle 18	1.1	4.4	1.00
Particle 19	0.4	4.8	0.52
Particle 20	0.3	3.9	0.40
Particle 21	0.8	5.1	0.85
Particle 22	0.6	5.6	0.72
Particle 23	0.4	4.2	0.50
Particle 24	1.7	5.8	1.46
Particle 25	0.6	3.5	0.62
Particle 26	0.9	5.8	0.96
Particle 27	0.5	4.1	0.58
Particle 28	0.6	4.7	0.68
Particle 29	0.7	3.5	0.69
Particle 30	0.4	6.0	0.56
Particle 31	0.3	4.4	0.42
Particle 32	0.8	5.1	0.85
Particle 33	0.3	4.4	0.42
Particle 34	0.8	4.2	0.80
Particle 35	0.7	3.4	0.68

Particle 36	0.8	5.1	0.85
Particle 37	0.5	6.1	0.66
Particle 38	0.4	4.3	0.51
Particle 39	0.3	4.1	0.41
Particle 40	0.7	3.1	0.66
Particle 41	1.0	4.1	0.92
Particle 42	0.4	5.1	0.53
Particle 43	0.3	5.7	0.46
Particle 44	0.4	3.7	0.48

Appendix T- Aspirated 0º Test 5 Size Distribution Data

Test 5	Height (cm)	Length (cm)	Equivalent Radius (cm)
Particle 1	0.7	4.4	0.74
Particle 2	0.8	3.6	0.76
Particle 3	1.1	4.8	1.03
Particle 4	1.2	6.0	1.17
Particle 5	0.8	4.1	0.79
Particle 6	0.5	5.1	0.62
Particle 7	0.7	4.1	0.72
Particle 8	0.4	3.2	0.46
Particle 9	0.5	3.7	0.56
Particle 10	1.1	4.1	0.98
Particle 11	0.7	2.8	0.64
Particle 12	0.6	2.6	0.56
Particle 13	0.8	2.5	0.67
Particle 14	0.7	3.8	0.70
Particle 15	0.7	4.3	0.73
Particle 16	0.4	2.8	0.44
Particle 17	0.6	4.1	0.65
Particle 18	0.4	4.7	0.52
Particle 19	1.1	4.3	0.99
Particle 20	1.2	5.1	1.11
Particle 21	1.6	3.4	1.18
Particle 22	1.1	2.1	0.78
Particle 23	0.4	3.2	0.46
Particle 24	1.2	3.4	0.97
Particle 25	0.8	7.3	0.96
Particle 26	0.6	3.4	0.61
Particle 27	0.3	1.8	0.31
Particle 28	1.5	3.4	1.13
Particle 29	0.4	2.3	0.41
Particle 30	1.2	3.3	0.96
Particle 31	0.7	2.8	0.64
Particle 32	0.6	2.5	0.55
Particle 33	0.4	0.8	0.29
Particle 34	0.6	4.1	0.65

Particle 35	0.8	3.6	0.76
Particle 36	1.1	2.4	0.82
Particle 37	0.6	2.6	0.56
Particle 38	1.4	3.8	1.12
Particle 39	0.8	3.1	0.72
Particle 40	0.7	3.2	0.66

Appendix U- Aspirated 0º Initial Velocities

Note:The first row is the cup column number and the first column is the cup row number. All measurements in m/s

0,u	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-1.49	-1.23	-0.98	-0.74	-0.49	-0.24	0.00	0.24	0.49	0.74	0.98	1.23	1.49
2	-1.50	-1.24	-0.99	-0.74	-0.50	-0.25	0.00	0.25	0.50	0.74	0.99	1.24	1.50
3	-1.50	-1.25	-1.00	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75	1.00	1.25	1.50
4	-1.52	-1.26	-1.01	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75	1.01	1.26	1.52
5	-1.53	-1.27	-1.01	-0.76	-0.50	-0.25	0.00	0.25	0.50	0.76	1.01	1.27	1.53
6	-1.54	-1.28	-1.02	-0.76	-0.51	-0.25	0.00	0.25	0.51	0.76	1.02	1.28	1.54
7	-1.55	-1.29	-1.03	-0.77	-0.51	-0.26	0.00	0.26	0.51	0.77	1.03	1.29	1.55
8	-1.56	-1.30	-1.04	-0.77	-0.51	-0.26	0.00	0.26	0.51	0.77	1.04	1.30	1.56
9	-1.57	-1.30	-1.04	-0.78	-0.52	-0.26	0.00	0.26	0.52	0.78	1.04	1.30	1.57
10	-1.58	-1.32	-1.05	-0.79	-0.52	-0.26	0.00	0.26	0.52	0.79	1.05	1.32	1.58
11	-1.59	-1.33	-1.06	-0.79	-0.53	-0.26	0.00	0.26	0.53	0.79	1.06	1.33	1.59
12	-1.61	-1.34	-1.07	-0.80	-0.53	-0.27	0.00	0.27	0.53	0.80	1.07	1.34	1.61
13	-1.62	-1.35	-1.08	-0.81	-0.54	-0.27	0.00	0.27	0.54	0.81	1.08	1.35	1.62
14	-1.63	-1.36	-1.09	-0.81	-0.54	-0.27	0.00	0.27	0.54	0.81	1.09	1.36	1.63
15	-1.65	-1.37	-1.10	-0.82	-0.55	-0.27	0.00	0.27	0.55	0.82	1.10	1.37	1.65
16	-1.66	-1.38	-1.10	-0.83	-0.55	-0.27	0.00	0.27	0.55	0.83	1.10	1.38	1.66
17	-1.68	-1.39	-1.11	-0.84	-0.55	-0.28	0.00	0.28	0.55	0.84	1.11	1.39	1.68
18	-1.69	-1.41	-1.12	-0.84	-0.56	-0.28	0.00	0.28	0.56	0.84	1.12	1.41	1.69
19	-1.71	-1.42	-1.13	-0.85	-0.56	-0.28	0.00	0.28	0.56	0.85	1.13	1.42	1.71
20	-1.72	-1.43	-1.14	-0.86	-0.57	-0.28	0.00	0.28	0.57	0.86	1.14	1.43	1.72

0,v	1	2	3	4	5	6	7	8	9	10	11	12	13
1	2.07	2.06	2.05	2.05	2.05	2.04	2.04	2.04	2.05	2.05	2.05	2.06	2.07
2	2.34	2.32	2.31	2.31	2.30	2.30	2.30	2.30	2.30	2.31	2.31	2.32	2.34
3	2.59	2.58	2.57	2.57	2.56	2.56	2.56	2.56	2.56	2.57	2.57	2.58	2.59
4	2.86	2.85	2.84	2.83	2.82	2.82	2.82	2.82	2.82	2.83	2.84	2.85	2.86
5	3.12	3.12	3.11	3.10	3.10	3.09	3.09	3.09	3.10	3.10	3.11	3.12	3.12
6	3.40	3.39	3.38	3.37	3.37	3.37	3.37	3.37	3.37	3.37	3.38	3.39	3.40
7	3.68	3.67	3.66	3.65	3.65	3.64	3.64	3.64	3.65	3.65	3.66	3.67	3.68
8	3.96	3.95	3.94	3.93	3.93	3.93	3.92	3.93	3.93	3.93	3.94	3.95	3.96
9	4.24	4.23	4.23	4.22	4.21	4.21	4.21	4.21	4.21	4.22	4.23	4.23	4.24
10	4.54	4.53	4.52	4.51	4.51	4.50	4.50	4.50	4.51	4.51	4.52	4.53	4.54
11	4.83	4.83	4.82	4.81	4.80	4.80	4.80	4.80	4.80	4.81	4.82	4.83	4.83
12	5.14	5.13	5.12	5.11	5.10	5.10	5.10	5.10	5.10	5.11	5.12	5.13	5.14
13	5.45	5.43	5.43	5.42	5.41	5.41	5.41	5.41	5.41	5.42	5.43	5.43	5.45
14	5.76	5.75	5.74	5.73	5.72	5.72	5.72	5.72	5.72	5.73	5.74	5.75	5.76
15	6.08	6.06	6.06	6.05	6.04	6.04	6.03	6.04	6.04	6.05	6.06	6.06	6.08
16	6.40	6.39	6.38	6.37	6.37	6.36	6.36	6.36	6.37	6.37	6.38	6.39	6.40
17	6.73	6.71	6.71	6.70	6.69	6.69	6.69	6.69	6.69	6.70	6.71	6.71	6.73
18	7.06	7.05	7.04	7.03	7.03	7.03	7.03	7.03	7.03	7.03	7.04	7.05	7.06
19	7.40	7.39	7.38	7.38	7.37	7.36	7.36	7.36	7.37	7.38	7.38	7.39	7.40
20	7.75	7.74	7.73	7.72	7.72	7.71	7.71	7.71	7.72	7.72	7.73	7.74	7.75

Appendix V- Aspirated 0º Single Particle Position and Velocity

x,y=-.56,0.9	r= 0.01 m		u_o= -1.36 m/s		v_o = 2.19 m/s	
t (s)	u (m/s)	v (m/s)	w (m/s)	x (m)	y (m)	z (m)
0.001	-1.36	2.19	-0.01	0.00	0.00	1.00
0.002	-1.36	2.19	-0.02	0.00	0.00	1.00
0.003	-1.36	2.19	-0.03	0.00	0.01	1.00
0.004	-1.36	2.18	-0.04	-0.01	0.01	1.00
0.005	-1.36	2.18	-0.05	-0.01	0.01	1.00
0.006	-1.36	2.18	-0.06	-0.01	0.01	1.00
0.007	-1.35	2.18	-0.07	-0.01	0.02	1.00
0.008	-1.35	2.18	-0.08	-0.01	0.02	1.00
0.009	-1.35	2.18	-0.09	-0.01	0.02	1.00
0.010	-1.35	2.18	-0.10	-0.01	0.02	1.00
0.011	-1.35	2.18	-0.11	-0.01	0.02	1.00
0.012	-1.35	2.17	-0.12	-0.02	0.03	1.00
0.013	-1.35	2.17	-0.13	-0.02	0.03	1.00
0.014	-1.35	2.17	-0.14	-0.02	0.03	1.00
0.015	-1.35	2.17	-0.15	-0.02	0.03	1.00
0.016	-1.35	2.17	-0.16	-0.02	0.03	1.00
0.017	-1.35	2.17	-0.17	-0.02	0.04	1.00
0.018	-1.35	2.17	-0.18	-0.02	0.04	1.00
0.019	-1.35	2.17	-0.19	-0.03	0.04	1.00
0.020	-1.34	2.17	-0.20	-0.03	0.04	1.00
0.021	-1.34	2.16	-0.20	-0.03	0.05	1.00
0.022	-1.34	2.16	-0.21	-0.03	0.05	1.00
0.023	-1.34	2.16	-0.22	-0.03	0.05	1.00
0.024	-1.34	2.16	-0.23	-0.03	0.05	1.00
0.025	-1.34	2.16	-0.24	-0.03	0.05	1.00
0.026	-1.34	2.16	-0.25	-0.04	0.06	1.00
0.027	-1.34	2.16	-0.26	-0.04	0.06	1.00
0.028	-1.34	2.16	-0.27	-0.04	0.06	1.00
0.029	-1.34	2.15	-0.28	-0.04	0.06	1.00
0.030	-1.34	2.15	-0.29	-0.04	0.07	1.00
0.031	-1.34	2.15	-0.30	-0.04	0.07	1.00
0.032	-1.34	2.15	-0.31	-0.04	0.07	0.99
0.033	-1.33	2.15	-0.32	-0.04	0.07	0.99
0.034	-1.33	2.15	-0.33	-0.05	0.07	0.99

0.035	-1.33	2.15	-0.34	-0.05	0.08	0.99
0.036	-1.33	2.15	-0.35	-0.05	0.08	0.99
0.037	-1.33	2.14	-0.36	-0.05	0.08	0.99
0.038	-1.33	2.14	-0.37	-0.05	0.08	0.99
0.039	-1.33	2.14	-0.38	-0.05	0.08	0.99
0.040	-1.33	2.14	-0.39	-0.05	0.09	0.99
0.041	-1.33	2.14	-0.40	-0.06	0.09	0.99
0.042	-1.33	2.14	-0.41	-0.06	0.09	0.99
0.043	-1.33	2.14	-0.42	-0.06	0.09	0.99
0.044	-1.33	2.14	-0.43	-0.06	0.10	0.99
0.045	-1.33	2.13	-0.44	-0.06	0.10	0.99
0.046	-1.32	2.13	-0.45	-0.06	0.10	0.99
0.047	-1.32	2.13	-0.46	-0.06	0.10	0.99
0.048	-1.32	2.13	-0.46	-0.06	0.10	0.99
0.049	-1.32	2.13	-0.47	-0.07	0.11	0.99
0.050	-1.32	2.13	-0.48	-0.07	0.11	0.99
0.051	-1.32	2.13	-0.49	-0.07	0.11	0.99
0.052	-1.32	2.13	-0.50	-0.07	0.11	0.99
0.053	-1.32	2.12	-0.51	-0.07	0.11	0.99
0.054	-1.32	2.12	-0.52	-0.07	0.12	0.99
0.055	-1.32	2.12	-0.53	-0.07	0.12	0.99
0.056	-1.32	2.12	-0.54	-0.07	0.12	0.98
0.057	-1.32	2.12	-0.55	-0.08	0.12	0.98
0.058	-1.32	2.12	-0.56	-0.08	0.12	0.98
0.059	-1.31	2.12	-0.57	-0.08	0.13	0.98
0.060	-1.31	2.12	-0.58	-0.08	0.13	0.98
0.061	-1.31	2.12	-0.59	-0.08	0.13	0.98
0.062	-1.31	2.11	-0.60	-0.08	0.13	0.98
0.063	-1.31	2.11	-0.61	-0.08	0.14	0.98
0.064	-1.31	2.11	-0.62	-0.09	0.14	0.98
0.065	-1.31	2.11	-0.63	-0.09	0.14	0.98
0.066	-1.31	2.11	-0.64	-0.09	0.14	0.98
0.067	-1.31	2.11	-0.65	-0.09	0.14	0.98
0.068	-1.31	2.11	-0.65	-0.09	0.15	0.98
0.069	-1.31	2.11	-0.66	-0.09	0.15	0.98
0.070	-1.31	2.10	-0.67	-0.09	0.15	0.98
0.071	-1.31	2.10	-0.68	-0.09	0.15	0.98
0.072	-1.31	2.10	-0.69	-0.10	0.15	0.97

0.073	-1.30	2.10	-0.70	-0.10	0.16	0.97
0.074	-1.30	2.10	-0.71	-0.10	0.16	0.97
0.075	-1.30	2.10	-0.72	-0.10	0.16	0.97
0.076	-1.30	2.10	-0.73	-0.10	0.16	0.97
0.077	-1.30	2.10	-0.74	-0.10	0.16	0.97
0.078	-1.30	2.09	-0.75	-0.10	0.17	0.97
0.079	-1.30	2.09	-0.76	-0.11	0.17	0.97
0.080	-1.30	2.09	-0.77	-0.11	0.17	0.97
0.081	-1.30	2.09	-0.78	-0.11	0.17	0.97
0.082	-1.30	2.09	-0.79	-0.11	0.18	0.97
0.083	-1.30	2.09	-0.80	-0.11	0.18	0.97
0.084	-1.30	2.09	-0.80	-0.11	0.18	0.97
0.085	-1.30	2.09	-0.81	-0.11	0.18	0.96
0.086	-1.29	2.08	-0.82	-0.11	0.18	0.96
0.087	-1.29	2.08	-0.83	-0.12	0.19	0.96
0.088	-1.29	2.08	-0.84	-0.12	0.19	0.96
0.089	-1.29	2.08	-0.85	-0.12	0.19	0.96
0.090	-1.29	2.08	-0.86	-0.12	0.19	0.96
0.091	-1.29	2.08	-0.87	-0.12	0.19	0.96
0.092	-1.29	2.08	-0.88	-0.12	0.20	0.96
0.093	-1.29	2.08	-0.89	-0.12	0.20	0.96
0.094	-1.29	2.08	-0.90	-0.12	0.20	0.96
0.095	-1.29	2.07	-0.91	-0.13	0.20	0.96
0.096	-1.29	2.07	-0.92	-0.13	0.20	0.96
0.097	-1.29	2.07	-0.93	-0.13	0.21	0.95
0.098	-1.29	2.07	-0.94	-0.13	0.21	0.95
0.099	-1.28	2.07	-0.94	-0.13	0.21	0.95
0.100	-1.28	2.07	-0.95	-0.13	0.21	0.95
0.101	-1.28	2.07	-0.96	-0.13	0.21	0.95
0.102	-1.28	2.07	-0.97	-0.13	0.22	0.95
0.103	-1.28	2.06	-0.98	-0.14	0.22	0.95
0.104	-1.28	2.06	-0.99	-0.14	0.22	0.95
0.105	-1.28	2.06	-1.00	-0.14	0.22	0.95
0.106	-1.28	2.06	-1.01	-0.14	0.23	0.95
0.107	-1.28	2.06	-1.02	-0.14	0.23	0.94
0.108	-1.28	2.06	-1.03	-0.14	0.23	0.94
0.109	-1.28	2.06	-1.04	-0.14	0.23	0.94
0.110	-1.28	2.06	-1.05	-0.14	0.23	0.94

0.111	-1.28	2.05	-1.06	-0.15	0.24	0.94
0.112	-1.28	2.05	-1.06	-0.15	0.24	0.94
0.113	-1.27	2.05	-1.07	-0.15	0.24	0.94
0.114	-1.27	2.05	-1.08	-0.15	0.24	0.94
0.115	-1.27	2.05	-1.09	-0.15	0.24	0.94
0.116	-1.27	2.05	-1.10	-0.15	0.25	0.93
0.117	-1.27	2.05	-1.11	-0.15	0.25	0.93
0.118	-1.27	2.05	-1.12	-0.16	0.25	0.93
0.119	-1.27	2.04	-1.13	-0.16	0.25	0.93
0.120	-1.27	2.04	-1.14	-0.16	0.25	0.93
0.121	-1.27	2.04	-1.15	-0.16	0.26	0.93
0.122	-1.27	2.04	-1.16	-0.16	0.26	0.93
0.123	-1.27	2.04	-1.16	-0.16	0.26	0.93
0.124	-1.27	2.04	-1.17	-0.16	0.26	0.93
0.125	-1.27	2.04	-1.18	-0.16	0.26	0.92
0.126	-1.26	2.04	-1.19	-0.17	0.27	0.92
0.127	-1.26	2.04	-1.20	-0.17	0.27	0.92
0.128	-1.26	2.03	-1.21	-0.17	0.27	0.92
0.129	-1.26	2.03	-1.22	-0.17	0.27	0.92
0.130	-1.26	2.03	-1.23	-0.17	0.27	0.92
0.131	-1.26	2.03	-1.24	-0.17	0.28	0.92
0.132	-1.26	2.03	-1.25	-0.17	0.28	0.92
0.133	-1.26	2.03	-1.26	-0.17	0.28	0.91
0.134	-1.26	2.03	-1.26	-0.18	0.28	0.91
0.135	-1.26	2.03	-1.27	-0.18	0.28	0.91
0.136	-1.26	2.02	-1.28	-0.18	0.29	0.91
0.137	-1.26	2.02	-1.29	-0.18	0.29	0.91
0.138	-1.26	2.02	-1.30	-0.18	0.29	0.91
0.139	-1.25	2.02	-1.31	-0.18	0.29	0.91
0.140	-1.25	2.02	-1.32	-0.18	0.29	0.91
0.141	-1.25	2.02	-1.33	-0.18	0.30	0.90
0.142	-1.25	2.02	-1.34	-0.19	0.30	0.90
0.143	-1.25	2.02	-1.35	-0.19	0.30	0.90
0.144	-1.25	2.01	-1.35	-0.19	0.30	0.90
0.145	-1.25	2.01	-1.36	-0.19	0.30	0.90
0.146	-1.25	2.01	-1.37	-0.19	0.31	0.90
0.147	-1.25	2.01	-1.38	-0.19	0.31	0.90
0.148	-1.25	2.01	-1.39	-0.19	0.31	0.89

0.149	-1.25	2.01	-1.40	-0.19	0.31	0.89
0.150	-1.25	2.01	-1.41	-0.20	0.31	0.89
0.151	-1.25	2.01	-1.42	-0.20	0.32	0.89
0.152	-1.24	2.00	-1.43	-0.20	0.32	0.89
0.153	-1.24	2.00	-1.44	-0.20	0.32	0.89
0.154	-1.24	2.00	-1.44	-0.20	0.32	0.89
0.155	-1.24	2.00	-1.45	-0.20	0.32	0.88
0.156	-1.24	2.00	-1.46	-0.20	0.33	0.88
0.157	-1.24	2.00	-1.47	-0.20	0.33	0.88
0.158	-1.24	2.00	-1.48	-0.21	0.33	0.88
0.159	-1.24	2.00	-1.49	-0.21	0.33	0.88
0.160	-1.24	1.99	-1.50	-0.21	0.33	0.88
0.161	-1.24	1.99	-1.51	-0.21	0.34	0.88
0.162	-1.24	1.99	-1.52	-0.21	0.34	0.87
0.163	-1.24	1.99	-1.52	-0.21	0.34	0.87
0.164	-1.24	1.99	-1.53	-0.21	0.34	0.87
0.165	-1.23	1.99	-1.54	-0.21	0.34	0.87
0.166	-1.23	1.99	-1.55	-0.22	0.35	0.87
0.167	-1.23	1.99	-1.56	-0.22	0.35	0.87
0.168	-1.23	1.98	-1.57	-0.22	0.35	0.87
0.169	-1.23	1.98	-1.58	-0.22	0.35	0.86
0.170	-1.23	1.98	-1.59	-0.22	0.35	0.86
0.171	-1.23	1.98	-1.60	-0.22	0.36	0.86
0.172	-1.23	1.98	-1.60	-0.22	0.36	0.86
0.173	-1.23	1.98	-1.61	-0.22	0.36	0.86
0.174	-1.23	1.98	-1.62	-0.23	0.36	0.86
0.175	-1.23	1.98	-1.63	-0.23	0.36	0.85
0.176	-1.23	1.97	-1.64	-0.23	0.37	0.85
0.177	-1.23	1.97	-1.65	-0.23	0.37	0.85
0.178	-1.22	1.97	-1.66	-0.23	0.37	0.85
0.179	-1.22	1.97	-1.67	-0.23	0.37	0.85
0.180	-1.22	1.97	-1.67	-0.23	0.37	0.85
0.181	-1.22	1.97	-1.68	-0.23	0.38	0.84
0.182	-1.22	1.97	-1.69	-0.23	0.38	0.84
0.183	-1.22	1.97	-1.70	-0.24	0.38	0.84
0.184	-1.22	1.96	-1.71	-0.24	0.38	0.84
0.185	-1.22	1.96	-1.72	-0.24	0.38	0.84
0.186	-1.22	1.96	-1.73	-0.24	0.39	0.84

0.187	-1.22	1.96	-1.74	-0.24	0.39	0.83
0.188	-1.22	1.96	-1.74	-0.24	0.39	0.83
0.189	-1.22	1.96	-1.75	-0.24	0.39	0.83
0.190	-1.22	1.96	-1.76	-0.24	0.39	0.83
0.191	-1.21	1.96	-1.77	-0.25	0.40	0.83
0.192	-1.21	1.95	-1.78	-0.25	0.40	0.82
0.193	-1.21	1.95	-1.79	-0.25	0.40	0.82
0.194	-1.21	1.95	-1.80	-0.25	0.40	0.82
0.195	-1.21	1.95	-1.80	-0.25	0.40	0.82
0.196	-1.21	1.95	-1.81	-0.25	0.41	0.82
0.197	-1.21	1.95	-1.82	-0.25	0.41	0.82
0.198	-1.21	1.95	-1.83	-0.25	0.41	0.81
0.199	-1.21	1.95	-1.84	-0.26	0.41	0.81
0.200	-1.21	1.94	-1.85	-0.26	0.41	0.81
0.201	-1.21	1.94	-1.86	-0.26	0.42	0.81
0.202	-1.21	1.94	-1.86	-0.26	0.42	0.81
0.203	-1.21	1.94	-1.87	-0.26	0.42	0.80
0.204	-1.20	1.94	-1.88	-0.26	0.42	0.80
0.205	-1.20	1.94	-1.89	-0.26	0.42	0.80
0.206	-1.20	1.94	-1.90	-0.26	0.43	0.80
0.207	-1.20	1.94	-1.91	-0.27	0.43	0.80
0.208	-1.20	1.93	-1.92	-0.27	0.43	0.80
0.209	-1.20	1.93	-1.92	-0.27	0.43	0.79
0.210	-1.20	1.93	-1.93	-0.27	0.43	0.79
0.211	-1.20	1.93	-1.94	-0.27	0.43	0.79
0.212	-1.20	1.93	-1.95	-0.27	0.44	0.79
0.213	-1.20	1.93	-1.96	-0.27	0.44	0.79
0.214	-1.20	1.93	-1.97	-0.27	0.44	0.78
0.215	-1.20	1.93	-1.98	-0.27	0.44	0.78
0.216	-1.19	1.92	-1.98	-0.28	0.44	0.78
0.217	-1.19	1.92	-1.99	-0.28	0.45	0.78
0.218	-1.19	1.92	-2.00	-0.28	0.45	0.78
0.219	-1.19	1.92	-2.01	-0.28	0.45	0.77
0.220	-1.19	1.92	-2.02	-0.28	0.45	0.77
0.221	-1.19	1.92	-2.03	-0.28	0.45	0.77
0.222	-1.19	1.92	-2.03	-0.28	0.46	0.77
0.223	-1.19	1.91	-2.04	-0.28	0.46	0.77
0.224	-1.19	1.91	-2.05	-0.29	0.46	0.76

0.225	-1.19	1.91	-2.06	-0.29	0.46	0.76
0.226	-1.19	1.91	-2.07	-0.29	0.46	0.76
0.227	-1.19	1.91	-2.08	-0.29	0.47	0.76
0.228	-1.19	1.91	-2.09	-0.29	0.47	0.76
0.229	-1.18	1.91	-2.09	-0.29	0.47	0.75
0.230	-1.18	1.91	-2.10	-0.29	0.47	0.75
0.231	-1.18	1.90	-2.11	-0.29	0.47	0.75
0.232	-1.18	1.90	-2.12	-0.29	0.47	0.75
0.233	-1.18	1.90	-2.13	-0.30	0.48	0.74
0.234	-1.18	1.90	-2.14	-0.30	0.48	0.74
0.235	-1.18	1.90	-2.14	-0.30	0.48	0.74
0.236	-1.18	1.90	-2.15	-0.30	0.48	0.74
0.237	-1.18	1.90	-2.16	-0.30	0.48	0.74
0.238	-1.18	1.90	-2.17	-0.30	0.49	0.73
0.239	-1.18	1.89	-2.18	-0.30	0.49	0.73
0.240	-1.18	1.89	-2.19	-0.30	0.49	0.73
0.241	-1.17	1.89	-2.19	-0.31	0.49	0.73
0.242	-1.17	1.89	-2.20	-0.31	0.49	0.73
0.243	-1.17	1.89	-2.21	-0.31	0.50	0.72
0.244	-1.17	1.89	-2.22	-0.31	0.50	0.72
0.245	-1.17	1.89	-2.23	-0.31	0.50	0.72
0.246	-1.17	1.88	-2.24	-0.31	0.50	0.72
0.247	-1.17	1.88	-2.24	-0.31	0.50	0.71
0.248	-1.17	1.88	-2.25	-0.31	0.51	0.71
0.249	-1.17	1.88	-2.26	-0.31	0.51	0.71
0.250	-1.17	1.88	-2.27	-0.32	0.51	0.71
0.251	-1.17	1.88	-2.28	-0.32	0.51	0.70
0.252	-1.17	1.88	-2.28	-0.32	0.51	0.70
0.253	-1.16	1.88	-2.29	-0.32	0.51	0.70
0.254	-1.16	1.87	-2.30	-0.32	0.52	0.70
0.255	-1.16	1.87	-2.31	-0.32	0.52	0.70
0.256	-1.16	1.87	-2.32	-0.32	0.52	0.69
0.257	-1.16	1.87	-2.33	-0.32	0.52	0.69
0.258	-1.16	1.87	-2.33	-0.33	0.52	0.69
0.259	-1.16	1.87	-2.34	-0.33	0.53	0.69
0.260	-1.16	1.87	-2.35	-0.33	0.53	0.68
0.261	-1.16	1.86	-2.36	-0.33	0.53	0.68
0.262	-1.16	1.86	-2.37	-0.33	0.53	0.68

0.263	-1.16	1.86	-2.37	-0.33	0.53	0.68
0.264	-1.16	1.86	-2.38	-0.33	0.54	0.67
0.265	-1.15	1.86	-2.39	-0.33	0.54	0.67
0.266	-1.15	1.86	-2.40	-0.33	0.54	0.67
0.267	-1.15	1.86	-2.41	-0.34	0.54	0.67
0.268	-1.15	1.86	-2.41	-0.34	0.54	0.66
0.269	-1.15	1.85	-2.42	-0.34	0.54	0.66
0.270	-1.15	1.85	-2.43	-0.34	0.55	0.66
0.271	-1.15	1.85	-2.44	-0.34	0.55	0.66
0.272	-1.15	1.85	-2.45	-0.34	0.55	0.66
0.273	-1.15	1.85	-2.45	-0.34	0.55	0.65
0.274	-1.15	1.85	-2.46	-0.34	0.55	0.65
0.275	-1.15	1.85	-2.47	-0.34	0.56	0.65
0.276	-1.15	1.84	-2.48	-0.35	0.56	0.65
0.277	-1.14	1.84	-2.49	-0.35	0.56	0.64
0.278	-1.14	1.84	-2.49	-0.35	0.56	0.64
0.279	-1.14	1.84	-2.50	-0.35	0.56	0.64
0.280	-1.14	1.84	-2.51	-0.35	0.56	0.64
0.281	-1.14	1.84	-2.52	-0.35	0.57	0.63
0.282	-1.14	1.84	-2.53	-0.35	0.57	0.63
0.283	-1.14	1.83	-2.53	-0.35	0.57	0.63
0.284	-1.14	1.83	-2.54	-0.36	0.57	0.63
0.285	-1.14	1.83	-2.55	-0.36	0.57	0.62
0.286	-1.14	1.83	-2.56	-0.36	0.58	0.62
0.287	-1.14	1.83	-2.57	-0.36	0.58	0.62
0.288	-1.14	1.83	-2.57	-0.36	0.58	0.61
0.289	-1.13	1.83	-2.58	-0.36	0.58	0.61
0.290	-1.13	1.83	-2.59	-0.36	0.58	0.61
0.291	-1.13	1.82	-2.60	-0.36	0.58	0.61
0.292	-1.13	1.82	-2.61	-0.36	0.59	0.60
0.293	-1.13	1.82	-2.61	-0.37	0.59	0.60
0.294	-1.13	1.82	-2.62	-0.37	0.59	0.60
0.295	-1.13	1.82	-2.63	-0.37	0.59	0.60
0.296	-1.13	1.82	-2.64	-0.37	0.59	0.59
0.297	-1.13	1.82	-2.64	-0.37	0.60	0.59
0.298	-1.13	1.81	-2.65	-0.37	0.60	0.59
0.299	-1.13	1.81	-2.66	-0.37	0.60	0.59
0.300	-1.12	1.81	-2.67	-0.37	0.60	0.58

0.301	-1.12	1.81	-2.68	-0.37	0.60	0.58
0.302	-1.12	1.81	-2.68	-0.38	0.60	0.58
0.303	-1.12	1.81	-2.69	-0.38	0.61	0.58
0.304	-1.12	1.81	-2.70	-0.38	0.61	0.57
0.305	-1.12	1.80	-2.71	-0.38	0.61	0.57
0.306	-1.12	1.80	-2.71	-0.38	0.61	0.57
0.307	-1.12	1.80	-2.72	-0.38	0.61	0.56
0.308	-1.12	1.80	-2.73	-0.38	0.62	0.56
0.309	-1.12	1.80	-2.74	-0.38	0.62	0.56
0.310	-1.12	1.80	-2.75	-0.38	0.62	0.56
0.311	-1.12	1.80	-2.75	-0.39	0.62	0.55
0.312	-1.11	1.79	-2.76	-0.39	0.62	0.55
0.313	-1.11	1.79	-2.77	-0.39	0.62	0.55
0.314	-1.11	1.79	-2.78	-0.39	0.63	0.55
0.315	-1.11	1.79	-2.78	-0.39	0.63	0.54
0.316	-1.11	1.79	-2.79	-0.39	0.63	0.54
0.317	-1.11	1.79	-2.80	-0.39	0.63	0.54
0.318	-1.11	1.79	-2.81	-0.39	0.63	0.53
0.319	-1.11	1.79	-2.81	-0.39	0.64	0.53
0.320	-1.11	1.78	-2.82	-0.40	0.64	0.53
0.321	-1.11	1.78	-2.83	-0.40	0.64	0.53
0.322	-1.11	1.78	-2.84	-0.40	0.64	0.52
0.323	-1.11	1.78	-2.84	-0.40	0.64	0.52
0.324	-1.10	1.78	-2.85	-0.40	0.64	0.52
0.325	-1.10	1.78	-2.86	-0.40	0.65	0.51
0.326	-1.10	1.78	-2.87	-0.40	0.65	0.51
0.327	-1.10	1.77	-2.87	-0.40	0.65	0.51
0.328	-1.10	1.77	-2.88	-0.40	0.65	0.51
0.329	-1.10	1.77	-2.89	-0.41	0.65	0.50
0.330	-1.10	1.77	-2.90	-0.41	0.65	0.50
0.331	-1.10	1.77	-2.90	-0.41	0.66	0.50
0.332	-1.10	1.77	-2.91	-0.41	0.66	0.49
0.333	-1.10	1.77	-2.92	-0.41	0.66	0.49
0.334	-1.10	1.76	-2.93	-0.41	0.66	0.49
0.335	-1.09	1.76	-2.93	-0.41	0.66	0.49
0.336	-1.09	1.76	-2.94	-0.41	0.67	0.48
0.337	-1.09	1.76	-2.95	-0.41	0.67	0.48
0.338	-1.09	1.76	-2.96	-0.42	0.67	0.48

0.339	-1.09	1.76	-2.96	-0.42	0.67	0.47
0.340	-1.09	1.76	-2.97	-0.42	0.67	0.47
0.341	-1.09	1.75	-2.98	-0.42	0.67	0.47
0.342	-1.09	1.75	-2.99	-0.42	0.68	0.46
0.343	-1.09	1.75	-2.99	-0.42	0.68	0.46
0.344	-1.09	1.75	-3.00	-0.42	0.68	0.46
0.345	-1.09	1.75	-3.01	-0.42	0.68	0.46
0.346	-1.08	1.75	-3.02	-0.42	0.68	0.45
0.347	-1.08	1.75	-3.02	-0.43	0.68	0.45
0.348	-1.08	1.74	-3.03	-0.43	0.69	0.45
0.349	-1.08	1.74	-3.04	-0.43	0.69	0.44
0.350	-1.08	1.74	-3.05	-0.43	0.69	0.44
0.351	-1.08	1.74	-3.05	-0.43	0.69	0.44
0.352	-1.08	1.74	-3.06	-0.43	0.69	0.43
0.353	-1.08	1.74	-3.07	-0.43	0.70	0.43
0.354	-1.08	1.74	-3.07	-0.43	0.70	0.43
0.355	-1.08	1.73	-3.08	-0.43	0.70	0.43
0.356	-1.08	1.73	-3.09	-0.43	0.70	0.42
0.357	-1.08	1.73	-3.10	-0.44	0.70	0.42
0.358	-1.07	1.73	-3.10	-0.44	0.70	0.42
0.359	-1.07	1.73	-3.11	-0.44	0.71	0.41
0.360	-1.07	1.73	-3.12	-0.44	0.71	0.41
0.361	-1.07	1.73	-3.13	-0.44	0.71	0.41
0.362	-1.07	1.72	-3.13	-0.44	0.71	0.40
0.363	-1.07	1.72	-3.14	-0.44	0.71	0.40
0.364	-1.07	1.72	-3.15	-0.44	0.71	0.40
0.365	-1.07	1.72	-3.15	-0.44	0.72	0.39
0.366	-1.07	1.72	-3.16	-0.45	0.72	0.39
0.367	-1.07	1.72	-3.17	-0.45	0.72	0.39
0.368	-1.07	1.72	-3.18	-0.45	0.72	0.38
0.369	-1.06	1.71	-3.18	-0.45	0.72	0.38
0.370	-1.06	1.71	-3.19	-0.45	0.72	0.38
0.371	-1.06	1.71	-3.20	-0.45	0.73	0.37
0.372	-1.06	1.71	-3.20	-0.45	0.73	0.37
0.373	-1.06	1.71	-3.21	-0.45	0.73	0.37
0.374	-1.06	1.71	-3.22	-0.45	0.73	0.37
0.375	-1.06	1.71	-3.23	-0.46	0.73	0.36
0.376	-1.06	1.70	-3.23	-0.46	0.73	0.36

0.377	-1.06	1.70	-3.24	-0.46	0.74	0.36
0.378	-1.06	1.70	-3.25	-0.46	0.74	0.35
0.379	-1.06	1.70	-3.25	-0.46	0.74	0.35
0.380	-1.05	1.70	-3.26	-0.46	0.74	0.35
0.381	-1.05	1.70	-3.27	-0.46	0.74	0.34
0.382	-1.05	1.70	-3.27	-0.46	0.74	0.34
0.383	-1.05	1.69	-3.28	-0.46	0.75	0.34
0.384	-1.05	1.69	-3.29	-0.46	0.75	0.33
0.385	-1.05	1.69	-3.30	-0.47	0.75	0.33
0.386	-1.05	1.69	-3.30	-0.47	0.75	0.33
0.387	-1.05	1.69	-3.31	-0.47	0.75	0.32
0.388	-1.05	1.69	-3.32	-0.47	0.76	0.32
0.389	-1.05	1.69	-3.32	-0.47	0.76	0.32
0.390	-1.05	1.68	-3.33	-0.47	0.76	0.31
0.391	-1.04	1.68	-3.34	-0.47	0.76	0.31
0.392	-1.04	1.68	-3.34	-0.47	0.76	0.31
0.393	-1.04	1.68	-3.35	-0.47	0.76	0.30
0.394	-1.04	1.68	-3.36	-0.48	0.77	0.30
0.395	-1.04	1.68	-3.36	-0.48	0.77	0.30
0.396	-1.04	1.67	-3.37	-0.48	0.77	0.29
0.397	-1.04	1.67	-3.38	-0.48	0.77	0.29
0.398	-1.04	1.67	-3.39	-0.48	0.77	0.29
0.399	-1.04	1.67	-3.39	-0.48	0.77	0.28
0.400	-1.04	1.67	-3.40	-0.48	0.78	0.28
0.401	-1.04	1.67	-3.41	-0.48	0.78	0.28
0.402	-1.03	1.67	-3.41	-0.48	0.78	0.27
0.403	-1.03	1.66	-3.42	-0.48	0.78	0.27
0.404	-1.03	1.66	-3.43	-0.49	0.78	0.27
0.405	-1.03	1.66	-3.43	-0.49	0.78	0.26
0.406	-1.03	1.66	-3.44	-0.49	0.79	0.26
0.407	-1.03	1.66	-3.45	-0.49	0.79	0.25
0.408	-1.03	1.66	-3.45	-0.49	0.79	0.25
0.409	-1.03	1.66	-3.46	-0.49	0.79	0.25
0.410	-1.03	1.65	-3.47	-0.49	0.79	0.24
0.411	-1.03	1.65	-3.47	-0.49	0.79	0.24
0.412	-1.03	1.65	-3.48	-0.49	0.80	0.24
0.413	-1.02	1.65	-3.49	-0.49	0.80	0.23
0.414	-1.02	1.65	-3.49	-0.50	0.80	0.23

0.415	-1.02	1.65	-3.50	-0.50	0.80	0.23
0.416	-1.02	1.65	-3.51	-0.50	0.80	0.22
0.417	-1.02	1.64	-3.51	-0.50	0.80	0.22
0.418	-1.02	1.64	-3.52	-0.50	0.81	0.22
0.419	-1.02	1.64	-3.53	-0.50	0.81	0.21
0.420	-1.02	1.64	-3.53	-0.50	0.81	0.21
0.421	-1.02	1.64	-3.54	-0.50	0.81	0.21
0.422	-1.02	1.64	-3.55	-0.50	0.81	0.20
0.423	-1.02	1.64	-3.55	-0.51	0.81	0.20
0.424	-1.01	1.63	-3.56	-0.51	0.81	0.20
0.425	-1.01	1.63	-3.57	-0.51	0.82	0.19
0.426	-1.01	1.63	-3.57	-0.51	0.82	0.19
0.427	-1.01	1.63	-3.58	-0.51	0.82	0.18
0.428	-1.01	1.63	-3.59	-0.51	0.82	0.18
0.429	-1.01	1.63	-3.59	-0.51	0.82	0.18
0.430	-1.01	1.62	-3.60	-0.51	0.82	0.17
0.431	-1.01	1.62	-3.61	-0.51	0.83	0.17
0.432	-1.01	1.62	-3.61	-0.51	0.83	0.17
0.433	-1.01	1.62	-3.62	-0.52	0.83	0.16
0.434	-1.01	1.62	-3.63	-0.52	0.83	0.16
0.435	-1.00	1.62	-3.63	-0.52	0.83	0.16
0.436	-1.00	1.62	-3.64	-0.52	0.83	0.15
0.437	-1.00	1.61	-3.64	-0.52	0.84	0.15
0.438	-1.00	1.61	-3.65	-0.52	0.84	0.14
0.439	-1.00	1.61	-3.66	-0.52	0.84	0.14
0.440	-1.00	1.61	-3.66	-0.52	0.84	0.14
0.441	-1.00	1.61	-3.67	-0.52	0.84	0.13
0.442	-1.00	1.61	-3.68	-0.52	0.84	0.13
0.443	-1.00	1.61	-3.68	-0.53	0.85	0.13
0.444	-1.00	1.60	-3.69	-0.53	0.85	0.12
0.445	-1.00	1.60	-3.70	-0.53	0.85	0.12
0.446	-0.99	1.60	-3.70	-0.53	0.85	0.12
0.447	-0.99	1.60	-3.71	-0.53	0.85	0.11
0.448	-0.99	1.60	-3.72	-0.53	0.85	0.11
0.449	-0.99	1.60	-3.72	-0.53	0.86	0.10
0.450	-0.99	1.60	-3.73	-0.53	0.86	0.10
0.451	-0.99	1.59	-3.73	-0.53	0.86	0.10
0.452	-0.99	1.59	-3.74	-0.53	0.86	0.09

0.453	-0.99	1.59	-3.75	-0.54	0.86	0.09
0.454	-0.99	1.59	-3.75	-0.54	0.86	0.09
0.455	-0.99	1.59	-3.76	-0.54	0.86	0.08
0.456	-0.99	1.59	-3.77	-0.54	0.87	0.08
0.457	-0.98	1.58	-3.77	-0.54	0.87	0.07
0.458	-0.98	1.58	-3.78	-0.54	0.87	0.07
0.459	-0.98	1.58	-3.78	-0.54	0.87	0.07
0.460	-0.98	1.58	-3.79	-0.54	0.87	0.06
0.461	-0.98	1.58	-3.80	-0.54	0.87	0.06
0.462	-0.98	1.58	-3.80	-0.54	0.88	0.06
0.463	-0.98	1.58	-3.81	-0.54	0.88	0.05
0.464	-0.98	1.57	-3.82	-0.55	0.88	0.05
0.465	-0.98	1.57	-3.82	-0.55	0.88	0.04
0.466	-0.98	1.57	-3.83	-0.55	0.88	0.04
0.467	-0.97	1.57	-3.83	-0.55	0.88	0.04
0.468	-0.97	1.57	-3.84	-0.55	0.89	0.03
0.469	-0.97	1.57	-3.85	-0.55	0.89	0.03
0.470	-0.97	1.57	-3.85	-0.55	0.89	0.02
0.471	-0.97	1.56	-3.86	-0.55	0.89	0.02
0.472	-0.97	1.56	-3.87	-0.55	0.89	0.02
0.473	-0.97	1.56	-3.87	-0.55	0.89	0.01
0.474	-0.97	1.56	-3.88	-0.56	0.89	0.01
0.475	-0.97	1.56	-3.88	-0.56	0.90	0.01
0.476	-0.97	1.56	-3.89	-0.56	0.90	0.00
0.477	-0.97	1.55	-3.90	-0.56	0.90	0.00
0.478	-0.96	1.55	-3.90	-0.56	0.90	-0.01
0.479	-0.96	1.55	-3.91	-0.56	0.90	-0.01
0.480	-0.96	1.55	-3.91	-0.56	0.90	-0.01
0.481	-0.96	1.55	-3.92	-0.56	0.91	-0.02
0.482	-0.96	1.55	-3.93	-0.56	0.91	-0.02
0.483	-0.96	1.55	-3.93	-0.56	0.91	-0.03
0.484	-0.96	1.54	-3.94	-0.57	0.91	-0.03
0.485	-0.96	1.54	-3.94	-0.57	0.91	-0.03
0.486	-0.96	1.54	-3.95	-0.57	0.91	-0.04
0.487	-0.96	1.54	-3.96	-0.57	0.91	-0.04
0.488	-0.96	1.54	-3.96	-0.57	0.92	-0.05
0.489	-0.95	1.54	-3.97	-0.57	0.92	-0.05
0.490	-0.95	1.54	-3.97	-0.57	0.92	-0.05

0.491	-0.95	1.53	-3.98	-0.57	0.92	-0.06
0.492	-0.95	1.53	-3.99	-0.57	0.92	-0.06
0.493	-0.95	1.53	-3.99	-0.57	0.92	-0.07
0.494	-0.95	1.53	-4.00	-0.57	0.93	-0.07
0.495	-0.95	1.53	-4.00	-0.58	0.93	-0.07
0.496	-0.95	1.53	-4.01	-0.58	0.93	-0.08
0.497	-0.95	1.52	-4.01	-0.58	0.93	-0.08
0.498	-0.95	1.52	-4.02	-0.58	0.93	-0.09
0.499	-0.95	1.52	-4.03	-0.58	0.93	-0.09
0.500	-0.94	1.52	-4.03	-0.58	0.93	-0.09
0.501	-0.94	1.52	-4.04	-0.58	0.94	-0.10
0.502	-0.94	1.52	-4.04	-0.58	0.94	-0.10
0.503	-0.94	1.52	-4.05	-0.58	0.94	-0.11
0.504	-0.94	1.51	-4.06	-0.58	0.94	-0.11
0.505	-0.94	1.51	-4.06	-0.59	0.94	-0.11
0.506	-0.94	1.51	-4.07	-0.59	0.94	-0.12
0.507	-0.94	1.51	-4.07	-0.59	0.95	-0.12
0.508	-0.94	1.51	-4.08	-0.59	0.95	-0.13
0.509	-0.94	1.51	-4.08	-0.59	0.95	-0.13
0.510	-0.93	1.51	-4.09	-0.59	0.95	-0.13

Appendix W- Aspirated 0º Mass Flow Rate

Avg 0º 100 psi asp

Dist.(m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.003	0.008	0.015	0.016	0.023	0.067	0.028	0.020	0.016	0.020	0.007	0.001
1.00	0.003	0.011	0.020	0.028	0.033	0.055	0.048	0.031	0.031	0.017	0.007	0.007
1.10	0.007	0.019	0.032	0.044	0.053	0.079	0.053	0.048	0.045	0.025	0.009	0.003
1.20	0.012	0.028	0.064	0.064	0.076	0.109	0.091	0.073	0.067	0.035	0.017	0.005
1.30	0.017	0.063	0.125	0.141	0.127	0.124	0.117	0.136	0.123	0.073	0.025	0.009
1.40	0.031	0.117	0.248	0.257	0.199	0.161	0.184	0.241	0.195	0.129	0.047	0.011
1.50	0.060	0.241	0.495	0.504	0.307	0.204	0.287	0.404	0.379	0.235	0.068	0.024
1.60	0.068	0.381	0.887	0.828	0.399	0.277	0.392	0.904	0.696	0.420	0.132	0.023
1.70	0.099	0.671	1.348	1.272	0.520	0.289	0.513	1.352	1.268	0.693	0.155	0.021
1.80	0.148	0.833	1.657	1.445	0.545	0.385	0.619	1.545	1.796	1.032	0.243	0.044
1.90	0.175	0.995	1.733	1.503	0.539	0.405	0.597	1.581	2.041	1.237	0.336	0.039
2.00	0.136	1.001	1.559	1.025	0.508	0.456	0.533	1.121	1.720	1.228	0.468	0.028
2.10	0.119	0.885	1.323	0.833	0.508	0.431	0.471	0.855	1.880	0.972	0.416	0.015
2.20	0.087	0.916	1.292	0.728	0.439	0.357	0.376	0.673	1.532	0.832	0.261	0.004
2.30	0.081	0.848	1.244	0.529	0.269	0.205	0.217	0.413	1.004	0.505	0.099	0.000
2.40	0.073	0.637	1.067	0.487	0.149	0.075	0.091	0.216	0.483	0.173	0.008	0.000
2.50	0.043	0.447	0.620	0.304	0.055	0.016	0.016	0.043	0.084	0.027	0.000	0.000
2.60	0.001	0.135	0.291	0.117	0.015	0.003	0.001	0.000	0.008	0.003	0.000	0.000
2.70	0.000	0.024	0.063	0.023	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000

Where all values are in $g/(m^2\text{-}s)$

Appendix X- Aspirated -15º Single Particle Position and Velocity

r= 0.01 m		u_o= -1.36 m/s		v_o= 2.12 m/s		w_o= -0.57 m/s
t (s)	u (m/s)	v (m/s)	w (m/s)	x (m)	y (m)	z (m)
0.001	-1.36	2.11	-0.58	0.00	0.00	1.00
0.002	-1.36	2.11	-0.59	0.00	0.00	1.00
0.003	-1.36	2.11	-0.60	0.00	0.01	1.00
0.004	-1.36	2.11	-0.60	-0.01	0.01	1.00
0.005	-1.36	2.11	-0.61	-0.01	0.01	1.00
0.006	-1.36	2.11	-0.62	-0.01	0.01	1.00
0.007	-1.35	2.11	-0.63	-0.01	0.01	1.00
0.008	-1.35	2.11	-0.64	-0.01	0.02	1.00
0.009	-1.35	2.10	-0.65	-0.01	0.02	0.99
0.010	-1.35	2.10	-0.66	-0.01	0.02	0.99
0.011	-1.35	2.10	-0.67	-0.01	0.02	0.99
0.012	-1.35	2.10	-0.68	-0.02	0.03	0.99
0.013	-1.35	2.10	-0.69	-0.02	0.03	0.99
0.014	-1.35	2.10	-0.70	-0.02	0.03	0.99
0.015	-1.35	2.10	-0.71	-0.02	0.03	0.99
0.016	-1.35	2.10	-0.72	-0.02	0.03	0.99
0.017	-1.35	2.09	-0.73	-0.02	0.04	0.99
0.018	-1.35	2.09	-0.74	-0.02	0.04	0.99
0.019	-1.35	2.09	-0.75	-0.03	0.04	0.99
0.020	-1.34	2.09	-0.76	-0.03	0.04	0.99
0.021	-1.34	2.09	-0.76	-0.03	0.04	0.99
0.022	-1.34	2.09	-0.77	-0.03	0.05	0.99
0.023	-1.34	2.09	-0.78	-0.03	0.05	0.98
0.024	-1.34	2.09	-0.79	-0.03	0.05	0.98
0.025	-1.34	2.09	-0.80	-0.03	0.05	0.98
0.026	-1.34	2.08	-0.81	-0.04	0.05	0.98
0.027	-1.34	2.08	-0.82	-0.04	0.06	0.98
0.028	-1.34	2.08	-0.83	-0.04	0.06	0.98
0.029	-1.34	2.08	-0.84	-0.04	0.06	0.98
0.030	-1.34	2.08	-0.85	-0.04	0.06	0.98
0.031	-1.34	2.08	-0.86	-0.04	0.06	0.98
0.032	-1.34	2.08	-0.87	-0.04	0.07	0.98
0.033	-1.33	2.08	-0.88	-0.04	0.07	0.98
0.034	-1.33	2.07	-0.89	-0.05	0.07	0.98

0.035	-1.33	2.07	-0.90	-0.05	0.07	0.97
0.036	-1.33	2.07	-0.90	-0.05	0.08	0.97
0.037	-1.33	2.07	-0.91	-0.05	0.08	0.97
0.038	-1.33	2.07	-0.92	-0.05	0.08	0.97
0.039	-1.33	2.07	-0.93	-0.05	0.08	0.97
0.040	-1.33	2.07	-0.94	-0.05	0.08	0.97
0.041	-1.33	2.07	-0.95	-0.06	0.09	0.97
0.042	-1.33	2.06	-0.96	-0.06	0.09	0.97
0.043	-1.33	2.06	-0.97	-0.06	0.09	0.97
0.044	-1.33	2.06	-0.98	-0.06	0.09	0.97
0.045	-1.32	2.06	-0.99	-0.06	0.09	0.96
0.046	-1.32	2.06	-1.00	-0.06	0.10	0.96
0.047	-1.32	2.06	-1.01	-0.06	0.10	0.96
0.048	-1.32	2.06	-1.02	-0.06	0.10	0.96
0.049	-1.32	2.06	-1.02	-0.07	0.10	0.96
0.050	-1.32	2.05	-1.03	-0.07	0.10	0.96
0.051	-1.32	2.05	-1.04	-0.07	0.11	0.96
0.052	-1.32	2.05	-1.05	-0.07	0.11	0.96
0.053	-1.32	2.05	-1.06	-0.07	0.11	0.96
0.054	-1.32	2.05	-1.07	-0.07	0.11	0.96
0.055	-1.32	2.05	-1.08	-0.07	0.11	0.95
0.056	-1.32	2.05	-1.09	-0.07	0.12	0.95
0.057	-1.32	2.05	-1.10	-0.08	0.12	0.95
0.058	-1.31	2.04	-1.11	-0.08	0.12	0.95
0.059	-1.31	2.04	-1.12	-0.08	0.12	0.95
0.060	-1.31	2.04	-1.13	-0.08	0.12	0.95
0.061	-1.31	2.04	-1.13	-0.08	0.13	0.95
0.062	-1.31	2.04	-1.14	-0.08	0.13	0.95
0.063	-1.31	2.04	-1.15	-0.08	0.13	0.95
0.064	-1.31	2.04	-1.16	-0.09	0.13	0.94
0.065	-1.31	2.04	-1.17	-0.09	0.13	0.94
0.066	-1.31	2.04	-1.18	-0.09	0.14	0.94
0.067	-1.31	2.03	-1.19	-0.09	0.14	0.94
0.068	-1.31	2.03	-1.20	-0.09	0.14	0.94
0.069	-1.31	2.03	-1.21	-0.09	0.14	0.94
0.070	-1.31	2.03	-1.22	-0.09	0.15	0.94
0.071	-1.30	2.03	-1.23	-0.09	0.15	0.94
0.072	-1.30	2.03	-1.23	-0.10	0.15	0.93

0.073	-1.30	2.03	-1.24	-0.10	0.15	0.93
0.074	-1.30	2.03	-1.25	-0.10	0.15	0.93
0.075	-1.30	2.02	-1.26	-0.10	0.16	0.93
0.076	-1.30	2.02	-1.27	-0.10	0.16	0.93
0.077	-1.30	2.02	-1.28	-0.10	0.16	0.93
0.078	-1.30	2.02	-1.29	-0.10	0.16	0.93
0.079	-1.30	2.02	-1.30	-0.10	0.16	0.93
0.080	-1.30	2.02	-1.31	-0.11	0.17	0.92
0.081	-1.30	2.02	-1.32	-0.11	0.17	0.92
0.082	-1.30	2.02	-1.33	-0.11	0.17	0.92
0.083	-1.29	2.01	-1.33	-0.11	0.17	0.92
0.084	-1.29	2.01	-1.34	-0.11	0.17	0.92
0.085	-1.29	2.01	-1.35	-0.11	0.18	0.92
0.086	-1.29	2.01	-1.36	-0.11	0.18	0.92
0.087	-1.29	2.01	-1.37	-0.12	0.18	0.92
0.088	-1.29	2.01	-1.38	-0.12	0.18	0.91
0.089	-1.29	2.01	-1.39	-0.12	0.18	0.91
0.090	-1.29	2.01	-1.40	-0.12	0.19	0.91
0.091	-1.29	2.00	-1.41	-0.12	0.19	0.91
0.092	-1.29	2.00	-1.42	-0.12	0.19	0.91
0.093	-1.29	2.00	-1.42	-0.12	0.19	0.91
0.094	-1.29	2.00	-1.43	-0.12	0.19	0.91
0.095	-1.29	2.00	-1.44	-0.13	0.20	0.90
0.096	-1.28	2.00	-1.45	-0.13	0.20	0.90
0.097	-1.28	2.00	-1.46	-0.13	0.20	0.90
0.098	-1.28	2.00	-1.47	-0.13	0.20	0.90
0.099	-1.28	1.99	-1.48	-0.13	0.20	0.90
0.100	-1.28	1.99	-1.49	-0.13	0.21	0.90
0.101	-1.28	1.99	-1.50	-0.13	0.21	0.89
0.102	-1.28	1.99	-1.50	-0.13	0.21	0.89
0.103	-1.28	1.99	-1.51	-0.14	0.21	0.89
0.104	-1.28	1.99	-1.52	-0.14	0.21	0.89
0.105	-1.28	1.99	-1.53	-0.14	0.22	0.89
0.106	-1.28	1.99	-1.54	-0.14	0.22	0.89
0.107	-1.28	1.98	-1.55	-0.14	0.22	0.89
0.108	-1.28	1.98	-1.56	-0.14	0.22	0.88
0.109	-1.27	1.98	-1.57	-0.14	0.22	0.88
0.110	-1.27	1.98	-1.57	-0.14	0.23	0.88

0.111	-1.27	1.98	-1.58	-0.15	0.23	0.88
0.112	-1.27	1.98	-1.59	-0.15	0.23	0.88
0.113	-1.27	1.98	-1.60	-0.15	0.23	0.88
0.114	-1.27	1.98	-1.61	-0.15	0.23	0.87
0.115	-1.27	1.97	-1.62	-0.15	0.24	0.87
0.116	-1.27	1.97	-1.63	-0.15	0.24	0.87
0.117	-1.27	1.97	-1.64	-0.15	0.24	0.87
0.118	-1.27	1.97	-1.65	-0.15	0.24	0.87
0.119	-1.27	1.97	-1.65	-0.16	0.24	0.87
0.120	-1.27	1.97	-1.66	-0.16	0.24	0.86
0.121	-1.26	1.97	-1.67	-0.16	0.25	0.86
0.122	-1.26	1.97	-1.68	-0.16	0.25	0.86
0.123	-1.26	1.96	-1.69	-0.16	0.25	0.86
0.124	-1.26	1.96	-1.70	-0.16	0.25	0.86
0.125	-1.26	1.96	-1.71	-0.16	0.25	0.86
0.126	-1.26	1.96	-1.71	-0.17	0.26	0.85
0.127	-1.26	1.96	-1.72	-0.17	0.26	0.85
0.128	-1.26	1.96	-1.73	-0.17	0.26	0.85
0.129	-1.26	1.96	-1.74	-0.17	0.26	0.85
0.130	-1.26	1.96	-1.75	-0.17	0.26	0.85
0.131	-1.26	1.95	-1.76	-0.17	0.27	0.85
0.132	-1.26	1.95	-1.77	-0.17	0.27	0.84
0.133	-1.25	1.95	-1.78	-0.17	0.27	0.84
0.134	-1.25	1.95	-1.78	-0.18	0.27	0.84
0.135	-1.25	1.95	-1.79	-0.18	0.27	0.84
0.136	-1.25	1.95	-1.80	-0.18	0.28	0.84
0.137	-1.25	1.95	-1.81	-0.18	0.28	0.84
0.138	-1.25	1.95	-1.82	-0.18	0.28	0.83
0.139	-1.25	1.94	-1.83	-0.18	0.28	0.83
0.140	-1.25	1.94	-1.84	-0.18	0.28	0.83
0.141	-1.25	1.94	-1.84	-0.18	0.29	0.83
0.142	-1.25	1.94	-1.85	-0.19	0.29	0.83
0.143	-1.25	1.94	-1.86	-0.19	0.29	0.82
0.144	-1.25	1.94	-1.87	-0.19	0.29	0.82
0.145	-1.24	1.94	-1.88	-0.19	0.29	0.82
0.146	-1.24	1.94	-1.89	-0.19	0.30	0.82
0.147	-1.24	1.93	-1.90	-0.19	0.30	0.82
0.148	-1.24	1.93	-1.90	-0.19	0.30	0.81

0.149	-1.24	1.93	-1.91	-0.19	0.30	0.81
0.150	-1.24	1.93	-1.92	-0.20	0.30	0.81
0.151	-1.24	1.93	-1.93	-0.20	0.31	0.81
0.152	-1.24	1.93	-1.94	-0.20	0.31	0.81
0.153	-1.24	1.93	-1.95	-0.20	0.31	0.81
0.154	-1.24	1.92	-1.96	-0.20	0.31	0.80
0.155	-1.24	1.92	-1.96	-0.20	0.31	0.80
0.156	-1.24	1.92	-1.97	-0.20	0.31	0.80
0.157	-1.23	1.92	-1.98	-0.20	0.32	0.80
0.158	-1.23	1.92	-1.99	-0.20	0.32	0.80
0.159	-1.23	1.92	-2.00	-0.21	0.32	0.79
0.160	-1.23	1.92	-2.01	-0.21	0.32	0.79
0.161	-1.23	1.92	-2.02	-0.21	0.32	0.79
0.162	-1.23	1.91	-2.02	-0.21	0.33	0.79
0.163	-1.23	1.91	-2.03	-0.21	0.33	0.79
0.164	-1.23	1.91	-2.04	-0.21	0.33	0.78
0.165	-1.23	1.91	-2.05	-0.21	0.33	0.78
0.166	-1.23	1.91	-2.06	-0.21	0.33	0.78
0.167	-1.23	1.91	-2.07	-0.22	0.34	0.78
0.168	-1.23	1.91	-2.07	-0.22	0.34	0.77
0.169	-1.22	1.91	-2.08	-0.22	0.34	0.77
0.170	-1.22	1.90	-2.09	-0.22	0.34	0.77
0.171	-1.22	1.90	-2.10	-0.22	0.34	0.77
0.172	-1.22	1.90	-2.11	-0.22	0.35	0.77
0.173	-1.22	1.90	-2.12	-0.22	0.35	0.76
0.174	-1.22	1.90	-2.12	-0.22	0.35	0.76
0.175	-1.22	1.90	-2.13	-0.23	0.35	0.76
0.176	-1.22	1.90	-2.14	-0.23	0.35	0.76
0.177	-1.22	1.89	-2.15	-0.23	0.36	0.76
0.178	-1.22	1.89	-2.16	-0.23	0.36	0.75
0.179	-1.22	1.89	-2.17	-0.23	0.36	0.75
0.180	-1.22	1.89	-2.17	-0.23	0.36	0.75
0.181	-1.21	1.89	-2.18	-0.23	0.36	0.75
0.182	-1.21	1.89	-2.19	-0.23	0.36	0.74
0.183	-1.21	1.89	-2.20	-0.24	0.37	0.74
0.184	-1.21	1.89	-2.21	-0.24	0.37	0.74
0.185	-1.21	1.88	-2.22	-0.24	0.37	0.74
0.186	-1.21	1.88	-2.22	-0.24	0.37	0.74

0.187	-1.21	1.88	-2.23	-0.24	0.37	0.73
0.188	-1.21	1.88	-2.24	-0.24	0.38	0.73
0.189	-1.21	1.88	-2.25	-0.24	0.38	0.73
0.190	-1.21	1.88	-2.26	-0.24	0.38	0.73
0.191	-1.21	1.88	-2.26	-0.25	0.38	0.72
0.192	-1.21	1.87	-2.27	-0.25	0.38	0.72
0.193	-1.20	1.87	-2.28	-0.25	0.39	0.72
0.194	-1.20	1.87	-2.29	-0.25	0.39	0.72
0.195	-1.20	1.87	-2.30	-0.25	0.39	0.72
0.196	-1.20	1.87	-2.31	-0.25	0.39	0.71
0.197	-1.20	1.87	-2.31	-0.25	0.39	0.71
0.198	-1.20	1.87	-2.32	-0.25	0.39	0.71
0.199	-1.20	1.87	-2.33	-0.25	0.40	0.71
0.200	-1.20	1.86	-2.34	-0.26	0.40	0.70
0.201	-1.20	1.86	-2.35	-0.26	0.40	0.70
0.202	-1.20	1.86	-2.35	-0.26	0.40	0.70
0.203	-1.20	1.86	-2.36	-0.26	0.40	0.70
0.204	-1.20	1.86	-2.37	-0.26	0.41	0.69
0.205	-1.19	1.86	-2.38	-0.26	0.41	0.69
0.206	-1.19	1.86	-2.39	-0.26	0.41	0.69
0.207	-1.19	1.85	-2.40	-0.26	0.41	0.69
0.208	-1.19	1.85	-2.40	-0.27	0.41	0.69
0.209	-1.19	1.85	-2.41	-0.27	0.41	0.68
0.210	-1.19	1.85	-2.42	-0.27	0.42	0.68
0.211	-1.19	1.85	-2.43	-0.27	0.42	0.68
0.212	-1.19	1.85	-2.44	-0.27	0.42	0.68
0.213	-1.19	1.85	-2.44	-0.27	0.42	0.67
0.214	-1.19	1.85	-2.45	-0.27	0.42	0.67
0.215	-1.19	1.84	-2.46	-0.27	0.43	0.67
0.216	-1.18	1.84	-2.47	-0.28	0.43	0.67
0.217	-1.18	1.84	-2.48	-0.28	0.43	0.66
0.218	-1.18	1.84	-2.48	-0.28	0.43	0.66
0.219	-1.18	1.84	-2.49	-0.28	0.43	0.66
0.220	-1.18	1.84	-2.50	-0.28	0.44	0.66
0.221	-1.18	1.84	-2.51	-0.28	0.44	0.65
0.222	-1.18	1.83	-2.52	-0.28	0.44	0.65
0.223	-1.18	1.83	-2.52	-0.28	0.44	0.65
0.224	-1.18	1.83	-2.53	-0.28	0.44	0.65

0.225	-1.18	1.83	-2.54	-0.29	0.44	0.64
0.226	-1.18	1.83	-2.55	-0.29	0.45	0.64
0.227	-1.17	1.83	-2.55	-0.29	0.45	0.64
0.228	-1.17	1.83	-2.56	-0.29	0.45	0.64
0.229	-1.17	1.82	-2.57	-0.29	0.45	0.63
0.230	-1.17	1.82	-2.58	-0.29	0.45	0.63
0.231	-1.17	1.82	-2.59	-0.29	0.46	0.63
0.232	-1.17	1.82	-2.59	-0.29	0.46	0.63
0.233	-1.17	1.82	-2.60	-0.30	0.46	0.62
0.234	-1.17	1.82	-2.61	-0.30	0.46	0.62
0.235	-1.17	1.82	-2.62	-0.30	0.46	0.62
0.236	-1.17	1.82	-2.63	-0.30	0.46	0.61
0.237	-1.17	1.81	-2.63	-0.30	0.47	0.61
0.238	-1.17	1.81	-2.64	-0.30	0.47	0.61
0.239	-1.16	1.81	-2.65	-0.30	0.47	0.61
0.240	-1.16	1.81	-2.66	-0.30	0.47	0.60
0.241	-1.16	1.81	-2.66	-0.30	0.47	0.60
0.242	-1.16	1.81	-2.67	-0.31	0.48	0.60
0.243	-1.16	1.81	-2.68	-0.31	0.48	0.60
0.244	-1.16	1.80	-2.69	-0.31	0.48	0.59
0.245	-1.16	1.80	-2.70	-0.31	0.48	0.59
0.246	-1.16	1.80	-2.70	-0.31	0.48	0.59
0.247	-1.16	1.80	-2.71	-0.31	0.48	0.59
0.248	-1.16	1.80	-2.72	-0.31	0.49	0.58
0.249	-1.16	1.80	-2.73	-0.31	0.49	0.58
0.250	-1.15	1.80	-2.73	-0.31	0.49	0.58
0.251	-1.15	1.79	-2.74	-0.32	0.49	0.57
0.252	-1.15	1.79	-2.75	-0.32	0.49	0.57
0.253	-1.15	1.79	-2.76	-0.32	0.50	0.57
0.254	-1.15	1.79	-2.76	-0.32	0.50	0.57
0.255	-1.15	1.79	-2.77	-0.32	0.50	0.56
0.256	-1.15	1.79	-2.78	-0.32	0.50	0.56
0.257	-1.15	1.79	-2.79	-0.32	0.50	0.56
0.258	-1.15	1.78	-2.80	-0.32	0.50	0.55
0.259	-1.15	1.78	-2.80	-0.33	0.51	0.55
0.260	-1.15	1.78	-2.81	-0.33	0.51	0.55
0.261	-1.14	1.78	-2.82	-0.33	0.51	0.55
0.262	-1.14	1.78	-2.83	-0.33	0.51	0.54

0.263	-1.14	1.78	-2.83	-0.33	0.51	0.54
0.264	-1.14	1.78	-2.84	-0.33	0.51	0.54
0.265	-1.14	1.77	-2.85	-0.33	0.52	0.54
0.266	-1.14	1.77	-2.86	-0.33	0.52	0.53
0.267	-1.14	1.77	-2.86	-0.33	0.52	0.53
0.268	-1.14	1.77	-2.87	-0.34	0.52	0.53
0.269	-1.14	1.77	-2.88	-0.34	0.52	0.52
0.270	-1.14	1.77	-2.89	-0.34	0.53	0.52
0.271	-1.14	1.77	-2.89	-0.34	0.53	0.52
0.272	-1.13	1.77	-2.90	-0.34	0.53	0.51
0.273	-1.13	1.76	-2.91	-0.34	0.53	0.51
0.274	-1.13	1.76	-2.92	-0.34	0.53	0.51
0.275	-1.13	1.76	-2.92	-0.34	0.53	0.51
0.276	-1.13	1.76	-2.93	-0.34	0.54	0.50
0.277	-1.13	1.76	-2.94	-0.35	0.54	0.50
0.278	-1.13	1.76	-2.95	-0.35	0.54	0.50
0.279	-1.13	1.76	-2.95	-0.35	0.54	0.49
0.280	-1.13	1.75	-2.96	-0.35	0.54	0.49
0.281	-1.13	1.75	-2.97	-0.35	0.54	0.49
0.282	-1.13	1.75	-2.98	-0.35	0.55	0.49
0.283	-1.12	1.75	-2.98	-0.35	0.55	0.48
0.284	-1.12	1.75	-2.99	-0.35	0.55	0.48
0.285	-1.12	1.75	-3.00	-0.35	0.55	0.48
0.286	-1.12	1.75	-3.01	-0.36	0.55	0.47
0.287	-1.12	1.74	-3.01	-0.36	0.56	0.47
0.288	-1.12	1.74	-3.02	-0.36	0.56	0.47
0.289	-1.12	1.74	-3.03	-0.36	0.56	0.46
0.290	-1.12	1.74	-3.03	-0.36	0.56	0.46
0.291	-1.12	1.74	-3.04	-0.36	0.56	0.46
0.292	-1.12	1.74	-3.05	-0.36	0.56	0.46
0.293	-1.12	1.74	-3.06	-0.36	0.57	0.45
0.294	-1.11	1.73	-3.06	-0.36	0.57	0.45
0.295	-1.11	1.73	-3.07	-0.37	0.57	0.45
0.296	-1.11	1.73	-3.08	-0.37	0.57	0.44
0.297	-1.11	1.73	-3.09	-0.37	0.57	0.44
0.298	-1.11	1.73	-3.09	-0.37	0.57	0.44
0.299	-1.11	1.73	-3.10	-0.37	0.58	0.43
0.300	-1.11	1.73	-3.11	-0.37	0.58	0.43

0.301	-1.11	1.72	-3.11	-0.37	0.58	0.43
0.302	-1.11	1.72	-3.12	-0.37	0.58	0.42
0.303	-1.11	1.72	-3.13	-0.37	0.58	0.42
0.304	-1.11	1.72	-3.14	-0.38	0.58	0.42
0.305	-1.10	1.72	-3.14	-0.38	0.59	0.42
0.306	-1.10	1.72	-3.15	-0.38	0.59	0.41
0.307	-1.10	1.72	-3.16	-0.38	0.59	0.41
0.308	-1.10	1.71	-3.16	-0.38	0.59	0.41
0.309	-1.10	1.71	-3.17	-0.38	0.59	0.40
0.310	-1.10	1.71	-3.18	-0.38	0.59	0.40
0.311	-1.10	1.71	-3.19	-0.38	0.60	0.40
0.312	-1.10	1.71	-3.19	-0.38	0.60	0.39
0.313	-1.10	1.71	-3.20	-0.39	0.60	0.39
0.314	-1.10	1.71	-3.21	-0.39	0.60	0.39
0.315	-1.10	1.70	-3.21	-0.39	0.60	0.38
0.316	-1.09	1.70	-3.22	-0.39	0.61	0.38
0.317	-1.09	1.70	-3.23	-0.39	0.61	0.38
0.318	-1.09	1.70	-3.24	-0.39	0.61	0.37
0.319	-1.09	1.70	-3.24	-0.39	0.61	0.37
0.320	-1.09	1.70	-3.25	-0.39	0.61	0.37
0.321	-1.09	1.69	-3.26	-0.39	0.61	0.36
0.322	-1.09	1.69	-3.26	-0.40	0.62	0.36
0.323	-1.09	1.69	-3.27	-0.40	0.62	0.36
0.324	-1.09	1.69	-3.28	-0.40	0.62	0.35
0.325	-1.09	1.69	-3.28	-0.40	0.62	0.35
0.326	-1.09	1.69	-3.29	-0.40	0.62	0.35
0.327	-1.08	1.69	-3.30	-0.40	0.62	0.34
0.328	-1.08	1.68	-3.31	-0.40	0.63	0.34
0.329	-1.08	1.68	-3.31	-0.40	0.63	0.34
0.330	-1.08	1.68	-3.32	-0.40	0.63	0.33
0.331	-1.08	1.68	-3.33	-0.41	0.63	0.33
0.332	-1.08	1.68	-3.33	-0.41	0.63	0.33
0.333	-1.08	1.68	-3.34	-0.41	0.63	0.32
0.334	-1.08	1.68	-3.35	-0.41	0.64	0.32
0.335	-1.08	1.67	-3.35	-0.41	0.64	0.32
0.336	-1.08	1.67	-3.36	-0.41	0.64	0.31
0.337	-1.07	1.67	-3.37	-0.41	0.64	0.31
0.338	-1.07	1.67	-3.37	-0.41	0.64	0.31

0.339	-1.07	1.67	-3.38	-0.41	0.64	0.30
0.340	-1.07	1.67	-3.39	-0.42	0.65	0.30
0.341	-1.07	1.67	-3.40	-0.42	0.65	0.30
0.342	-1.07	1.66	-3.40	-0.42	0.65	0.29
0.343	-1.07	1.66	-3.41	-0.42	0.65	0.29
0.344	-1.07	1.66	-3.42	-0.42	0.65	0.29
0.345	-1.07	1.66	-3.42	-0.42	0.65	0.28
0.346	-1.07	1.66	-3.43	-0.42	0.66	0.28
0.347	-1.07	1.66	-3.44	-0.42	0.66	0.28
0.348	-1.06	1.66	-3.44	-0.42	0.66	0.27
0.349	-1.06	1.65	-3.45	-0.42	0.66	0.27
0.350	-1.06	1.65	-3.46	-0.43	0.66	0.27
0.351	-1.06	1.65	-3.46	-0.43	0.66	0.26
0.352	-1.06	1.65	-3.47	-0.43	0.67	0.26
0.353	-1.06	1.65	-3.48	-0.43	0.67	0.26
0.354	-1.06	1.65	-3.48	-0.43	0.67	0.25
0.355	-1.06	1.65	-3.49	-0.43	0.67	0.25
0.356	-1.06	1.64	-3.50	-0.43	0.67	0.25
0.357	-1.06	1.64	-3.50	-0.43	0.67	0.24
0.358	-1.05	1.64	-3.51	-0.43	0.68	0.24
0.359	-1.05	1.64	-3.52	-0.44	0.68	0.23
0.360	-1.05	1.64	-3.52	-0.44	0.68	0.23
0.361	-1.05	1.64	-3.53	-0.44	0.68	0.23
0.362	-1.05	1.63	-3.54	-0.44	0.68	0.22
0.363	-1.05	1.63	-3.54	-0.44	0.68	0.22
0.364	-1.05	1.63	-3.55	-0.44	0.69	0.22
0.365	-1.05	1.63	-3.56	-0.44	0.69	0.21
0.366	-1.05	1.63	-3.56	-0.44	0.69	0.21
0.367	-1.05	1.63	-3.57	-0.44	0.69	0.21
0.368	-1.05	1.63	-3.58	-0.44	0.69	0.20
0.369	-1.04	1.62	-3.58	-0.45	0.69	0.20
0.370	-1.04	1.62	-3.59	-0.45	0.69	0.20
0.371	-1.04	1.62	-3.60	-0.45	0.70	0.19
0.372	-1.04	1.62	-3.60	-0.45	0.70	0.19
0.373	-1.04	1.62	-3.61	-0.45	0.70	0.18
0.374	-1.04	1.62	-3.62	-0.45	0.70	0.18
0.375	-1.04	1.62	-3.62	-0.45	0.70	0.18
0.376	-1.04	1.61	-3.63	-0.45	0.70	0.17

0.377	-1.04	1.61	-3.64	-0.45	0.71	0.17
0.378	-1.04	1.61	-3.64	-0.46	0.71	0.17
0.379	-1.03	1.61	-3.65	-0.46	0.71	0.16
0.380	-1.03	1.61	-3.65	-0.46	0.71	0.16
0.381	-1.03	1.61	-3.66	-0.46	0.71	0.16
0.382	-1.03	1.61	-3.67	-0.46	0.71	0.15
0.383	-1.03	1.60	-3.67	-0.46	0.72	0.15
0.384	-1.03	1.60	-3.68	-0.46	0.72	0.14
0.385	-1.03	1.60	-3.69	-0.46	0.72	0.14
0.386	-1.03	1.60	-3.69	-0.46	0.72	0.14
0.387	-1.03	1.60	-3.70	-0.46	0.72	0.13
0.388	-1.03	1.60	-3.71	-0.47	0.72	0.13
0.389	-1.03	1.60	-3.71	-0.47	0.73	0.13
0.390	-1.02	1.59	-3.72	-0.47	0.73	0.12
0.391	-1.02	1.59	-3.72	-0.47	0.73	0.12
0.392	-1.02	1.59	-3.73	-0.47	0.73	0.12
0.393	-1.02	1.59	-3.74	-0.47	0.73	0.11
0.394	-1.02	1.59	-3.74	-0.47	0.73	0.11
0.395	-1.02	1.59	-3.75	-0.47	0.74	0.10
0.396	-1.02	1.58	-3.76	-0.47	0.74	0.10
0.397	-1.02	1.58	-3.76	-0.47	0.74	0.10
0.398	-1.02	1.58	-3.77	-0.48	0.74	0.09
0.399	-1.02	1.58	-3.78	-0.48	0.74	0.09
0.400	-1.01	1.58	-3.78	-0.48	0.74	0.09
0.401	-1.01	1.58	-3.79	-0.48	0.74	0.08
0.402	-1.01	1.58	-3.79	-0.48	0.75	0.08
0.403	-1.01	1.57	-3.80	-0.48	0.75	0.07
0.404	-1.01	1.57	-3.81	-0.48	0.75	0.07
0.405	-1.01	1.57	-3.81	-0.48	0.75	0.07
0.406	-1.01	1.57	-3.82	-0.48	0.75	0.06
0.407	-1.01	1.57	-3.82	-0.48	0.75	0.06
0.408	-1.01	1.57	-3.83	-0.49	0.76	0.05
0.409	-1.01	1.57	-3.84	-0.49	0.76	0.05
0.410	-1.01	1.56	-3.84	-0.49	0.76	0.05
0.411	-1.00	1.56	-3.85	-0.49	0.76	0.04
0.412	-1.00	1.56	-3.86	-0.49	0.76	0.04
0.413	-1.00	1.56	-3.86	-0.49	0.76	0.04
0.414	-1.00	1.56	-3.87	-0.49	0.76	0.03

0.415	-1.00	1.56	-3.87	-0.49	0.77	0.03
0.416	-1.00	1.55	-3.88	-0.49	0.77	0.02
0.417	-1.00	1.55	-3.89	-0.49	0.77	0.02
0.418	-1.00	1.55	-3.89	-0.50	0.77	0.02
0.419	-1.00	1.55	-3.90	-0.50	0.77	0.01
0.420	-1.00	1.55	-3.90	-0.50	0.77	0.01
0.421	-0.99	1.55	-3.91	-0.50	0.78	0.00
0.422	-0.99	1.55	-3.92	-0.50	0.78	0.00
0.423	-0.99	1.54	-3.92	-0.50	0.78	0.00
0.424	-0.99	1.54	-3.93	-0.50	0.78	-0.01
0.425	-0.99	1.54	-3.93	-0.50	0.78	-0.01
0.426	-0.99	1.54	-3.94	-0.50	0.78	-0.02
0.427	-0.99	1.54	-3.95	-0.50	0.78	-0.02
0.428	-0.99	1.54	-3.95	-0.51	0.79	-0.02
0.429	-0.99	1.54	-3.96	-0.51	0.79	-0.03
0.430	-0.99	1.53	-3.96	-0.51	0.79	-0.03

Appendix Y- Aspirated 0º Predicted Final Positions

Note:The first row is the cup column number and the first column is the cup row number. All measurements in m/s

x	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.60	-0.49	-0.38	-0.27	-0.17	-0.05	0.05	0.17	0.27	0.38	0.49	0.60
2	-0.59	-0.49	-0.38	-0.27	-0.16	-0.05	0.05	0.16	0.27	0.38	0.49	0.59
3	-0.59	-0.49	-0.38	-0.27	-0.16	-0.05	0.05	0.16	0.27	0.38	0.49	0.59
4	-0.59	-0.48	-0.38	-0.27	-0.16	-0.05	0.05	0.16	0.27	0.38	0.48	0.59
5	-0.58	-0.48	-0.37	-0.27	-0.16	-0.05	0.05	0.16	0.27	0.37	0.48	0.58
6	-0.58	-0.48	-0.37	-0.26	-0.16	-0.05	0.05	0.16	0.26	0.37	0.48	0.58
7	-0.57	-0.47	-0.37	-0.26	-0.16	-0.05	0.05	0.16	0.26	0.37	0.47	0.57
8	-0.57	-0.47	-0.36	-0.26	-0.16	-0.05	0.05	0.16	0.26	0.36	0.47	0.57
9	-0.57	-0.47	-0.36	-0.26	-0.16	-0.05	0.05	0.16	0.26	0.36	0.47	0.57
10	-0.56	-0.46	-0.36	-0.26	-0.15	-0.05	0.05	0.15	0.26	0.36	0.46	0.56
11	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
12	-0.55	-0.46	-0.35	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.35	0.46	0.55
13	-0.55	-0.45	-0.35	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.35	0.45	0.55
14	-0.54	-0.45	-0.35	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.35	0.45	0.54
15	-0.54	-0.44	-0.34	-0.24	-0.15	-0.05	0.05	0.15	0.24	0.34	0.44	0.54
16	-0.53	-0.44	-0.34	-0.24	-0.15	-0.05	0.05	0.15	0.24	0.34	0.44	0.53
17	-0.53	-0.44	-0.34	-0.24	-0.15	-0.05	0.05	0.15	0.24	0.34	0.44	0.53
18	-0.53	-0.43	-0.34	-0.24	-0.14	-0.05	0.05	0.14	0.24	0.34	0.43	0.53
19	-0.52	-0.43	-0.33	-0.24	-0.14	-0.05	0.05	0.14	0.24	0.33	0.43	0.52

y	1	2	3	4	5	6	7	8	9	10	11	12
1	0.89	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.89
2	0.99	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.00	1.00	1.00	0.99
3	1.09	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.09
4	1.19	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.19
5	1.29	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.29
6	1.39	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.39
7	1.49	1.49	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.49	1.49
8	1.59	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.59
9	1.69	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.69
10	1.79	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.79
11	1.89	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.89
12	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.99
13	2.10	2.10	2.10	2.10	2.11	2.11	2.11	2.11	2.10	2.10	2.10	2.10
14	2.19	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.19
15	2.30	2.30	2.30	2.30	2.30	2.31	2.31	2.30	2.30	2.30	2.30	2.30
16	2.39	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.39
17	2.50	2.50	2.50	2.50	2.51	2.51	2.51	2.51	2.50	2.50	2.50	2.50
18	2.59	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.59
19	2.69	2.70	2.70	2.70	2.70	2.71	2.71	2.70	2.70	2.70	2.70	2.69

Appendix Z- Aspirated -15º Predicted Final Positions

Note:The first row is the cup column number and the first column is the cup row number. All measurements in m/s

x	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.54	-0.44	-0.34	-0.24	-0.15	-0.05	0.05	0.15	0.24	0.34	0.44	0.54
2	-0.53	-0.43	-0.34	-0.24	-0.15	-0.05	0.05	0.15	0.24	0.34	0.43	0.53
3	-0.52	-0.43	-0.33	-0.24	-0.14	-0.05	0.05	0.14	0.24	0.33	0.43	0.52
4	-0.51	-0.42	-0.33	-0.23	-0.14	-0.05	0.05	0.14	0.23	0.33	0.42	0.51
5	-0.50	-0.41	-0.32	-0.23	-0.14	-0.04	0.04	0.14	0.23	0.32	0.41	0.50
6	-0.49	-0.40	-0.31	-0.22	-0.14	-0.04	0.04	0.14	0.22	0.31	0.40	0.49
7	-0.48	-0.40	-0.31	-0.22	-0.13	-0.04	0.04	0.13	0.22	0.31	0.40	0.48
8	-0.47	-0.39	-0.30	-0.21	-0.13	-0.04	0.04	0.13	0.21	0.30	0.39	0.47
9	-0.46	-0.38	-0.30	-0.21	-0.13	-0.04	0.04	0.13	0.21	0.30	0.38	0.46
10	-0.46	-0.37	-0.29	-0.21	-0.13	-0.04	0.04	0.13	0.21	0.29	0.37	0.46
11	-0.45	-0.37	-0.29	-0.20	-0.12	-0.04	0.04	0.12	0.20	0.29	0.37	0.45
12	-0.44	-0.36	-0.28	-0.20	-0.12	-0.04	0.04	0.12	0.20	0.28	0.36	0.44
13	-0.43	-0.36	-0.28	-0.20	-0.12	-0.04	0.04	0.12	0.20	0.28	0.36	0.43
14	-0.42	-0.35	-0.27	-0.19	-0.12	-0.04	0.04	0.12	0.19	0.27	0.35	0.42
15	-0.42	-0.34	-0.27	-0.19	-0.11	-0.04	0.04	0.11	0.19	0.27	0.34	0.42
16	-0.41	-0.34	-0.26	-0.18	-0.11	-0.04	0.04	0.11	0.18	0.26	0.34	0.41
17	-0.40	-0.33	-0.26	-0.18	-0.11	-0.04	0.04	0.11	0.18	0.26	0.33	0.40
18	-0.39	-0.32	-0.25	-0.18	-0.11	-0.04	0.04	0.11	0.18	0.25	0.32	0.39
19	-0.39	-0.32	-0.25	-0.17	-0.11	-0.03	0.03	0.11	0.17	0.25	0.32	0.39

y	1	2	3	4	5	6	7	8	9	10	11	12
1	0.77	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.77
2	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.85	0.85	0.85
3	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
4	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.00	1.00	1.00	1.00
5	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.07	1.07	1.07
6	1.14	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.14	1.14	1.14	1.14
7	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
8	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
9	1.34	1.34	1.34	1.35	1.35	1.35	1.35	1.35	1.35	1.34	1.34	1.34
10	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
11	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
12	1.53	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.53	1.53	1.53	1.53
13	1.59	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.59
14	1.65	1.65	1.65	1.65	1.66	1.66	1.66	1.66	1.65	1.65	1.65	1.65
15	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71
16	1.76	1.76	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.76	1.76
17	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82
18	1.87	1.87	1.87	1.88	1.88	1.88	1.88	1.88	1.88	1.87	1.87	1.87
19	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93

Appendix AA- Aspirated 15º Predicted Final Positions

Note:The first row is the cup column number and the first column is the cup row number. All measurements in m/s

x	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.67	-0.55	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.55	0.67
2	-0.67	-0.55	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.55	0.67
3	-0.67	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.67
4	-0.68	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.68
5	-0.68	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.68
6	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
7	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
8	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
9	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
10	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
11	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
12	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
13	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
14	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
15	-0.68	-0.56	-0.44	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.44	0.56	0.68
16	-0.68	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.68
17	-0.68	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.68
18	-0.68	-0.56	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.56	0.68
19	-0.67	-0.55	-0.43	-0.31	-0.19	-0.06	0.06	0.19	0.31	0.43	0.55	0.67

y	1	2	3	4	5	6	7	8	9	10	11	12
1	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.97	0.97	0.97	0.96
2	1.08	1.09	1.09	1.09	1.10	1.10	1.10	1.10	1.09	1.09	1.09	1.08
3	1.20	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.21	1.21	1.21	1.20
4	1.33	1.33	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.33	1.33
5	1.45	1.46	1.46	1.47	1.47	1.47	1.47	1.47	1.47	1.46	1.46	1.45
6	1.58	1.58	1.59	1.59	1.59	1.60	1.60	1.59	1.59	1.59	1.58	1.58
7	1.71	1.71	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.71	1.71
8	1.84	1.84	1.85	1.85	1.86	1.86	1.86	1.86	1.85	1.85	1.84	1.84
9	1.97	1.98	1.98	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.98	1.97
10	2.11	2.11	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.11	2.11
11	2.24	2.25	2.25	2.26	2.26	2.26	2.26	2.26	2.26	2.25	2.25	2.24
12	2.38	2.38	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.38	2.38
13	2.52	2.52	2.53	2.53	2.53	2.54	2.54	2.53	2.53	2.53	2.52	2.52
14	2.66	2.66	2.66	2.67	2.67	2.67	2.67	2.67	2.67	2.66	2.66	2.66
15	2.80	2.80	2.81	2.81	2.81	2.81	2.81	2.81	2.81	2.81	2.80	2.80
16	2.93	2.94	2.94	2.95	2.95	2.95	2.95	2.95	2.95	2.94	2.94	2.93
17	3.08	3.08	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.08	3.08
18	3.22	3.22	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.22	3.22
19	3.36	3.37	3.37	3.38	3.38	3.38	3.38	3.38	3.38	3.37	3.37	3.36

Appendix AB- Aspirated 0º Adjusted Mass Distribution Data

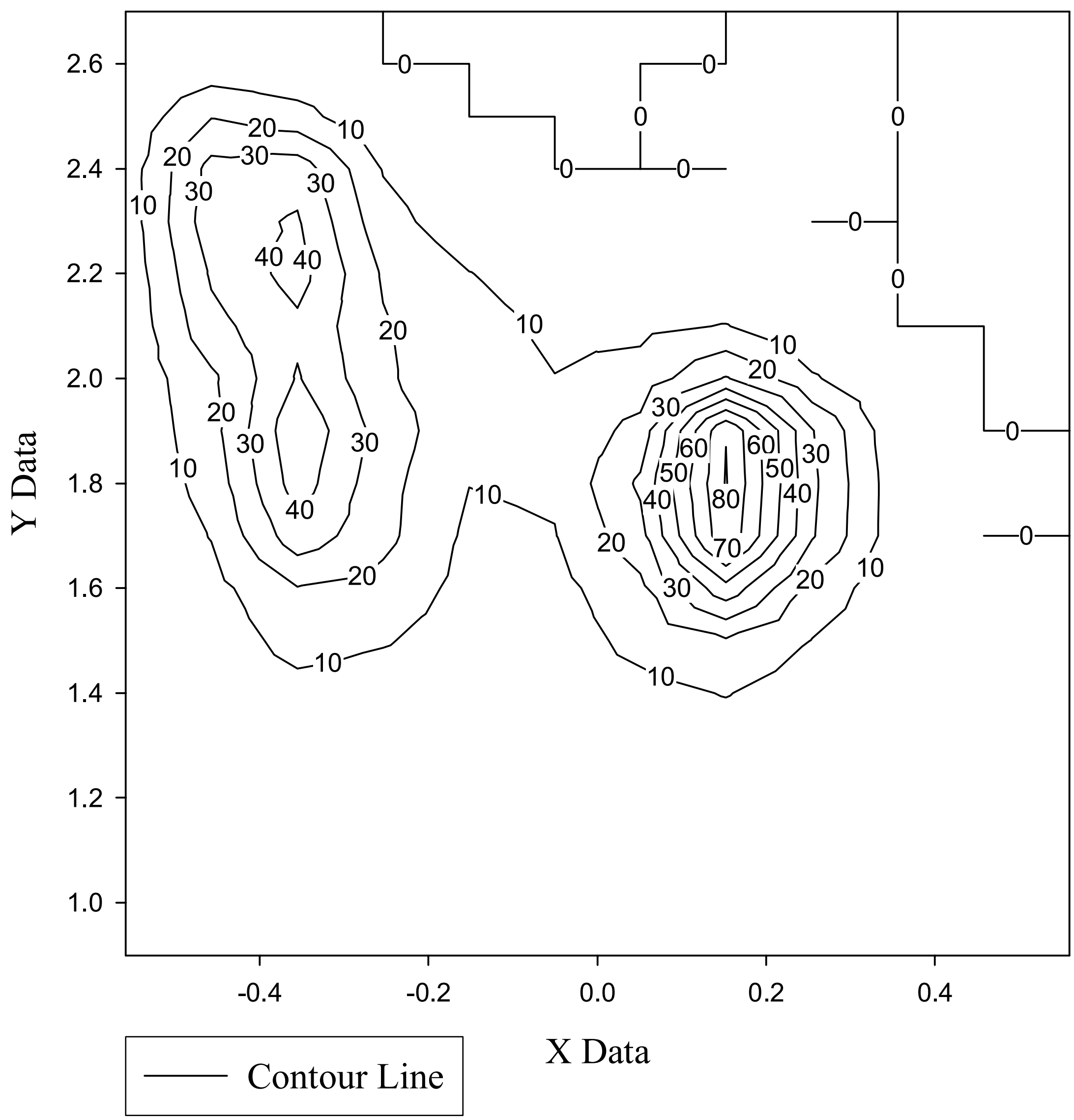
Test 3 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.1	0.3	0.4	0.9	0.9	0.6	0.4	0.4	0.4	0.1	0.0
1.00	0.1	0.3	0.3	0.7	0.9	1.0	1.0	0.7	0.7	0.3	0.1	0.1
1.10	0.0	0.3	0.7	1.0	1.4	1.4	1.4	1.6	1.4	0.6	0.1	0.0
1.20	0.1	0.4	1.7	1.6	1.6	3.1	3.0	2.0	2.3	0.9	0.1	0.0
1.30	0.1	1.3	2.7	3.0	2.7	3.0	3.3	5.1	3.3	1.6	0.4	0.1
1.40	0.6	2.9	6.7	5.6	3.6	5.0	7.2	10.4	4.9	2.0	0.3	0.0
1.50	0.6	4.0	13.7	10.7	5.6	5.0	12.9	18.7	9.7	2.9	0.3	0.1
1.60	0.7	6.6	19.6	16.7	6.6	6.6	17.6	46.6	16.9	3.0	0.4	0.1
1.70	0.6	10.4	36.2	22.7	8.0	9.6	26.5	78.2	31.0	3.7	0.0	0.0
1.80	1.6	13.7	45.0	23.3	10.2	11.4	31.7	80.8	32.2	3.9	0.3	0.1
1.90	1.7	16.4	48.2	25.7	12.0	11.6	23.6	79.7	30.7	2.1	0.0	0.0
2.00	2.6	18.0	40.9	21.6	12.3	10.2	13.4	30.9	11.2	0.9	0.0	0.0
2.10	2.1	26.9	37.9	20.9	13.3	8.7	7.9	10.4	1.9	0.0	0.0	0.0
2.20	2.9	31.3	43.9	18.9	10.3	5.1	4.0	1.9	0.1	0.0	0.0	0.0
2.30	4.0	36.2	41.0	13.6	4.1	1.0	0.9	0.3	0.0	0.0	0.0	0.0
2.40	4.4	33.5	36.0	9.4	1.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0
2.50	2.4	19.6	13.6	1.7	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
2.60	0.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
2.70	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1711.6g 97%

All measurements in grams

Test 3 Adjusted Mass Distribution



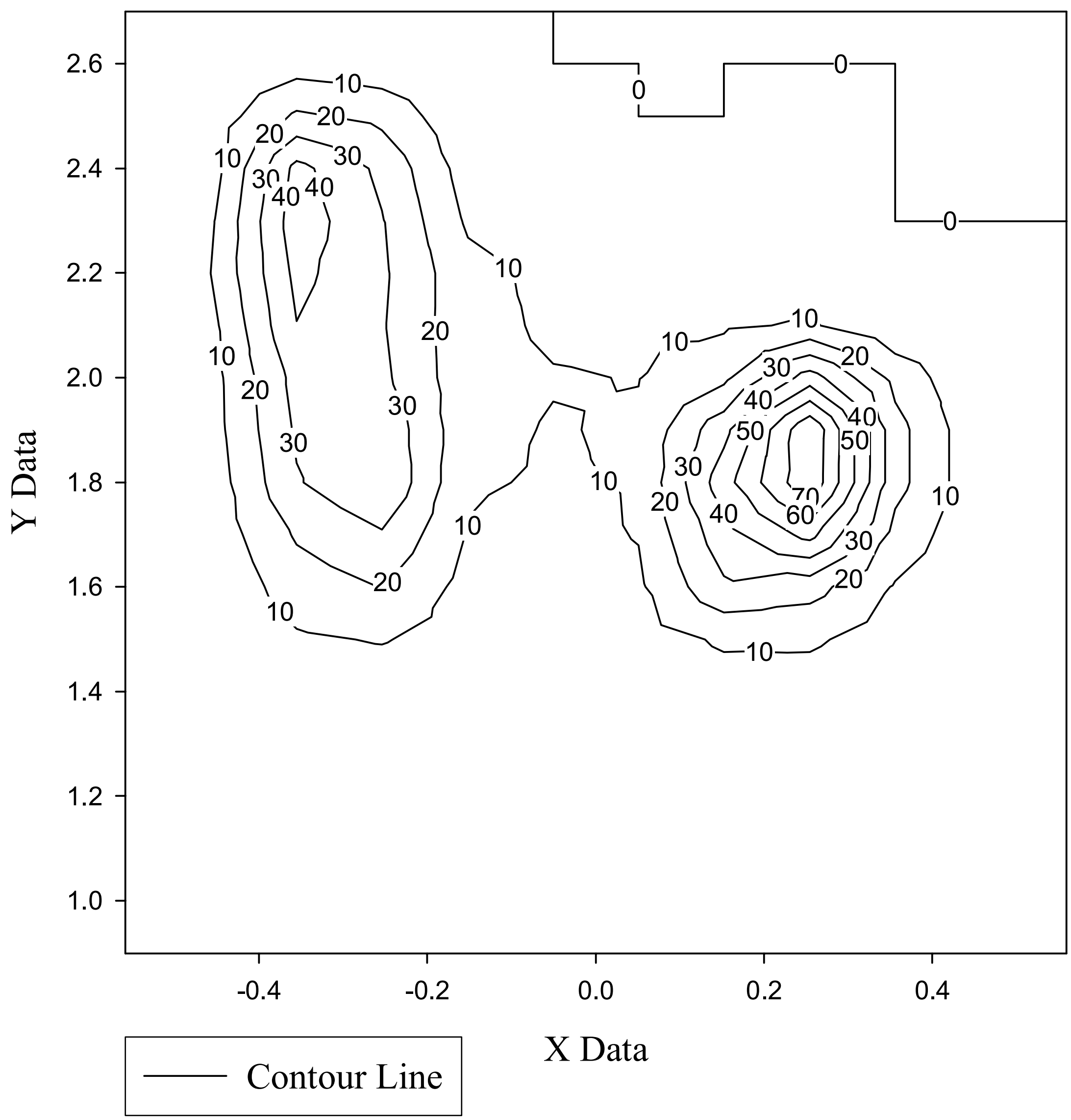
Test 4 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.1	0.1	0.1	0.4	0.7	0.6	0.4	0.4	0.3	0.1	0.0
1.00	0.0	0.1	0.3	0.6	0.6	0.9	0.6	0.6	0.6	0.4	0.1	0.1
1.10	0.1	0.3	0.4	0.6	1.0	1.1	1.1	1.0	0.9	0.6	0.1	0.0
1.20	0.1	0.3	0.7	0.9	1.1	1.9	2.0	2.1	1.6	0.9	0.9	0.1
1.30	0.1	0.4	2.1	2.7	2.0	2.7	3.0	3.6	3.3	1.1	0.4	0.1
1.40	0.1	0.9	4.7	4.7	3.7	3.6	4.6	6.4	5.6	2.3	0.7	0.3
1.50	0.4	1.9	8.7	10.6	5.7	4.3	6.0	11.2	11.4	5.3	1.0	0.4
1.60	0.3	1.6	15.0	20.3	6.6	6.3	8.3	28.5	24.0	9.2	1.4	0.1
1.70	0.1	3.4	21.2	29.0	9.6	6.7	10.4	36.2	53.2	16.6	1.9	0.0
1.80	0.7	4.3	29.2	39.9	10.9	9.2	10.6	45.9	78.7	23.6	2.0	0.0
1.90	0.6	5.7	31.5	37.8	12.9	9.3	11.4	36.9	79.4	23.7	1.9	0.0
2.00	0.3	6.1	33.5	32.2	13.3	10.6	9.7	17.6	44.8	16.7	0.4	0.0
2.10	0.1	7.0	39.8	30.9	13.2	8.4	8.2	8.6	11.2	2.3	0.3	0.0
2.20	0.1	10.0	42.8	31.6	13.0	7.4	5.1	4.9	2.3	0.6	0.1	0.0
2.30	0.3	8.4	45.9	30.6	8.6	4.1	1.7	1.1	0.3	0.0	0.0	0.0
2.40	0.0	5.1	43.2	27.6	5.3	1.3	0.1	0.1	0.1	0.0	0.0	0.0
2.50	0.0	3.9	21.7	17.3	1.9	0.1	0.0	0.0	0.1	0.0	0.0	0.0
2.60	0.1	1.1	5.6	3.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.70	0.0	0.1	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1643.9g 93%

All measurements in grams

Test 4 Adjusted Mass Distribution



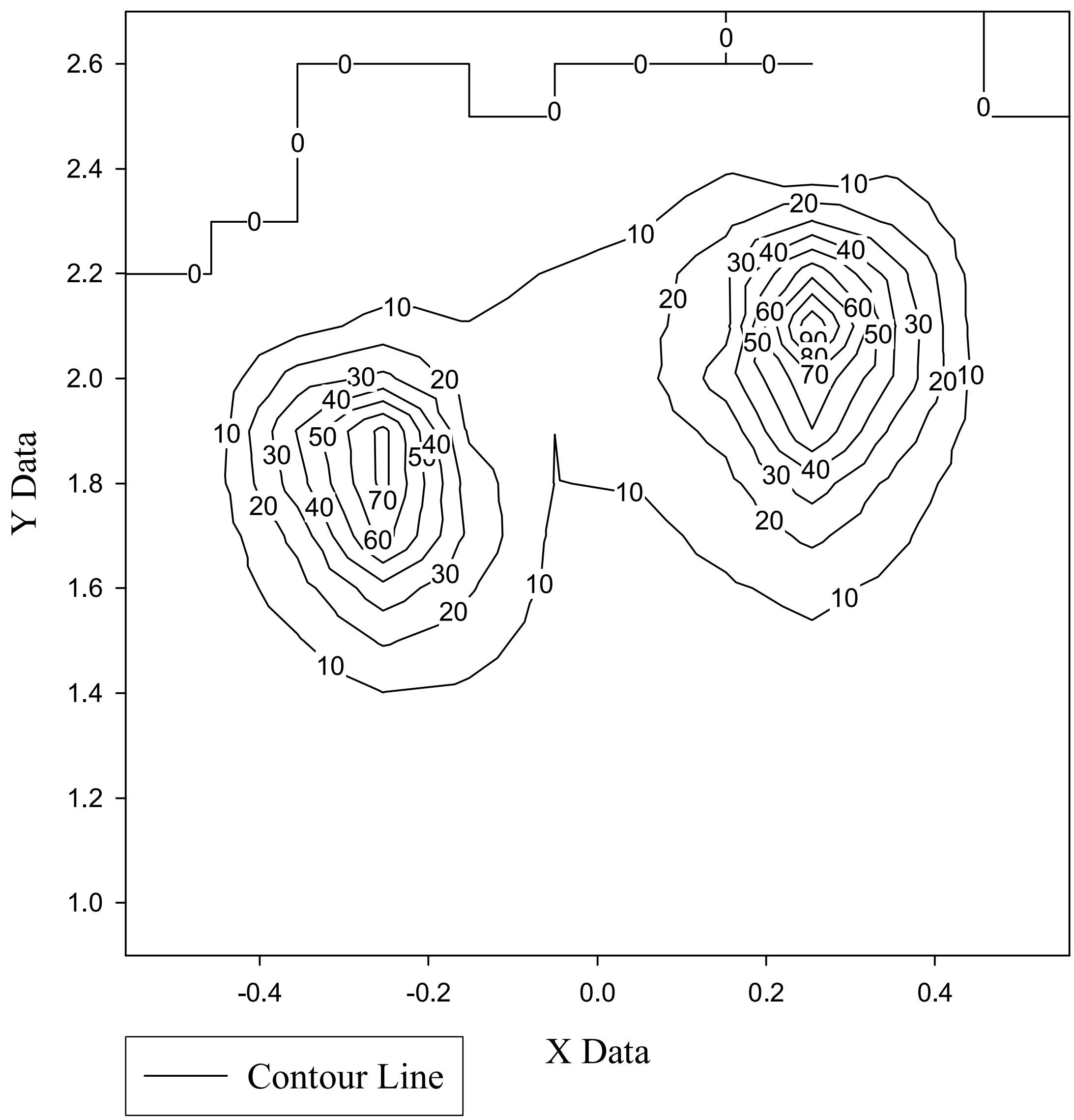
Test 5 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.1	0.3	0.4	0.3	0.6	0.6	0.4	0.3	0.9	0.1	0.0
1.00	0.0	0.1	0.4	0.6	0.7	0.7	0.9	0.7	0.9	0.4	0.1	0.1
1.10	0.1	0.4	0.7	1.0	1.1	1.3	1.3	0.9	0.9	0.4	0.1	0.0
1.20	0.1	0.3	1.1	1.7	2.3	2.1	1.6	1.4	1.6	0.6	0.1	0.0
1.30	0.0	0.7	2.9	4.9	5.1	3.0	2.4	2.3	2.4	1.4	0.4	0.0
1.40	0.0	1.0	3.9	9.9	8.3	3.7	3.3	3.1	4.0	2.9	0.4	0.1
1.50	0.1	1.6	9.2	21.2	14.2	5.4	4.6	4.9	8.2	4.4	1.0	0.1
1.60	0.1	3.3	15.6	36.6	21.2	7.2	6.0	8.7	12.9	7.2	1.7	0.3
1.70	0.1	3.1	23.2	64.4	27.7	8.0	7.2	12.9	22.2	11.7	1.7	0.0
1.80	0.1	5.0	35.5	73.1	25.2	9.9	10.6	16.9	35.0	16.0	3.1	0.7
1.90	0.0	3.9	40.8	73.4	18.4	10.0	13.6	23.2	59.6	25.7	3.9	0.4
2.00	0.0	1.9	24.6	32.6	14.3	12.0	16.2	35.0	68.9	37.6	4.9	0.3
2.10	0.0	0.4	6.4	13.3	10.3	12.7	16.7	27.2	99.4	38.9	3.3	0.3
2.20	0.0	0.0	0.3	4.1	7.4	10.6	14.3	27.5	67.5	33.5	3.3	0.0
2.30	0.0	0.0	0.0	0.6	3.1	5.6	8.6	17.2	30.5	17.4	1.7	0.0
2.40	0.0	0.0	0.0	0.1	0.6	1.3	3.4	9.2	1.3	8.4	0.6	0.0
2.50	0.0	0.0	0.0	0.1	0.0	0.0	0.4	1.9	2.4	1.4	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

Total: 1740.6g 98%

All measurements in grams

Test 5 Adjusted Mass Distribution



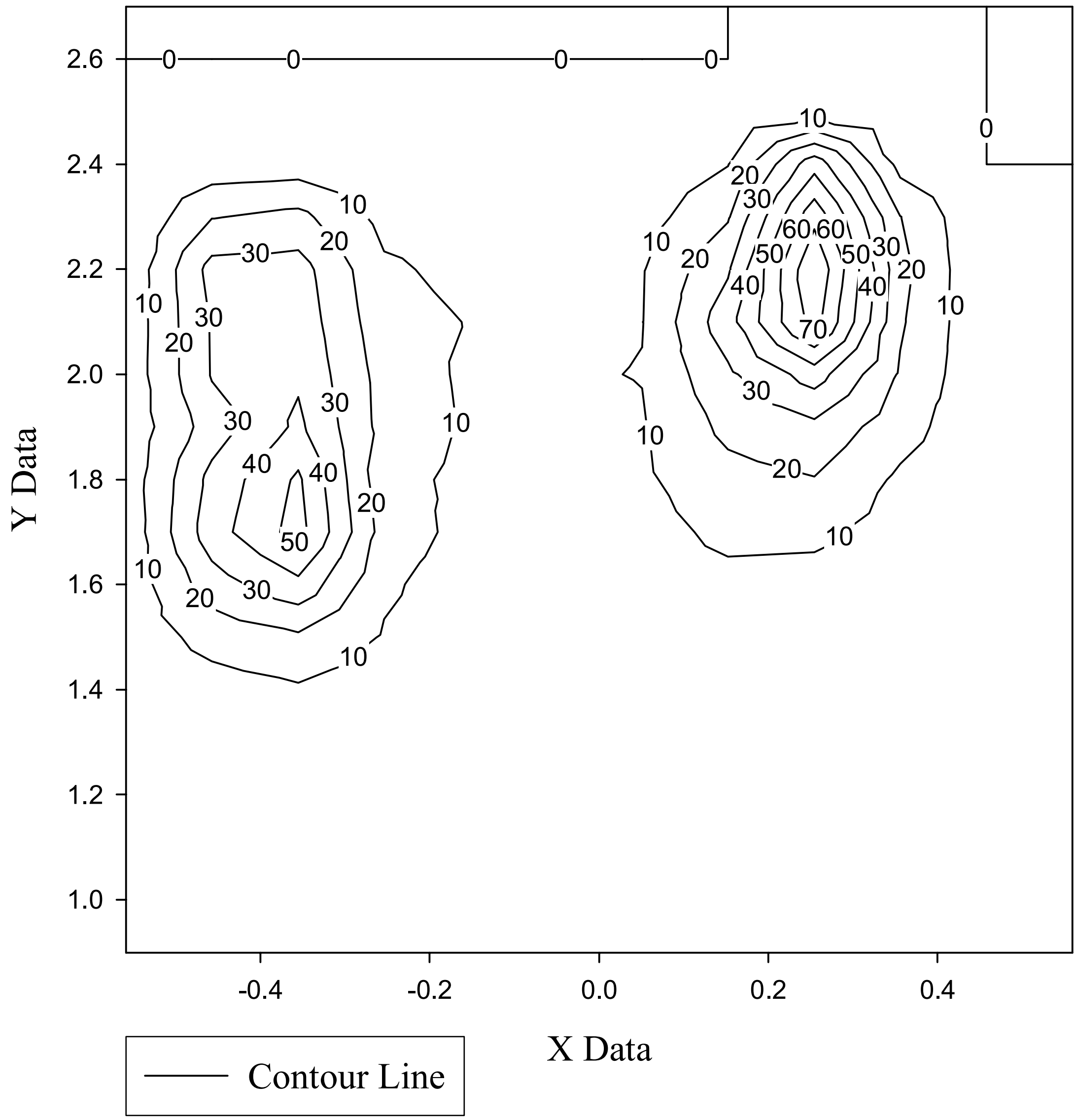
Test 6 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.1	0.3	0.6	0.6	0.4	1.3	1.0	0.6	0.3	0.3	0.1	0.0
1.00	0.1	0.4	0.9	0.7	0.9	1.9	2.3	1.0	0.6	0.3	0.1	0.1
1.10	0.3	0.7	1.1	1.6	1.3	2.9	1.1	1.0	1.1	0.6	0.1	0.1
1.20	0.6	1.6	2.6	1.9	2.0	2.0	1.9	1.1	0.9	0.6	0.1	0.1
1.30	1.3	3.3	4.4	3.4	2.4	2.6	2.0	2.3	1.7	1.0	0.4	0.1
1.40	1.7	5.9	8.7	5.4	3.7	2.9	2.9	3.6	2.1	1.7	0.7	0.1
1.50	3.6	13.6	18.2	9.2	4.7	4.4	4.4	5.0	2.9	2.4	1.0	0.1
1.60	3.1	25.3	37.5	11.6	5.0	5.0	6.1	7.6	6.9	4.1	1.4	0.3
1.70	2.9	35.8	53.9	15.6	6.6	5.4	6.6	12.2	12.0	6.1	1.7	0.3
1.80	3.9	33.0	51.6	13.3	7.6	6.1	8.4	16.4	19.6	8.3	1.6	0.3
1.90	2.9	24.7	42.0	16.4	8.7	7.0	9.2	22.6	27.6	14.0	2.3	0.3
2.00	3.0	30.7	38.5	15.9	8.2	9.0	10.3	28.0	44.6	18.9	1.9	0.0
2.10	2.7	31.0	36.2	13.7	9.6	8.2	9.7	36.2	74.5	21.3	1.6	0.0
2.20	1.6	33.6	34.2	11.7	7.0	7.9	9.3	28.7	79.5	23.0	0.6	0.0
2.30	0.1	19.6	23.0	6.7	5.1	4.9	5.7	19.0	67.1	20.3	0.3	0.0
2.40	0.0	4.0	4.7	1.7	1.7	2.0	3.1	9.7	46.3	6.7	0.0	0.0
2.50	0.0	0.3	0.4	0.3	0.3	0.4	0.3	1.4	5.4	1.3	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1750.7g 99%

All measurements in grams

Test 6 Adjusted Mass Distribution



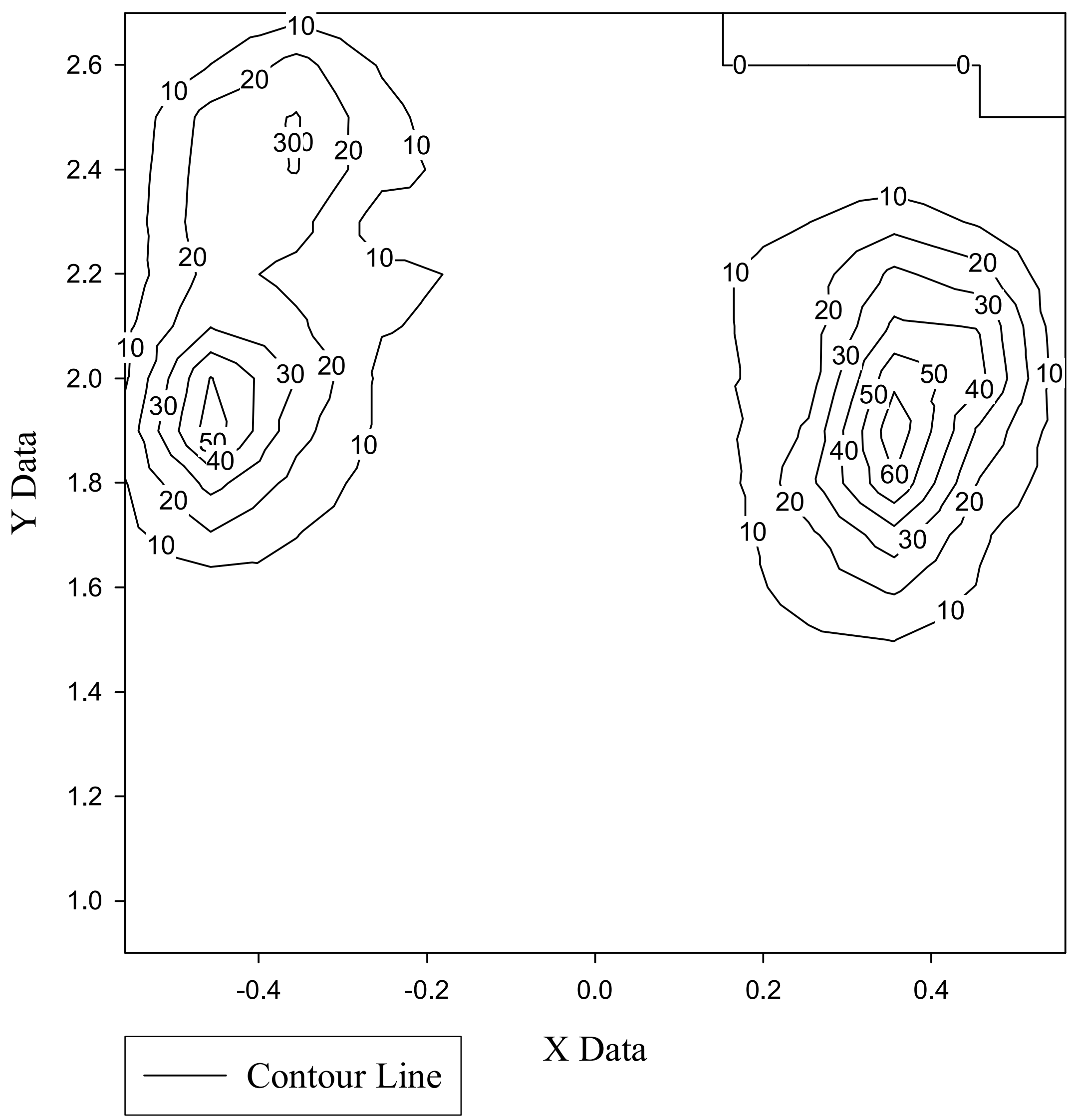
Test 7 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.1	0.1	0.3	0.1	0.4	3.7	0.3	0.3	0.3	0.3	0.1	0.1
1.00	0.0	0.1	0.3	0.4	0.6	1.4	0.4	0.3	0.6	0.4	0.1	0.1
1.10	0.1	0.3	0.4	0.6	0.9	1.7	0.7	0.7	0.6	0.6	0.4	0.1
1.20	0.3	0.4	0.7	0.9	1.1	2.6	1.3	1.1	0.9	0.9	0.6	0.3
1.30	0.3	1.0	1.3	1.1	1.3	2.0	1.9	1.3	2.4	2.7	1.0	0.6
1.40	0.9	2.0	2.6	2.0	2.0	2.1	1.9	2.3	4.3	5.0	2.9	0.6
1.50	1.7	4.9	3.3	2.4	2.7	2.7	2.9	3.6	8.4	10.2	4.0	1.7
1.60	3.0	4.1	7.4	3.6	3.4	4.7	4.0	5.6	14.0	21.6	9.2	1.6
1.70	6.9	19.2	10.2	4.7	3.9	1.3	4.4	5.6	17.6	36.2	11.3	2.0
1.80	9.6	33.3	16.4	5.4	4.7	4.7	5.0	5.7	27.2	58.9	19.0	3.6
1.90	13.6	55.9	23.5	7.9	5.7	5.6	6.3	7.3	21.6	67.1	28.0	3.4
2.00	8.7	50.6	29.7	7.7	6.4	7.2	7.6	8.7	15.0	57.6	43.0	2.7
2.10	7.7	29.6	21.6	10.6	8.2	8.2	8.0	9.3	14.7	41.8	39.5	1.3
2.20	4.7	23.3	17.4	11.7	9.3	7.3	7.6	9.3	14.9	32.2	24.0	0.4
2.30	4.3	26.7	23.5	5.3	7.9	6.4	6.4	6.7	9.9	16.4	8.6	0.0
2.40	3.4	25.7	30.5	13.3	6.9	3.4	3.0	4.1	3.9	3.4	0.3	0.0
2.50	2.1	24.2	30.7	13.2	3.7	1.1	1.0	1.1	0.9	0.1	0.0	0.0
2.60	0.0	10.2	23.7	9.0	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0
2.70	0.0	2.3	6.3	1.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1729.2 G 98 %

All measurements in grams

Test 7 Adjusted Mass Distribution



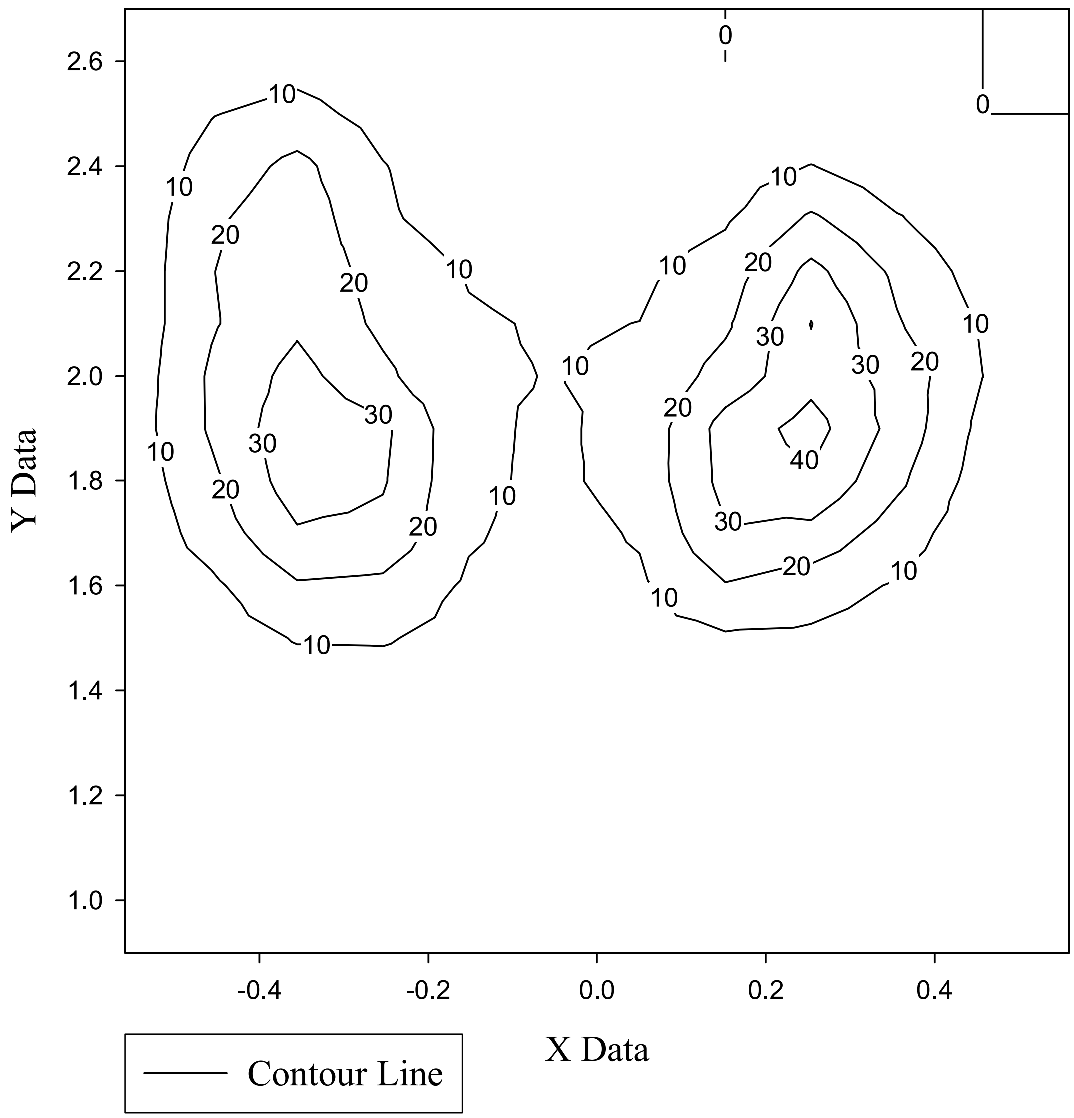
Avg 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.1	0.2	0.3	0.3	0.5	1.4	0.6	0.4	0.3	0.4	0.1	0.0
1.00	0.1	0.2	0.4	0.6	0.7	1.2	1.0	0.7	0.7	0.4	0.1	0.1
1.10	0.1	0.4	0.7	0.9	1.1	1.7	1.1	1.0	1.0	0.5	0.2	0.1
1.20	0.3	0.6	1.4	1.4	1.6	2.3	1.9	1.6	1.4	0.7	0.4	0.1
1.30	0.4	1.3	2.7	3.0	2.7	2.7	2.5	2.9	2.6	1.6	0.5	0.2
1.40	0.7	2.5	5.3	5.5	4.3	3.5	3.9	5.2	4.2	2.8	1.0	0.2
1.50	1.3	5.2	10.6	10.8	6.6	4.4	6.1	8.7	8.1	5.0	1.5	0.5
1.60	1.5	8.2	19.0	17.8	8.6	5.9	8.4	19.4	14.9	9.0	2.8	0.5
1.70	2.1	14.4	28.9	27.3	11.2	6.2	11.0	29.0	27.2	14.9	3.3	0.5
1.80	3.2	17.9	35.5	31.0	11.7	8.3	13.3	33.1	38.5	22.1	5.2	0.9
1.90	3.7	21.3	37.2	32.2	11.6	8.7	12.8	33.9	43.8	26.5	7.2	0.8
2.00	2.9	21.5	33.4	22.0	10.9	9.8	11.4	24.1	36.9	26.3	10.0	0.6
2.10	2.5	19.0	28.4	17.9	10.9	9.2	10.1	18.3	40.3	20.8	8.9	0.3
2.20	1.9	19.6	27.7	15.6	9.4	7.7	8.1	14.4	32.9	17.8	5.6	0.1
2.30	1.7	18.2	26.7	11.4	5.8	4.4	4.7	8.9	21.5	10.8	2.1	0.0
2.40	1.6	13.7	22.9	10.4	3.2	1.6	1.9	4.6	10.4	3.7	0.2	0.0
2.50	0.9	9.6	13.3	6.5	1.2	0.3	0.3	0.9	1.8	0.6	0.0	0.0
2.60	0.0	2.9	6.2	2.5	0.3	0.1	0.0	0.0	0.2	0.1	0.0	0.0
2.70	0.0	0.5	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1715.2 G 97 %

All measurements in grams

Test 3-7 Average Adjusted Mass Distribution



Appendix AC- Aspirated -15º Adjusted Mass Distribution Data

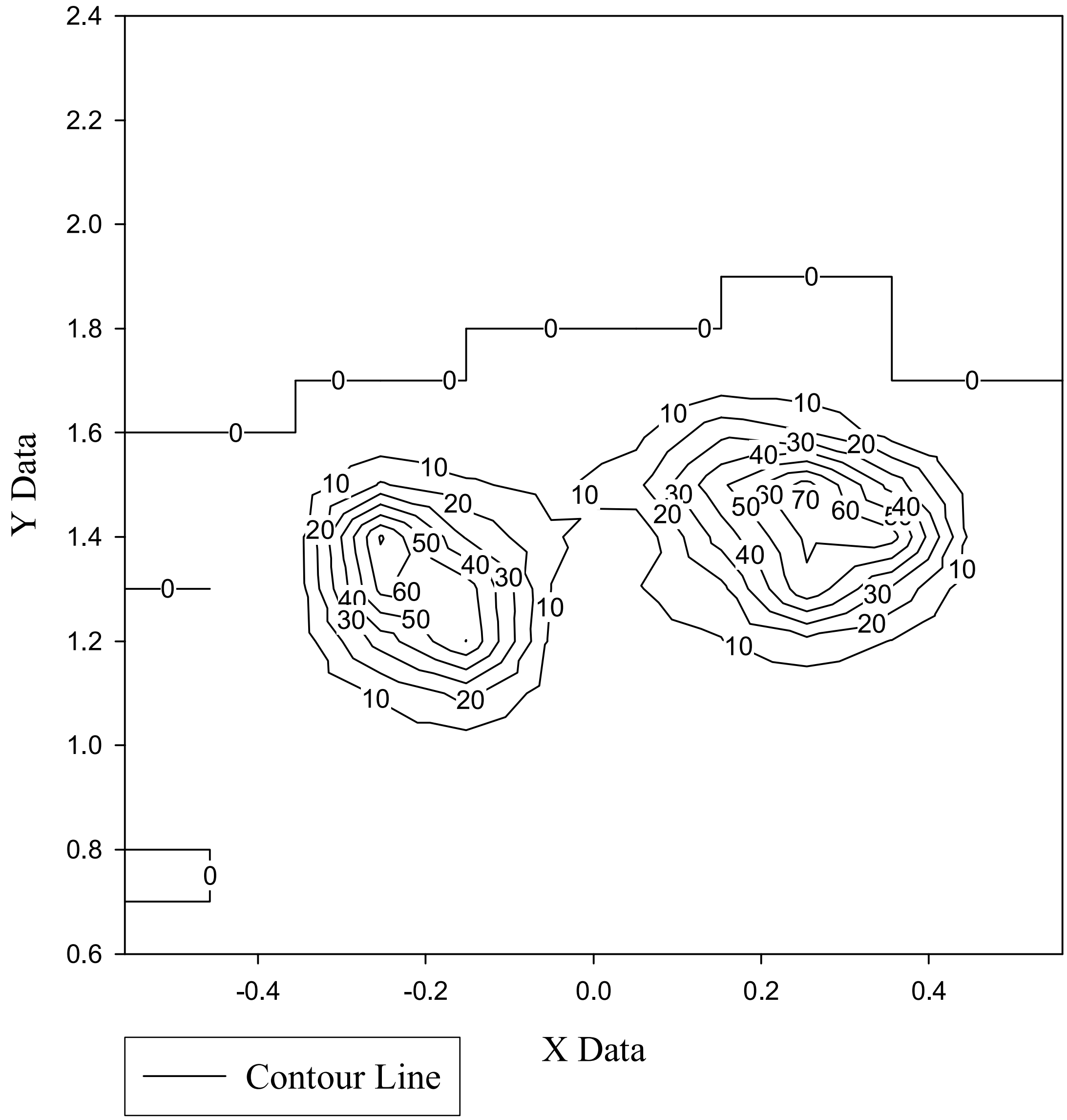
Test 10 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.1	0.1	0.1	0.1	0.3	1.0	0.4	0.1	0.1	0.1	0.0
0.70	0.0	0.0	0.1	0.3	0.3	0.9	1.0	0.6	0.4	0.3	0.1	0.0
0.80	0.0	0.0	0.3	1.1	0.9	0.9	1.9	0.7	0.7	0.4	0.1	0.1
0.90	0.0	0.1	0.6	1.1	1.7	2.0	3.9	1.3	1.3	0.6	0.0	0.1
1.00	0.1	0.1	0.7	4.6	4.9	3.0	6.1	2.0	1.6	1.6	0.4	0.1
1.10	0.0	0.1	1.4	11.2	23.0	4.7	7.4	4.3	2.9	3.1	0.6	0.1
1.20	0.0	0.1	2.6	34.3	60.1	7.7	6.7	9.4	16.6	9.6	1.1	0.1
1.30	0.0	0.0	3.3	62.9	55.9	9.9	9.3	17.0	57.9	28.3	1.6	0.1
1.40	0.0	0.1	3.9	71.2	28.9	11.3	1.9	34.3	62.1	64.6	2.4	0.0
1.50	0.0	0.1	0.6	21.0	11.3	7.3	17.2	48.2	73.8	36.2	1.4	0.0
1.60	0.0	0.0	0.0	0.9	0.9	2.4	6.4	27.2	20.6	5.0	0.1	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.1	0.7	3.0	2.1	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1072.9g 91%

All measurements in grams

Test 10 Adjusted Mass Distribution



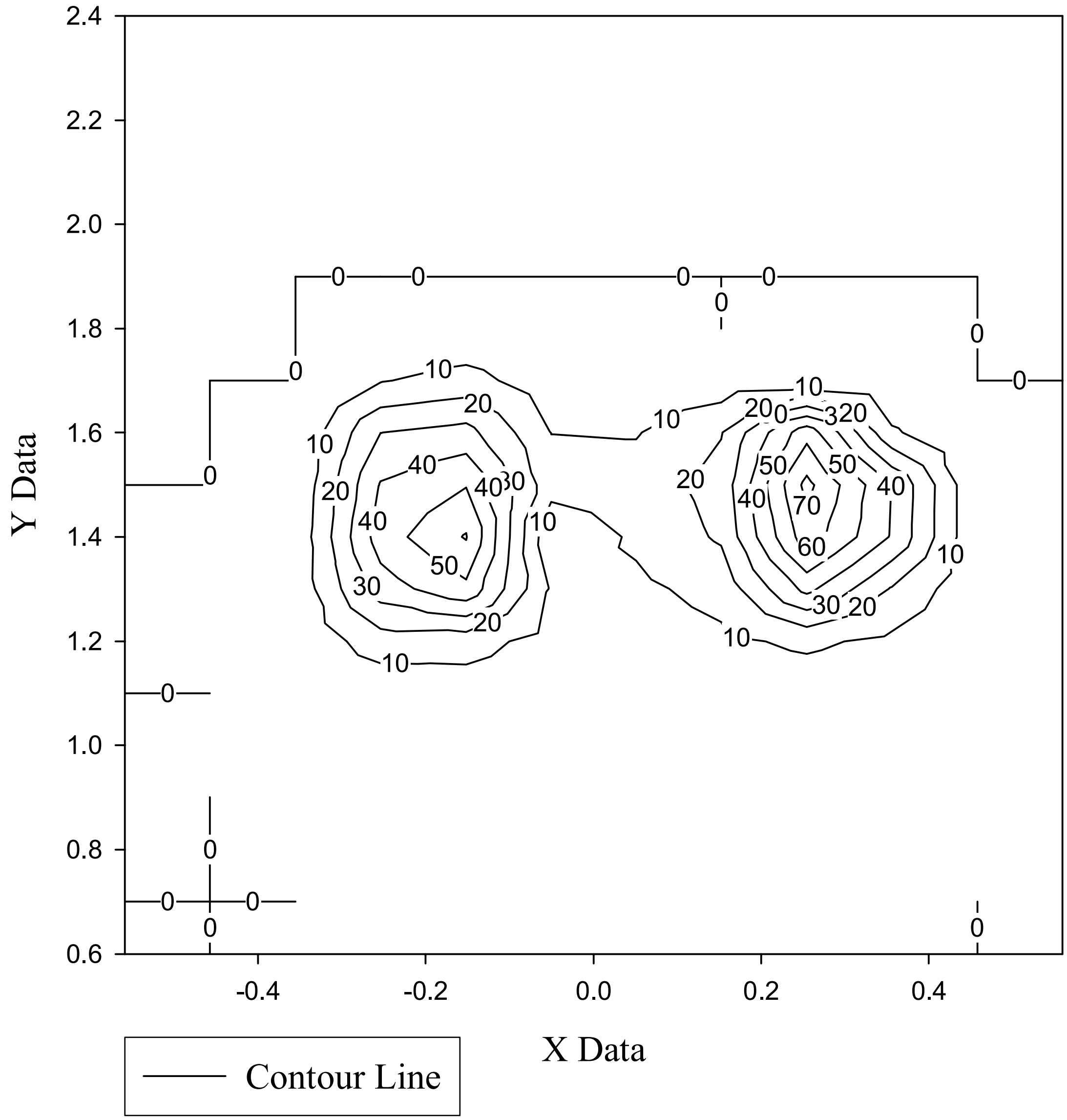
Test 11 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	0.1	0.1	0.1	0.3	0.4	0.1	0.1	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.3	0.1	0.4	0.3	0.3	0.3	0.1	0.0	0.1
0.80	0.1	0.0	0.1	0.4	0.6	0.4	0.7	0.6	0.6	0.3	0.1	0.0
0.90	0.1	0.0	0.1	0.4	0.7	0.9	1.1	1.0	0.9	0.3	0.1	0.0
1.00	0.0	0.1	0.4	1.4	1.6	1.9	2.0	2.0	1.7	0.9	0.3	0.1
1.10	0.0	0.0	1.0	2.6	4.9	3.1	2.7	3.7	4.9	3.1	0.4	0.0
1.20	0.0	0.1	1.9	15.4	14.2	6.0	5.0	8.2	11.7	7.9	1.1	0.3
1.30	0.0	0.1	2.7	35.0	47.6	8.7	8.0	13.2	42.9	19.2	1.9	0.1
1.40	0.0	0.1	2.1	45.0	60.8	1.4	11.7	21.5	65.9	39.0	0.9	0.0
1.50	0.0	0.0	1.1	40.8	49.3	14.2	15.0	23.6	72.9	39.8	0.9	0.0
1.60	0.0	0.0	0.6	29.9	33.6	9.9	9.3	19.4	56.5	11.4	0.1	0.0
1.70	0.0	0.0	0.0	9.4	13.6	4.3	3.1	3.0	4.3	0.7	0.0	0.0
1.80	0.0	0.0	0.0	0.7	1.7	0.6	0.1	0.0	0.1	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1022.2g 87%

All measurements in grams

Test 11 Adjusted Mass Distribution



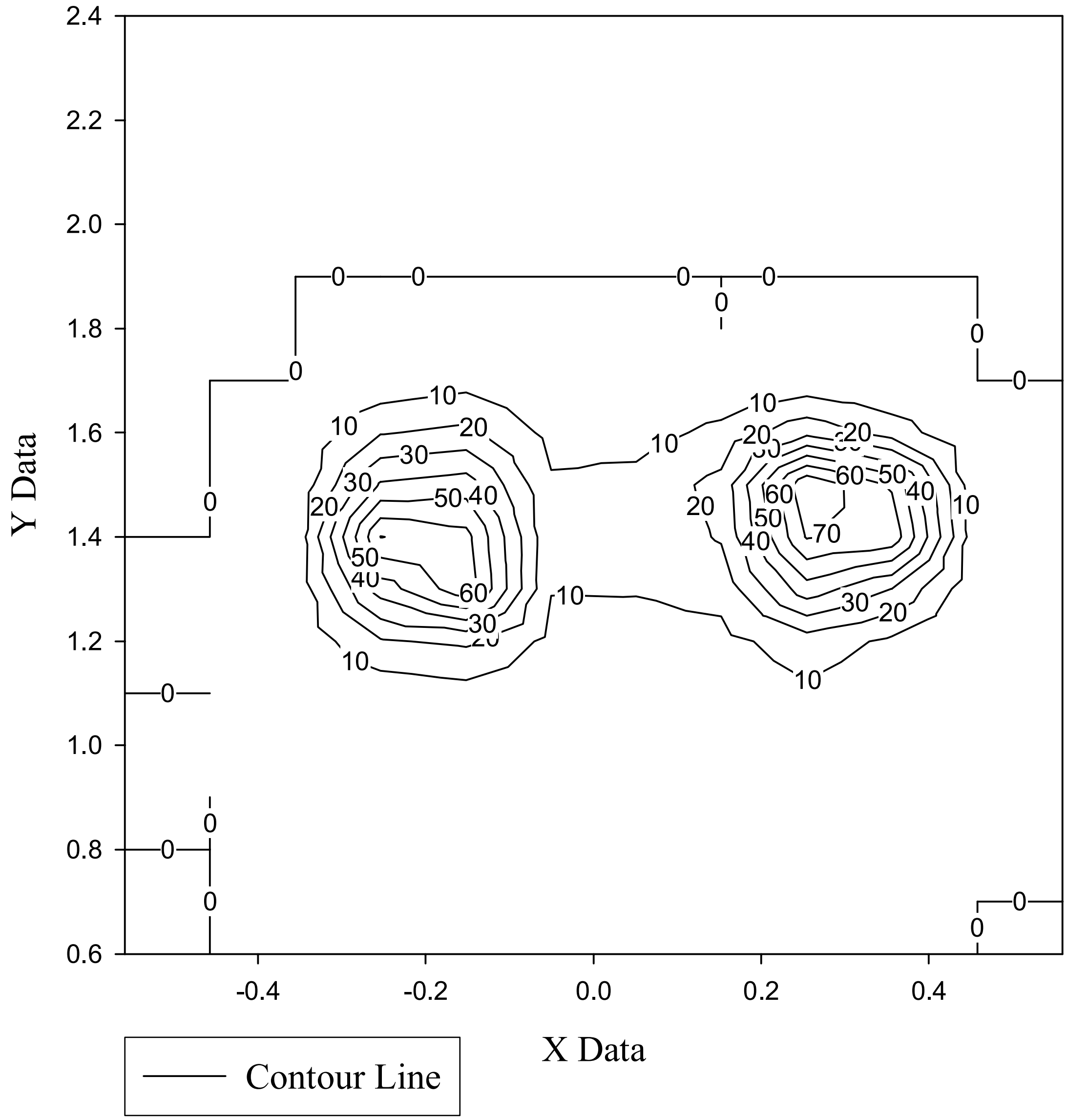
Test 12 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	0.1	0.1	0.1	0.3	0.7	0.4	0.1	0.1	0.0	0.1
0.70	0.0	0.0	0.1	0.3	0.3	0.3	1.6	0.7	0.3	0.3	0.0	0.0
0.80	0.0	0.0	0.1	0.4	0.4	0.6	0.7	0.9	0.4	0.1	0.1	0.0
0.90	0.1	0.0	0.3	0.7	0.9	1.0	1.4	1.1	0.7	0.6	0.3	0.0
1.00	0.0	0.1	0.4	1.4	2.0	3.1	2.4	2.1	2.3	1.1	0.6	0.1
1.10	0.0	0.0	1.0	3.1	6.1	4.6	4.6	3.4	8.3	3.4	0.7	0.0
1.20	0.0	0.3	2.0	19.0	21.7	7.2	6.4	6.9	15.2	8.2	1.6	0.0
1.30	0.0	0.1	2.7	44.6	67.1	10.4	10.6	13.4	45.8	30.0	1.7	0.1
1.40	0.0	0.0	2.1	70.4	63.3	11.6	12.4	21.0	70.9	67.1	2.0	0.0
1.50	0.0	0.0	1.6	41.2	44.9	11.2	13.2	23.2	78.7	58.8	1.6	0.1
1.60	0.0	0.0	0.4	19.2	22.6	7.0	6.0	12.4	27.0	15.3	0.1	0.0
1.70	0.0	0.0	0.0	2.7	6.3	1.6	1.4	2.3	2.9	0.3	0.0	0.0
1.80	0.0	0.0	0.0	0.3	0.4	0.1	0.1	0.0	0.1	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1107.4g 94%

All measurements in grams

Test 12 Adjusted Mass Distribution



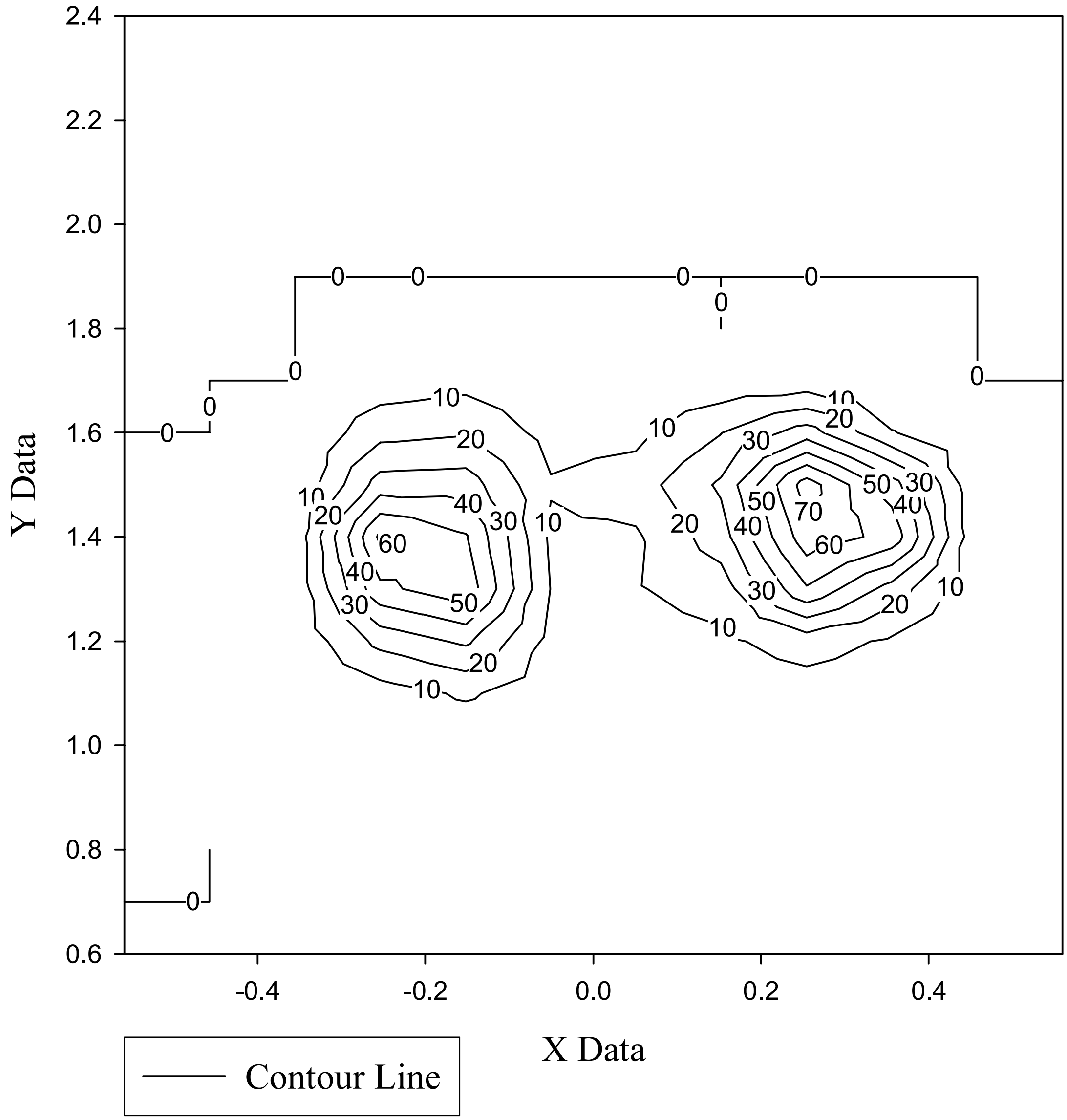
Avg -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	0.1	0.1	0.1	0.3	0.7	0.3	0.1	0.1	0.0	0.0
0.70	0.0	0.0	0.1	0.3	0.2	0.5	1.0	0.5	0.3	0.2	0.0	0.0
0.80	0.0	0.0	0.2	0.7	0.6	0.6	1.1	0.7	0.6	0.3	0.1	0.0
0.90	0.1	0.0	0.3	0.8	1.1	1.3	2.1	1.1	1.0	0.5	0.1	0.0
1.00	0.0	0.1	0.5	2.5	2.8	2.7	3.5	2.0	1.9	1.2	0.4	0.1
1.10	0.0	0.0	1.1	5.6	11.3	4.1	4.9	3.8	5.3	3.2	0.6	0.0
1.20	0.0	0.2	2.1	22.9	32.0	7.0	6.1	8.2	14.5	8.5	1.3	0.1
1.30	0.0	0.1	2.9	47.5	56.9	9.7	9.3	14.5	48.9	25.8	1.7	0.1
1.40	0.0	0.1	2.7	62.2	51.0	8.1	8.7	25.6	66.3	56.9	1.8	0.0
1.50	0.0	0.0	1.1	34.3	35.2	10.9	15.1	31.7	75.1	44.9	1.3	0.0
1.60	0.0	0.0	0.3	16.6	19.0	6.4	7.2	19.7	34.7	10.6	0.1	0.0
1.70	0.0	0.0	0.0	4.1	6.6	2.0	1.8	2.8	3.1	0.3	0.0	0.0
1.80	0.0	0.0	0.0	0.3	0.7	0.2	0.1	0.0	0.1	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 1067.5g 90%

All measurements in grams

Test 10-12 Average Adjusted Mass Distribution



Appendix AD- Aspirated 15º Adjusted Mass Distribution Data

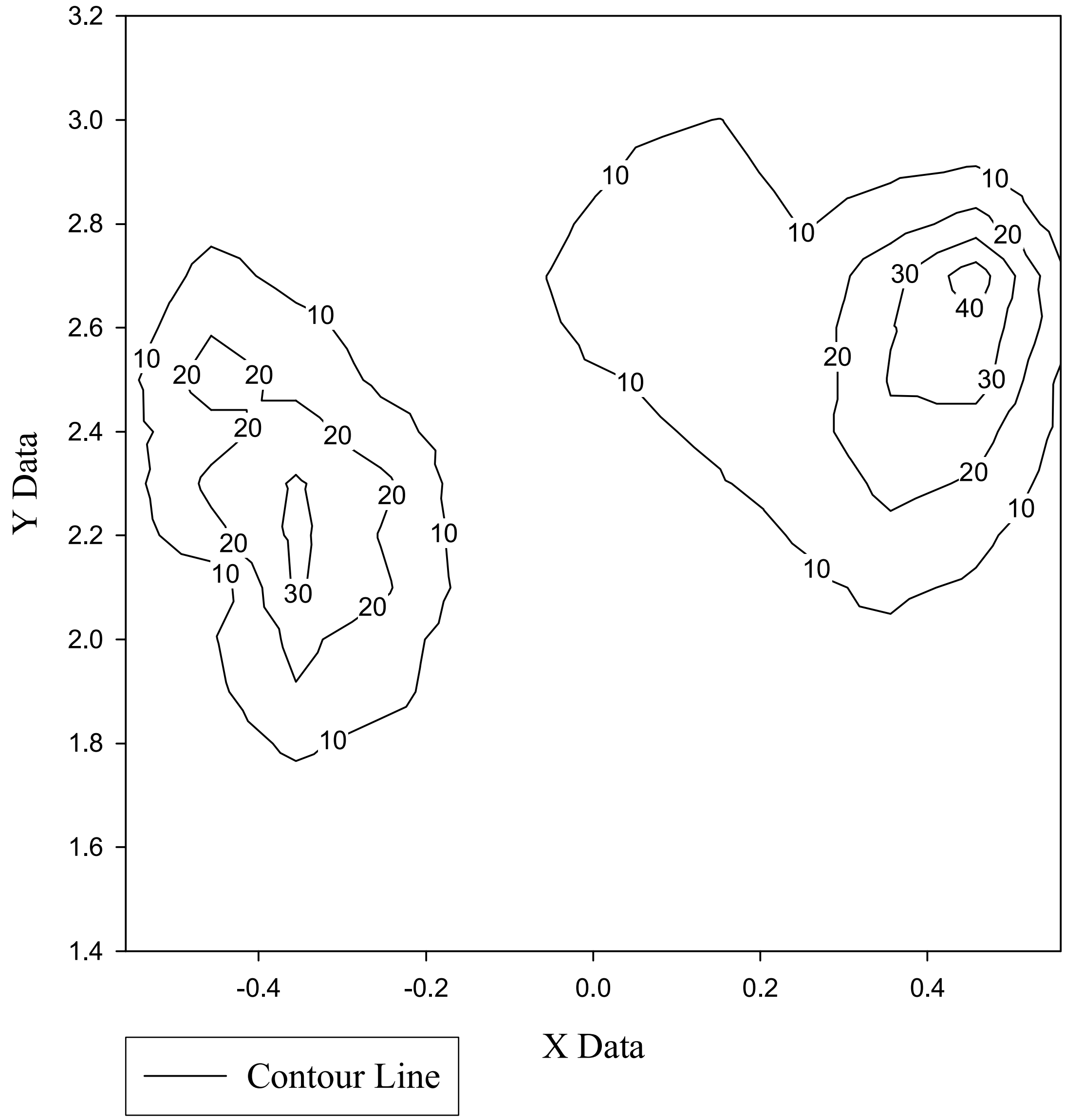
Test 15 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.1	0.6	0.7	0.7	1.0	2.1	2.1	1.3	0.9	0.9	0.4	0.3
1.50	0.4	0.9	1.3	1.7	1.4	2.6	2.0	1.4	1.3	0.9	0.4	0.3
1.60	0.6	1.9	2.9	3.1	1.7	4.0	2.3	2.3	2.0	1.6	0.7	0.6
1.70	0.9	3.7	6.0	4.6	3.9	2.7	4.0	2.7	2.7	2.7	1.9	0.7
1.80	1.6	4.6	12.0	6.4	4.1	3.4	4.1	4.4	4.7	4.3	2.1	0.9
1.90	1.6	7.4	19.4	14.0	4.1	3.7	4.7	4.7	5.7	4.7	3.7	0.6
2.00	2.3	9.0	22.5	14.6	5.7	4.6	5.0	6.3	9.3	8.7	4.4	1.3
2.10	2.6	2.7	31.3	22.0	7.3	5.4	5.6	6.6	8.7	11.3	8.9	3.0
2.20	5.4	17.2	32.2	19.4	6.6	5.1	6.1	7.6	10.7	17.2	11.9	5.0
2.30	6.3	22.3	31.0	22.7	5.1	6.4	8.4	9.7	11.9	23.2	18.7	5.7
2.40	7.2	16.0	25.0	13.6	5.4	7.9	9.3	10.7	15.9	28.3	24.2	8.0
2.50	7.3	25.6	16.6	8.3	6.0	8.6	10.2	11.9	13.4	30.7	35.0	8.2
2.60	4.4	19.0	12.7	6.1	6.1	9.3	13.4	11.7	14.6	29.5	37.9	14.2
2.70	2.4	13.2	7.2	4.6	4.7	10.3	16.4	14.9	11.7	27.5	45.9	11.7
2.80	1.4	7.6	5.9	1.1	3.6	8.2	15.0	16.2	9.3	15.6	24.2	5.4
2.90	1.1	3.0	2.6	1.3	2.3	5.4	11.2	12.9	6.6	8.6	10.9	2.6
3.00	0.1	0.1	0.6	0.7	1.6	3.7	8.7	10.2	4.1	3.4	3.4	0.4
3.10	0.0	0.3	0.3	0.1	0.6	1.7	6.0	4.4	1.7	0.4	0.3	0.0
3.20	0.0	0.0	0.0	0.0	0.0	0.1	2.1	1.6	0.0	0.0	0.0	0.0

Total: 1679.5 g 95 %

All measurements in grams

Test 15 Adjusted Mass Distribution



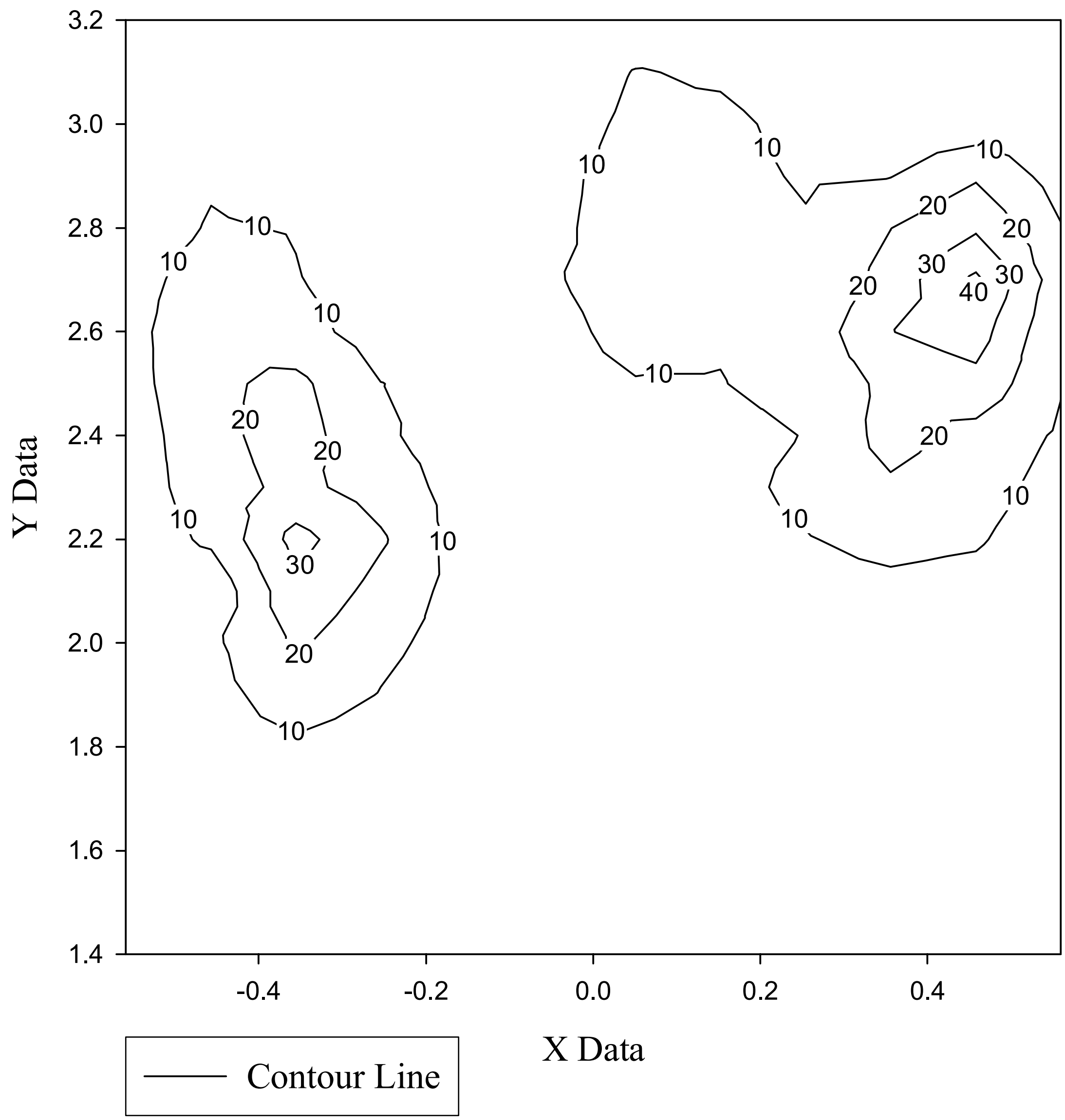
Test 16 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.3	0.6	0.7	0.6	1.3	1.1	1.1	1.0	0.7	0.6	0.3	0.1
1.50	0.4	0.9	1.4	1.4	1.6	2.0	1.4	1.1	0.9	0.9	0.4	0.3
1.60	0.6	1.3	2.7	2.1	1.7	2.0	1.6	1.7	1.4	1.6	0.7	0.3
1.70	1.4	2.3	4.9	3.0	2.1	2.4	2.6	2.0	2.3	1.9	1.3	0.4
1.80	1.1	5.9	8.3	4.9	3.1	2.9	2.6	3.6	3.6	3.6	1.9	0.7
1.90	1.6	6.4	15.3	9.6	3.9	4.0	3.6	3.6	3.4	4.9	2.9	1.0
2.00	2.1	8.0	21.6	12.3	5.9	4.1	4.4	4.9	6.1	5.7	3.3	2.0
2.10	2.0	2.3	27.7	16.6	5.9	5.1	5.1	5.4	7.0	8.0	6.7	2.1
2.20	3.4	11.9	33.3	21.3	5.7	5.0	5.6	6.6	9.6	12.3	11.0	4.1
2.30	3.9	15.9	22.6	15.6	5.6	6.0	6.9	7.3	12.0	18.4	14.0	6.3
2.40	4.3	17.2	24.6	11.4	5.3	8.2	7.7	7.2	10.3	23.7	16.6	8.7
2.50	5.9	18.2	22.5	10.2	6.7	8.2	9.7	9.7	12.9	22.5	27.0	10.6
2.60	5.7	19.9	13.6	5.7	6.3	8.6	11.6	10.7	13.4	29.7	34.6	11.0
2.70	4.6	16.2	10.6	4.3	6.3	9.6	12.2	11.2	11.0	23.6	42.0	13.7
2.80	4.0	10.9	9.4	1.0	4.6	8.6	13.2	15.6	11.0	19.9	28.6	10.6
2.90	2.9	8.9	5.9	3.0	3.6	8.2	12.9	13.3	8.9	9.7	18.9	5.7
3.00	0.1	4.0	2.7	2.1	2.1	5.0	12.3	12.4	6.7	3.4	4.1	1.9
3.10	0.3	1.3	0.7	0.7	1.7	2.3	10.6	8.6	4.0	2.3	0.6	0.3
3.20	0.0	0.1	0.0	0.0	0.3	1.1	3.1	5.4	1.1	0.1	0.1	0.1

Total: 1592.6 g 90 %

All measurements in grams

Test 16 Adjusted Mass Distribution



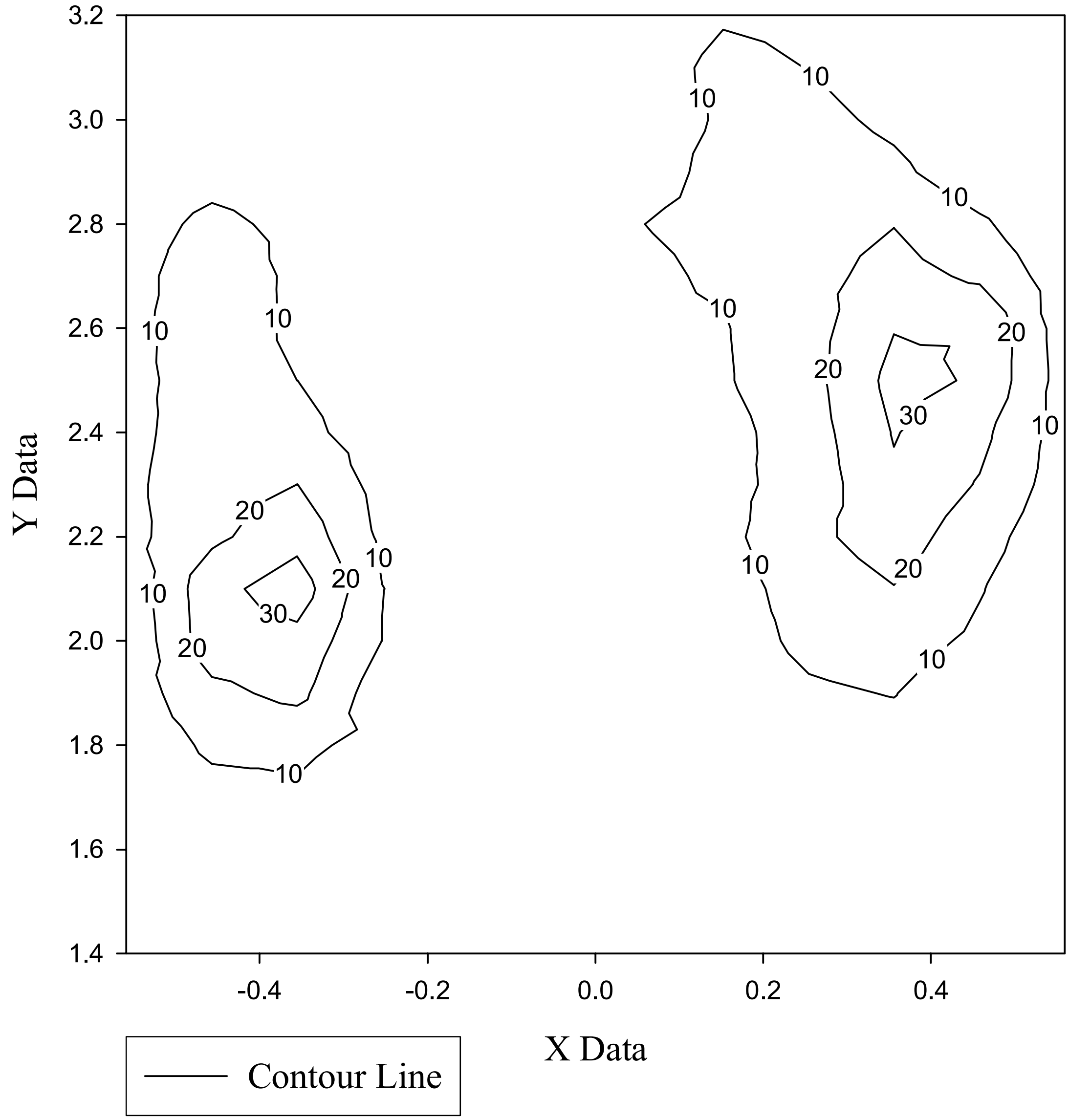
Test 18 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.6	1.0	1.1	1.0	1.3	1.3	1.1	1.3	1.1	1.1	0.6	0.3
1.50	1.1	1.7	1.9	2.1	1.9	2.0	1.7	1.9	2.0	1.9	0.9	0.3
1.60	1.1	3.9	4.7	3.1	2.3	2.3	2.4	2.3	2.7	2.3	1.3	0.6
1.70	3.3	7.3	8.9	4.3	2.3	2.9	2.4	2.7	3.6	4.3	3.0	0.7
1.80	3.9	11.6	11.6	7.7	2.9	2.7	3.3	4.4	6.7	7.2	3.6	1.3
1.90	4.7	17.3	22.7	4.1	3.0	3.0	3.1	4.7	8.9	10.3	4.1	0.7
2.00	1.3	26.2	27.0	9.9	3.3	3.0	3.7	5.9	12.0	13.7	8.3	3.3
2.10	3.0	26.7	35.3	10.2	3.4	3.7	4.7	6.3	13.7	19.6	10.6	2.6
2.20	6.7	17.9	26.7	8.2	3.0	3.4	4.7	7.4	17.3	25.3	13.7	3.1
2.30	7.7	16.7	20.0	6.6	4.3	5.0	5.7	7.2	14.2	28.5	19.3	4.9
2.40	6.7	16.2	12.7	5.3	3.6	4.4	6.1	6.6	15.4	30.6	22.7	5.6
2.50	7.2	14.6	10.0	4.6	4.1	4.9	6.3	9.0	16.6	33.0	28.9	5.6
2.60	7.0	16.3	8.0	4.4	3.9	5.3	8.7	9.4	16.0	29.6	29.5	4.7
2.70	5.4	17.4	7.7	3.9	3.1	4.7	8.6	11.0	16.9	23.5	18.3	4.4
2.80	5.3	12.4	7.4	2.9	2.7	4.1	9.9	11.6	16.2	19.7	11.7	1.4
2.90	2.9	6.6	4.6	2.1	1.7	3.6	6.6	12.3	16.2	12.3	3.6	0.0
3.00	0.1	2.1	2.7	0.9	0.7	2.1	6.6	10.7	13.0	7.9	1.3	0.0
3.10	0.0	0.6	0.9	0.6	0.6	1.4	5.6	12.3	9.9	4.6	0.3	0.0
3.20	0.0	0.0	0.0	0.0	0.0	0.4	4.0	9.2	8.4	1.9	0.0	0.0

Total: 1629.3 g 92 %

All measurements in grams

Test 18 Adjusted Mass Distribution



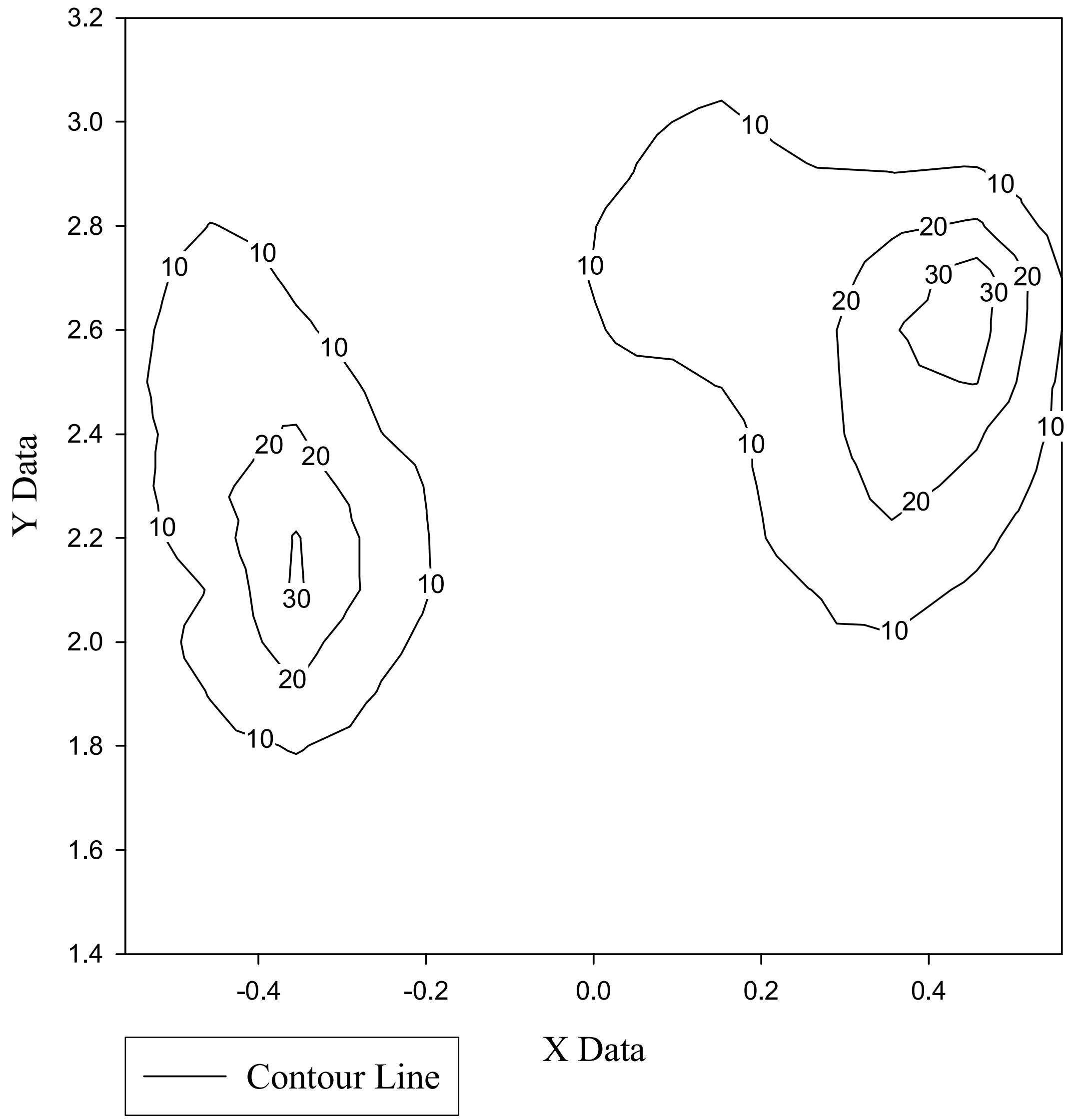
Avg 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.3	0.7	0.9	0.8	1.2	1.5	1.5	1.2	0.9	0.9	0.4	0.2
1.50	0.7	1.1	1.5	1.8	1.6	2.2	1.7	1.5	1.4	1.2	0.6	0.3
1.60	0.8	2.3	3.4	2.8	1.9	2.8	2.1	2.1	2.0	1.8	0.9	0.5
1.70	1.9	4.4	6.6	4.0	2.8	2.7	3.0	2.5	2.9	3.0	2.0	0.6
1.80	2.2	7.3	10.6	6.3	3.4	3.0	3.3	4.1	5.0	5.0	2.5	1.0
1.90	2.6	10.4	19.2	9.2	3.7	3.6	3.8	4.3	6.0	6.6	3.6	0.8
2.00	1.9	14.4	23.7	12.3	5.0	3.9	4.4	5.7	9.2	9.4	5.3	2.2
2.10	2.5	10.6	31.5	16.3	5.5	4.8	5.1	6.1	9.8	13.0	8.7	2.6
2.20	5.2	15.6	30.7	16.3	5.1	4.5	5.5	7.2	12.5	18.3	12.2	4.1
2.30	6.0	18.3	24.5	15.0	5.0	5.8	7.0	8.1	12.7	23.4	17.4	5.6
2.40	6.1	16.4	20.8	10.1	4.8	6.8	7.7	8.2	13.9	27.6	21.2	7.4
2.50	6.8	19.4	16.3	7.7	5.6	7.2	8.7	10.2	14.3	28.7	30.3	8.1
2.60	5.7	18.4	11.4	5.4	5.4	7.7	11.2	10.6	14.7	29.6	34.0	10.0
2.70	4.1	15.6	8.5	4.2	4.7	8.2	12.4	12.3	13.2	24.8	35.4	10.0
2.80	3.6	10.3	7.6	1.7	3.6	7.0	12.7	14.4	12.2	18.4	21.5	5.8
2.90	2.3	6.1	4.3	2.1	2.5	5.7	10.2	12.8	10.5	10.2	11.1	2.8
3.00	0.1	2.1	2.0	1.2	1.5	3.6	9.2	11.1	8.0	4.9	3.0	0.8
3.10	0.1	0.7	0.6	0.5	1.0	1.8	7.4	8.4	5.2	2.4	0.4	0.1
3.20	0.0	0.0	0.0	0.0	0.1	0.6	3.1	5.4	3.2	0.7	0.0	0.0

Total: 1633.8 g 92 %

All measurements in grams

Test 15-18 Average Adjusted Mass Distribution



Appendix AE- Nonaspirated 0º Adjusted Mass Distribution Data

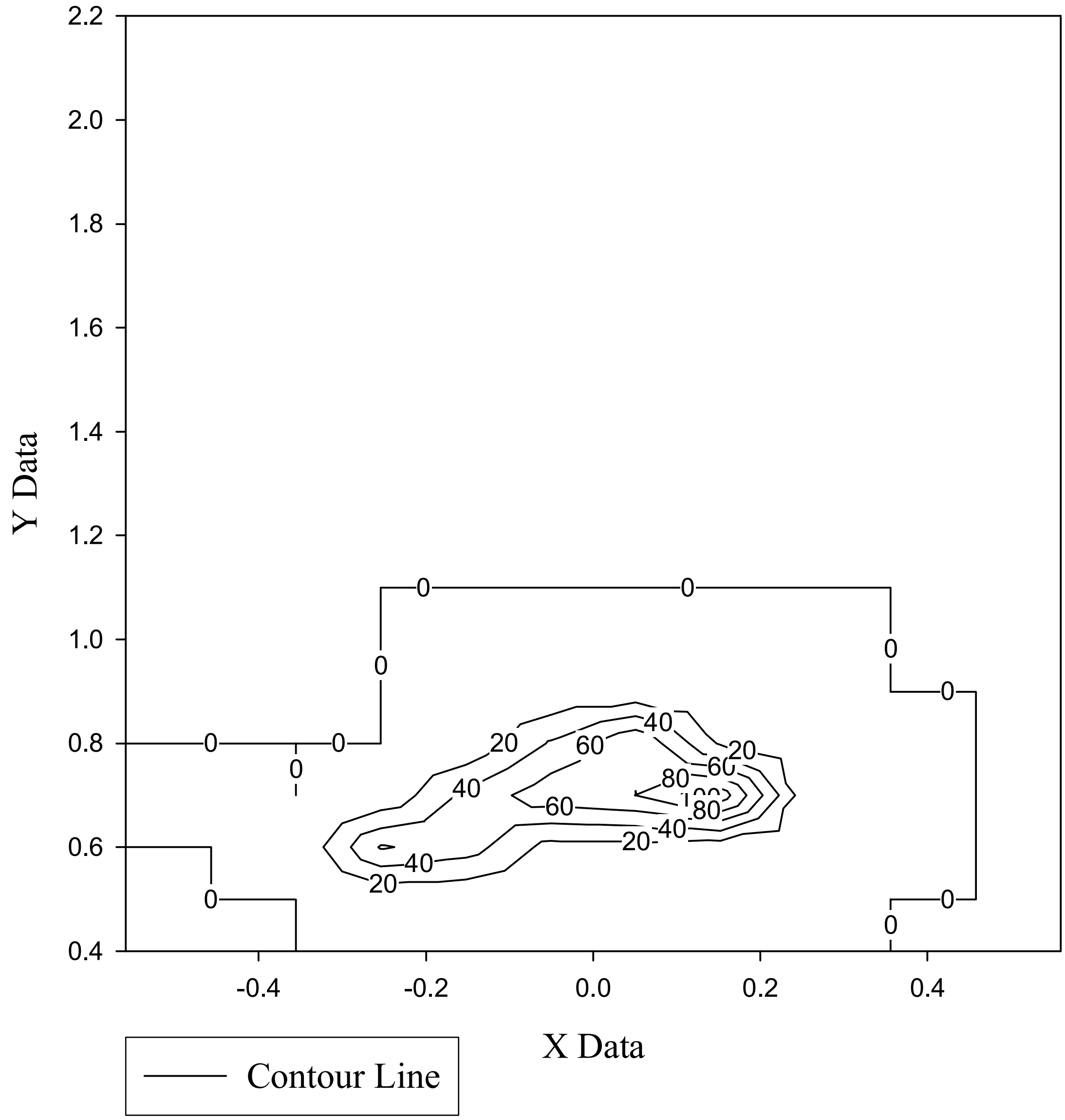
Test 23 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.1	1.1	0.4	0.3	0.1	0.1	0.0	0.0	0.0
0.50	0.0	0.0	0.0	2.6	2.3	2.9	2.6	1.3	0.1	0.0	0.0	0.0
0.60	0.0	0.0	0.1	61.9	49.6	12.7	12.4	7.2	0.4	0.1	0.0	0.0
0.70	0.0	0.1	0.0	2.7	45.3	72.8	80.1	112.3	7.4	0.1	0.0	0.0
0.80	0.0	0.0	0.0	0.0	1.9	42.3	79.1	17.3	0.3	0.1	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.1	1.9	3.7	0.7	0.3	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.1	0.1	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 628.1 g 106 %

All measurements in grams

Test 23 Adjusted Mass Distribution



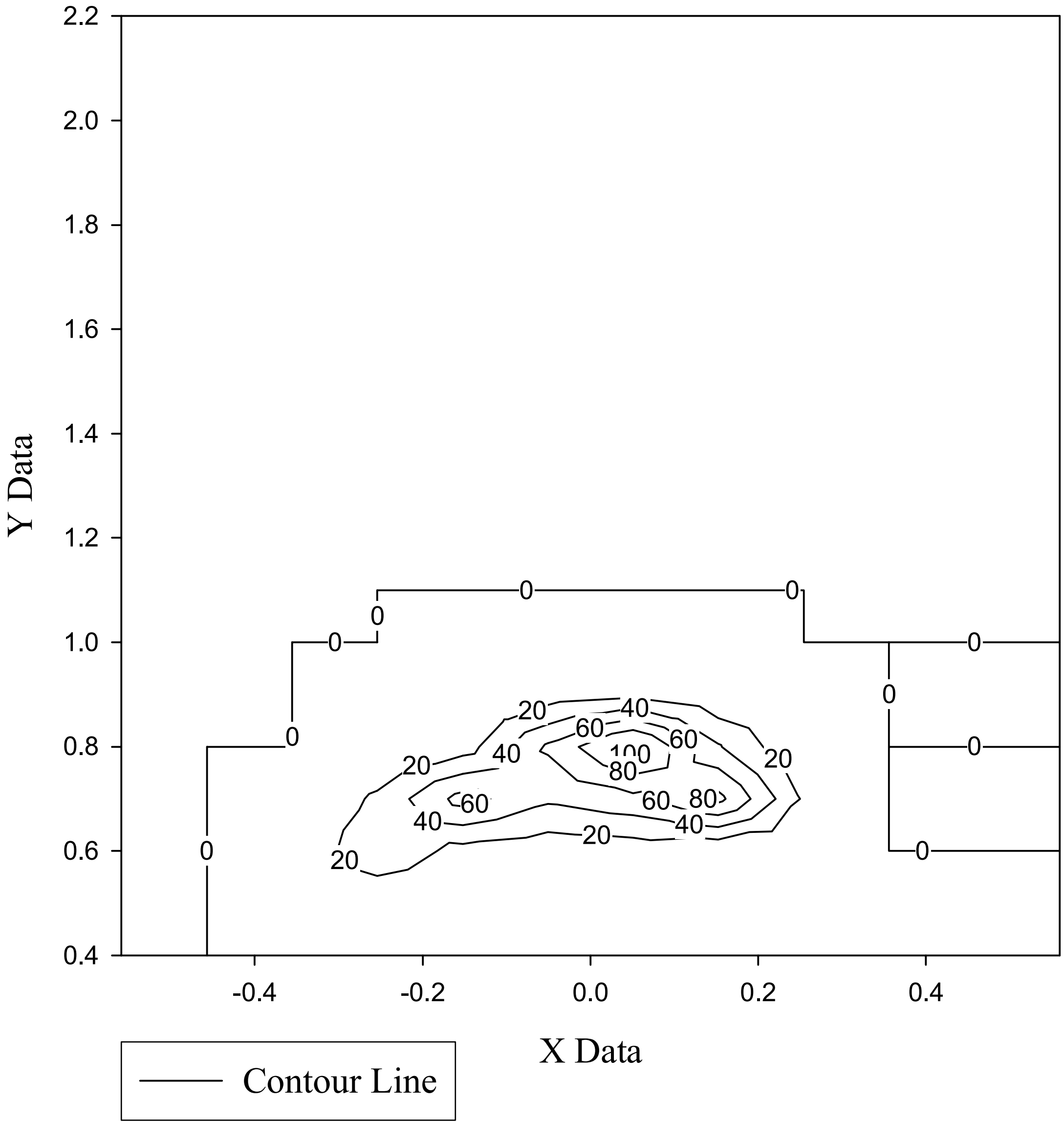
Test 24 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.1	0.1	0.1	0.6	0.3	0.1	0.1	0.0	0.0	0.0
0.50	0.0	0.0	0.1	0.3	0.3	1.0	1.3	0.6	0.4	0.1	0.1	0.0
0.60	0.0	0.0	0.1	37.8	12.4	6.3	8.2	1.7	0.7	0.0	0.0	0.0
0.70	0.0	0.0	0.1	23.5	67.9	43.3	54.2	86.1	17.3	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.4	9.9	63.3	110.0	41.9	0.3	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.1	0.4	8.9	15.7	2.0	0.1	0.0	0.1	0.0
1.00	0.0	0.0	0.0	0.0	0.1	0.6	0.7	0.3	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 620.5 g 105 %

All measurements in grams

Test 24 Adjusted Mass Distribution



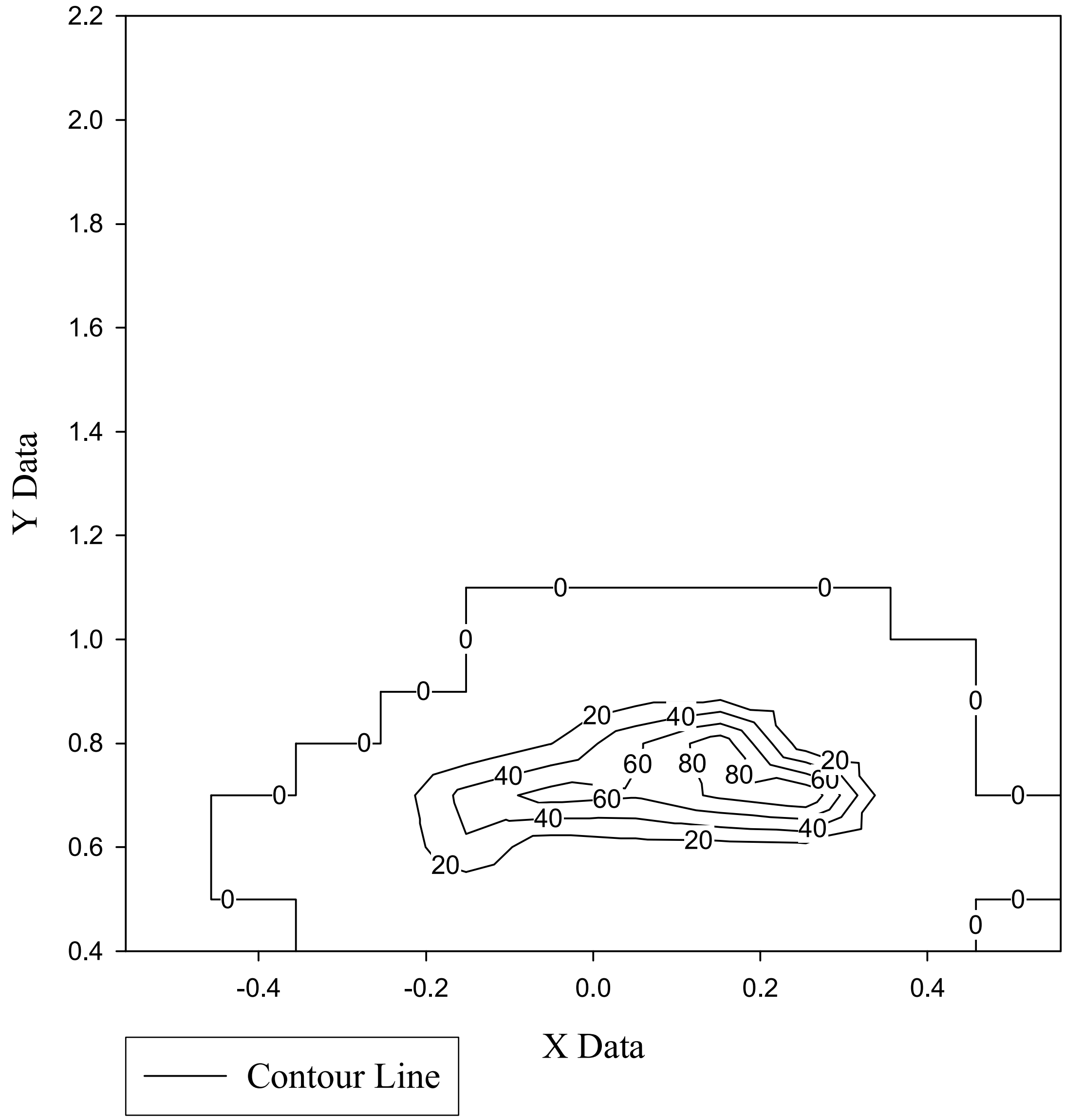
Test 25 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.1	0.4	0.9	0.4	0.3	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	0.4	1.0	2.0	2.0	0.6	0.1	0.0	0.0
0.60	0.0	0.0	0.1	0.6	37.5	5.3	11.0	11.3	13.6	0.1	0.1	0.0
0.70	0.0	0.0	0.0	1.7	47.2	68.2	62.8	84.5	99.5	1.7	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.7	19.4	56.9	93.0	5.9	0.1	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	1.0	5.1	5.3	0.4	0.1	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.1	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 643.2 g 109 %

All measurements in grams

Test 25 Adjusted Mass Distribution

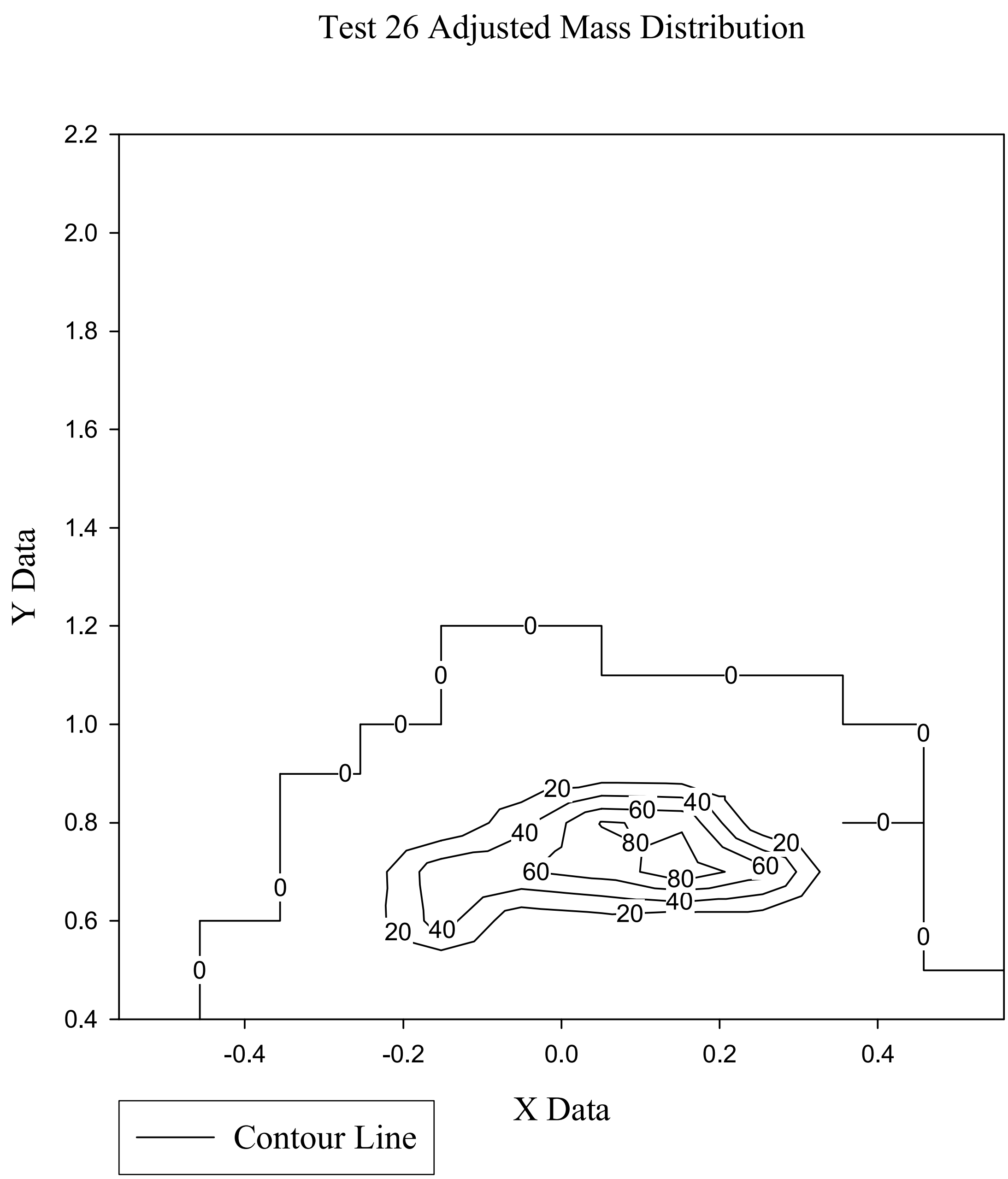


Test 26 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.1	0.0	0.3	0.4	1.1	0.1	0.0	0.0	0.1	0.0
0.50	0.0	0.0	0.1	0.1	0.1	1.1	2.0	1.3	0.3	0.1	0.0	0.0
0.60	0.0	0.0	0.0	6.3	49.2	5.0	11.2	6.1	6.6	0.4	0.0	0.0
0.70	0.0	0.0	0.0	3.9	53.5	58.5	68.4	92.7	68.9	0.4	0.0	0.0
0.80	0.0	0.0	0.0	0.1	0.9	33.2	81.2	76.9	2.9	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.1	1.1	6.0	4.9	0.6	0.1	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.3	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 648.1 g 110 %

All measurements in grams



Test 26 Adjusted Mass Distribution
Y Data
X Data
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
-0.4
-0.2
0.0
0.2
0.4
0
20
40
60
80
Contour Line

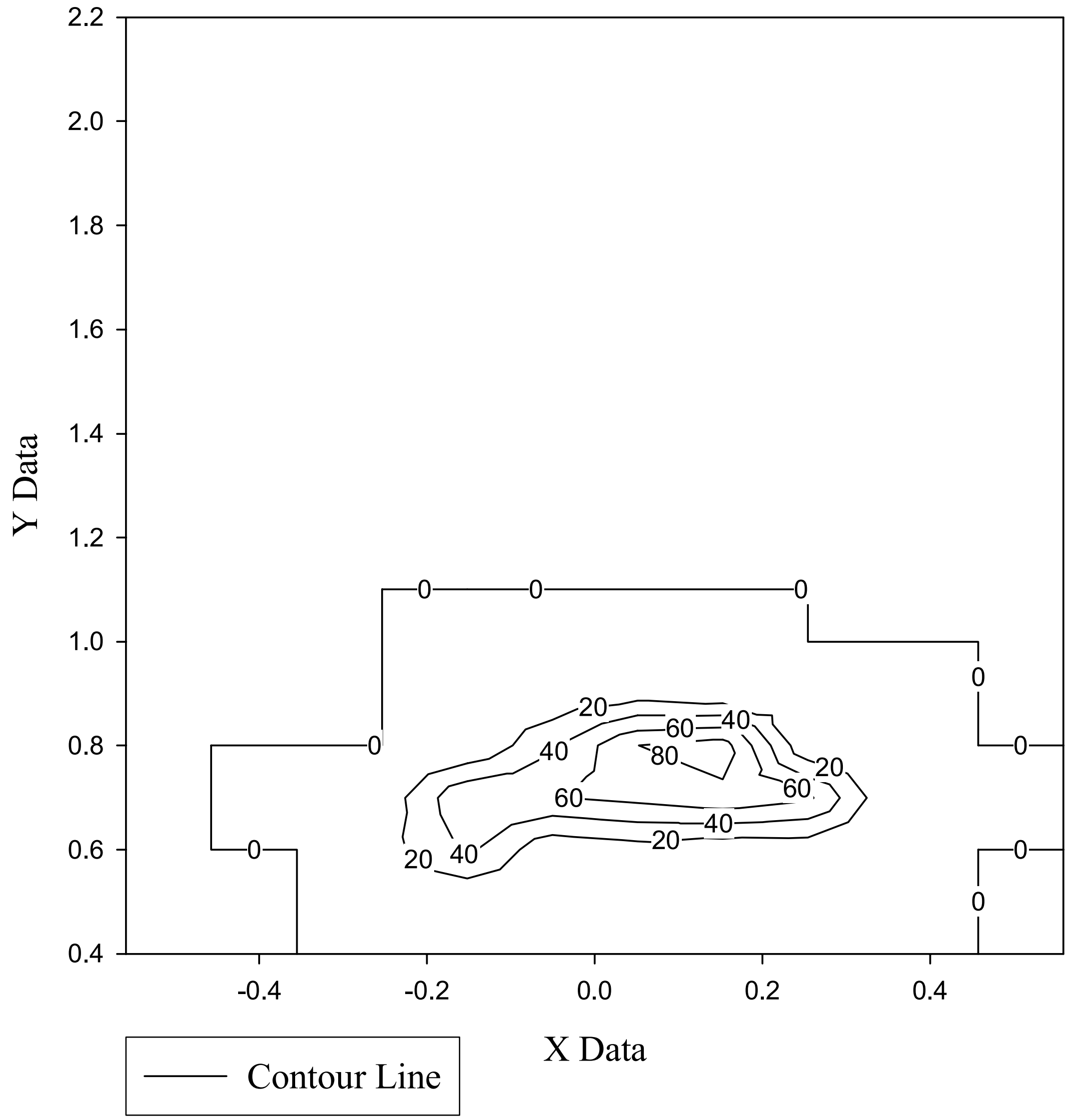
Test 27 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0
0.50	0.0	0.0	0.0	0.1	0.1	1.6	1.3	0.9	0.3	0.1	0.0	0.0
0.60	0.0	0.0	0.0	10.6	44.5	4.9	11.6	5.1	6.0	0.1	0.0	0.0
0.70	0.0	0.0	0.1	6.0	58.1	58.8	65.8	74.8	64.4	0.3	0.1	0.0
0.80	0.0	0.0	0.0	0.0	0.7	36.9	79.8	89.5	2.4	0.1	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.1	2.6	10.7	3.6	0.3	0.1	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.1	0.3	0.7	0.4	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 644.6 g 109 %

All measurements in grams

Test 27 Adjusted Mass Distribution



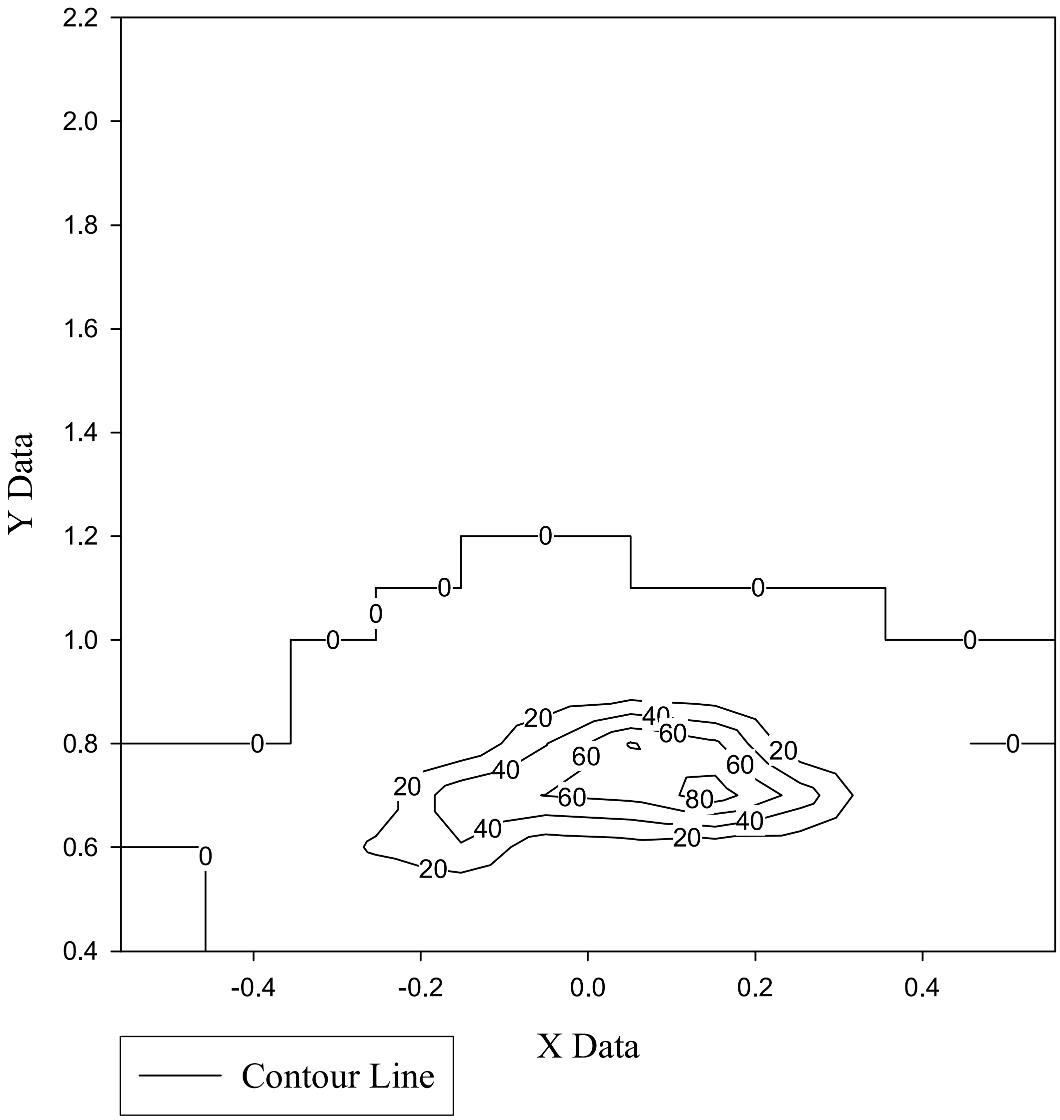
Avg 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.0	0.0	0.1	0.1	0.4	0.4	0.6	0.2	0.1	0.0	0.0	0.0
1.50	0.0	0.0	0.1	0.7	0.7	1.5	1.8	1.2	0.3	0.1	0.0	0.0
1.60	0.0	0.0	0.1	23.4	38.6	6.8	10.9	6.3	5.5	0.2	0.0	0.0
1.70	0.0	0.0	0.1	7.6	54.4	60.3	66.2	90.1	51.5	0.5	0.0	0.0
1.80	0.0	0.0	0.0	0.1	2.8	39.0	81.4	63.7	2.3	0.1	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.2	3.1	8.3	3.3	0.3	0.1	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.4	0.1	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 636.9 g 108 %

All measurements in grams

Test 23-27 Average Adjusted Mass Distribution



Appendix AF- Nonaspirated -15º Adjusted Mass Distribution Data

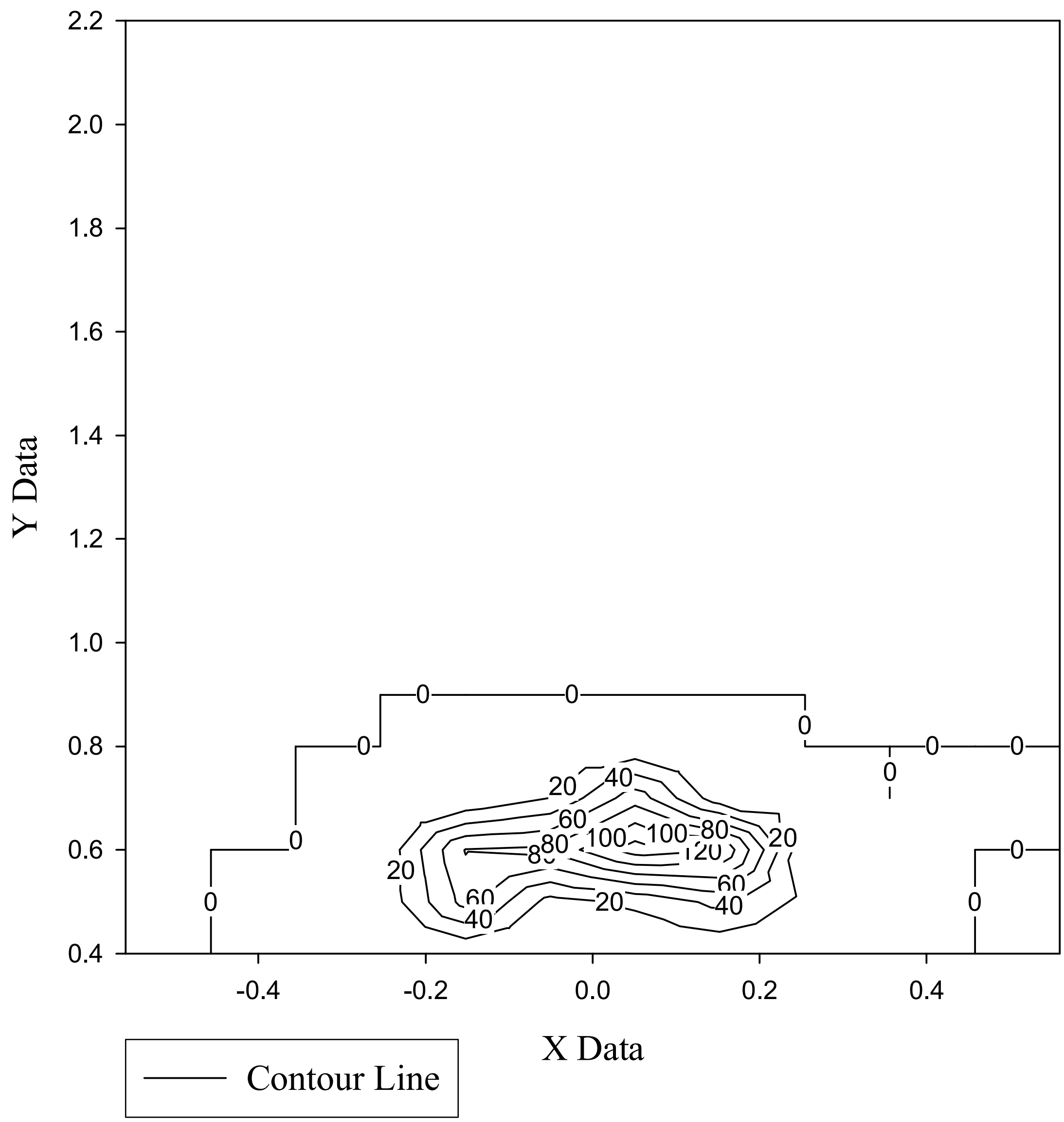
Test 28 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.4	1.7	3.4	1.0	0.7	0.1	0.0	0.0
0.50	0.0	0.0	0.1	4.0	67.5	12.3	23.3	45.8	13.7	0.1	0.0	0.0
0.60	0.0	0.0	0.0	2.7	81.2	84.5	130.1	120.4	3.3	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.1	0.9	20.4	71.6	7.2	0.3	0.0	0.1	0.0
0.80	0.0	0.0	0.0	0.0	0.3	0.7	2.9	0.6	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 701.8 g 119 %

All measurements in grams

Test 28 Adjusted Mass Distribution



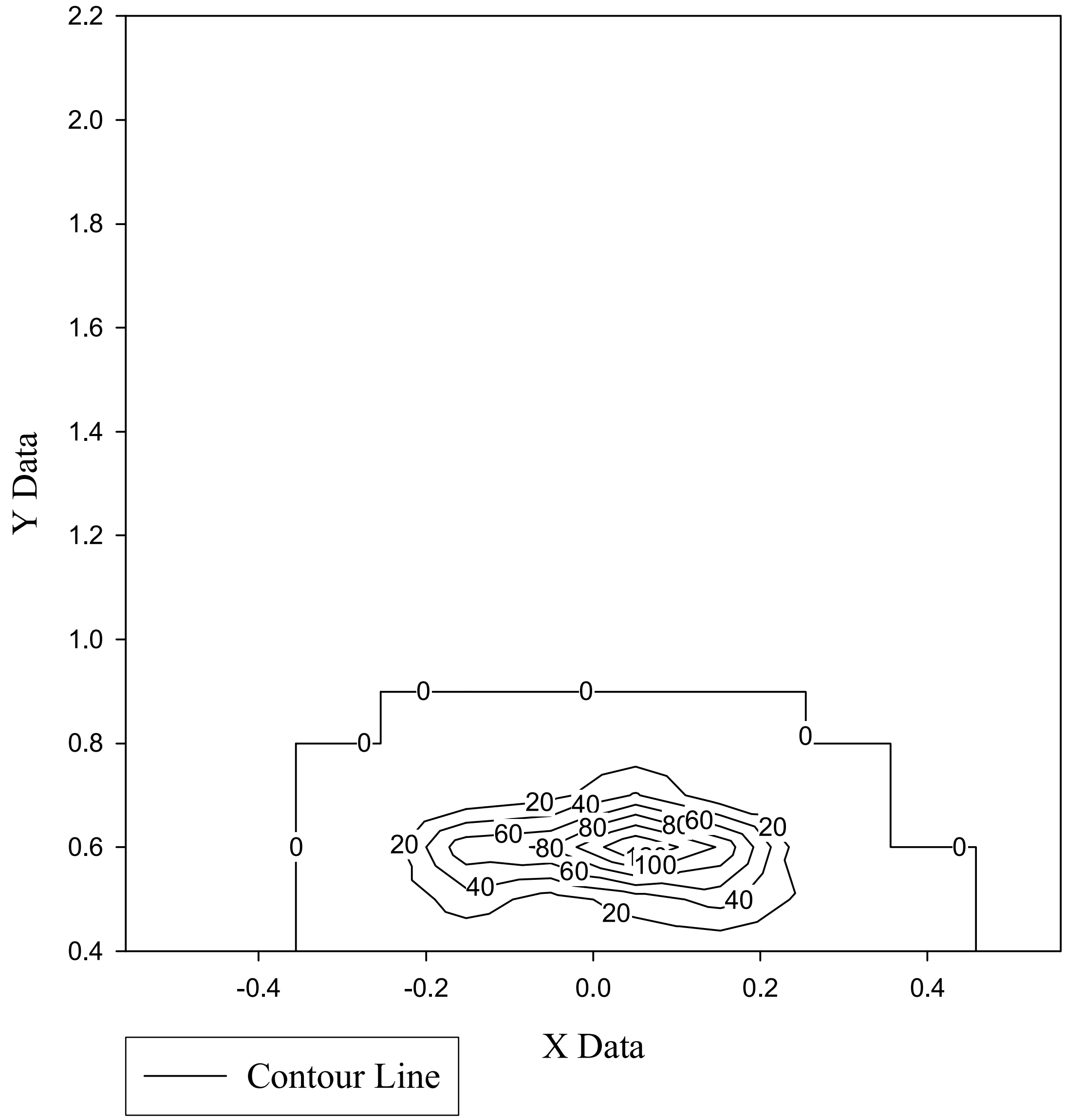
Test 29 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.1	1.7	3.6	1.6	0.1	0.0	0.0	0.0
0.50	0.0	0.0	0.0	1.1	31.0	11.0	28.9	48.2	13.6	0.1	0.0	0.0
0.60	0.0	0.0	0.0	1.4	74.4	81.9	142.9	97.1	0.9	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.1	0.4	12.4	41.9	4.6	0.3	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.1	0.7	1.7	0.4	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 602.5 g 102 %

All measurements in grams

Test 29 Adjusted Mass Distribution



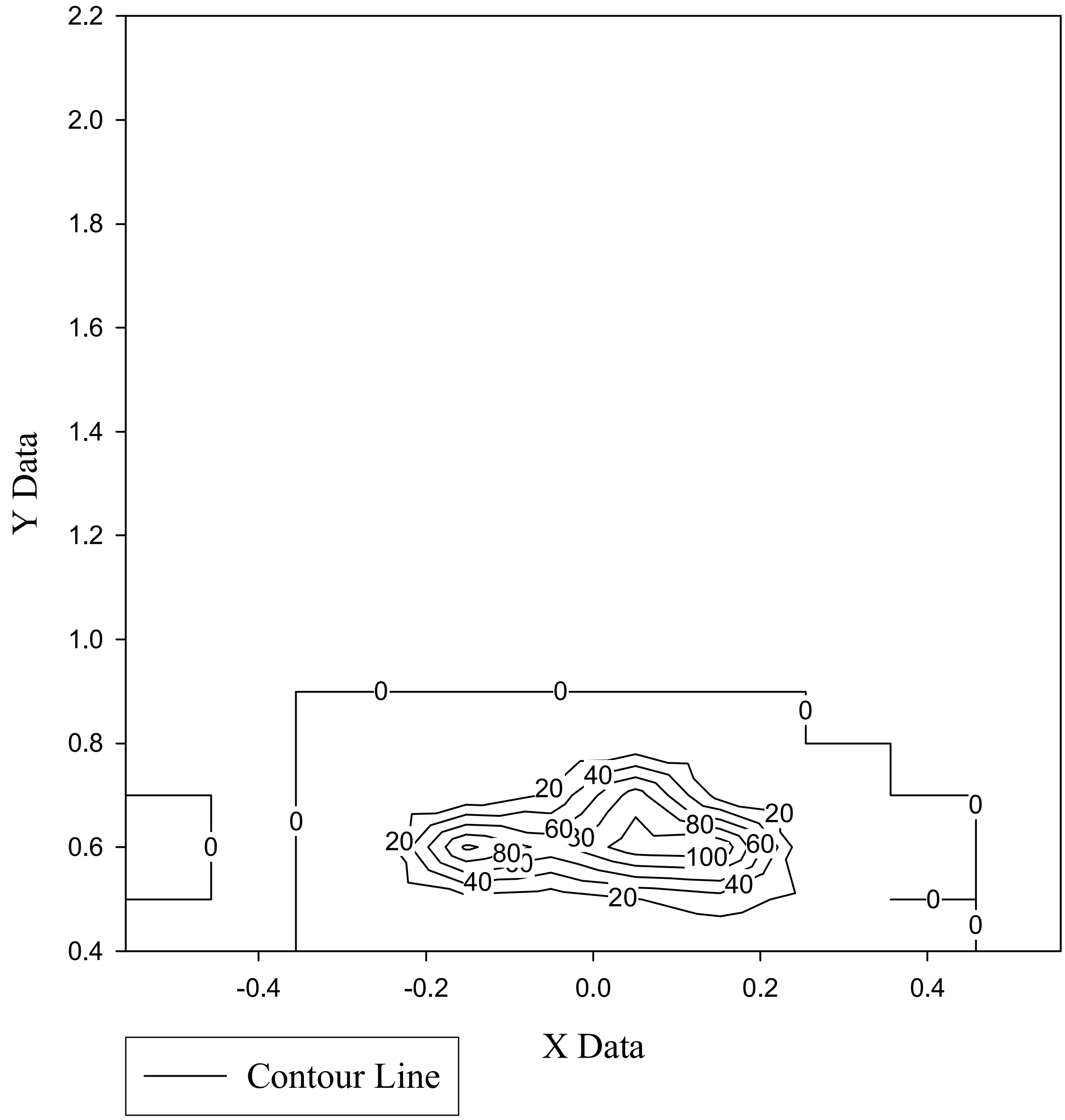
Test 30 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.1	1.0	1.3	1.0	0.1	0.1	0.0	0.0
0.50	0.0	0.0	0.0	1.4	12.9	6.6	19.3	29.3	13.4	0.0	0.0	0.0
0.60	0.1	0.0	0.0	4.3	104.5	72.4	113.1	117.1	2.0	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.1	1.4	23.2	90.2	10.2	0.1	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.1	0.1	0.9	1.9	0.6	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 629.2 g 107 %

All measurements in grams

Test 30 Adjusted Mass Distribution



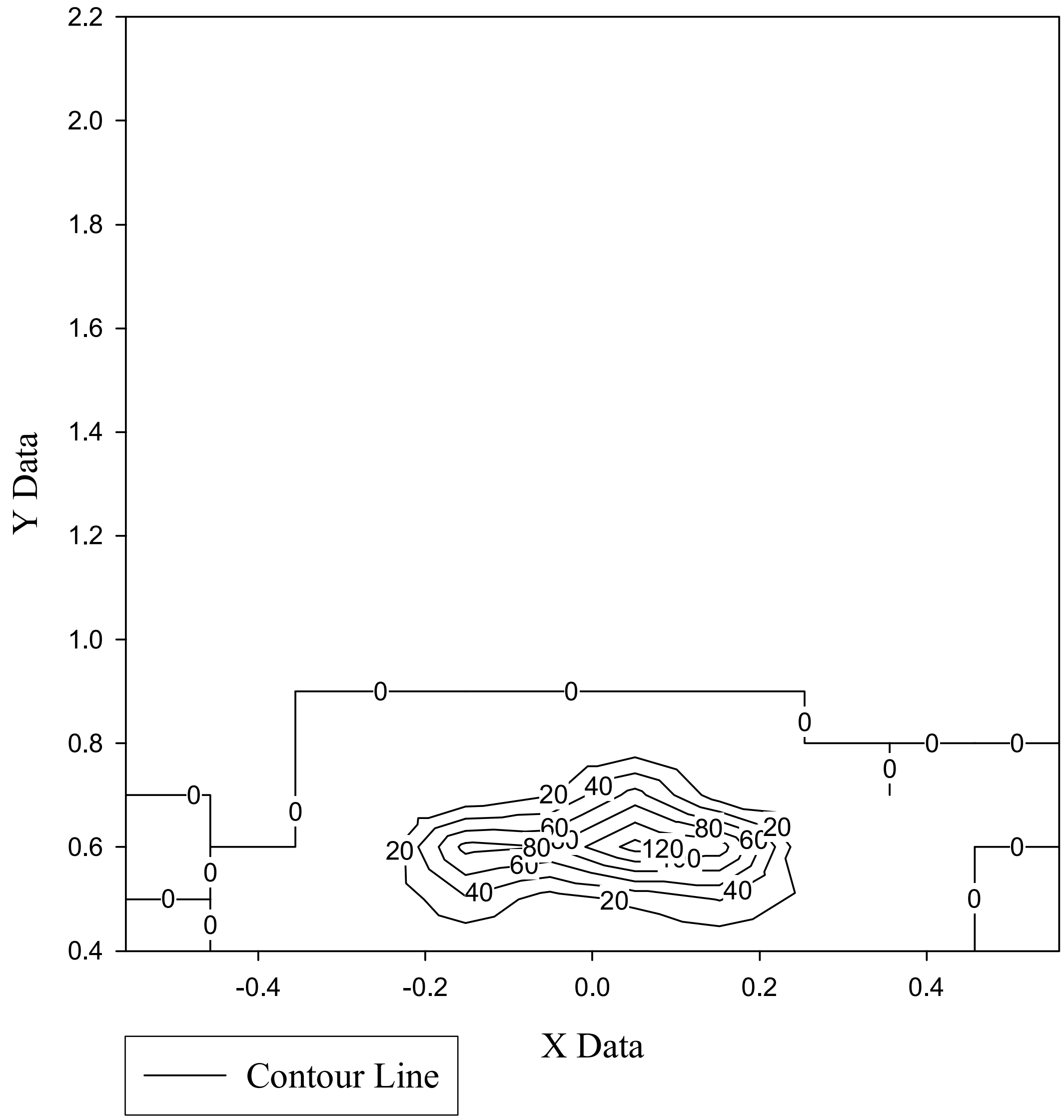
Avg -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	0.2	1.5	2.8	1.2	0.3	0.1	0.0	0.0
0.50	0.0	0.0	0.0	2.2	37.1	10.0	23.8	41.1	13.6	0.1	0.0	0.0
0.60	0.0	0.0	0.0	2.8	86.7	79.6	128.7	111.5	2.0	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.1	0.9	18.7	67.9	7.3	0.2	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.2	0.8	2.1	0.5	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 644.5 g 109 %

All measurements in grams

Test 28-30 Average Adjusted Mass Distribution



Appendix AG- Nonaspirated 15º Adjusted Mass Distribution Data

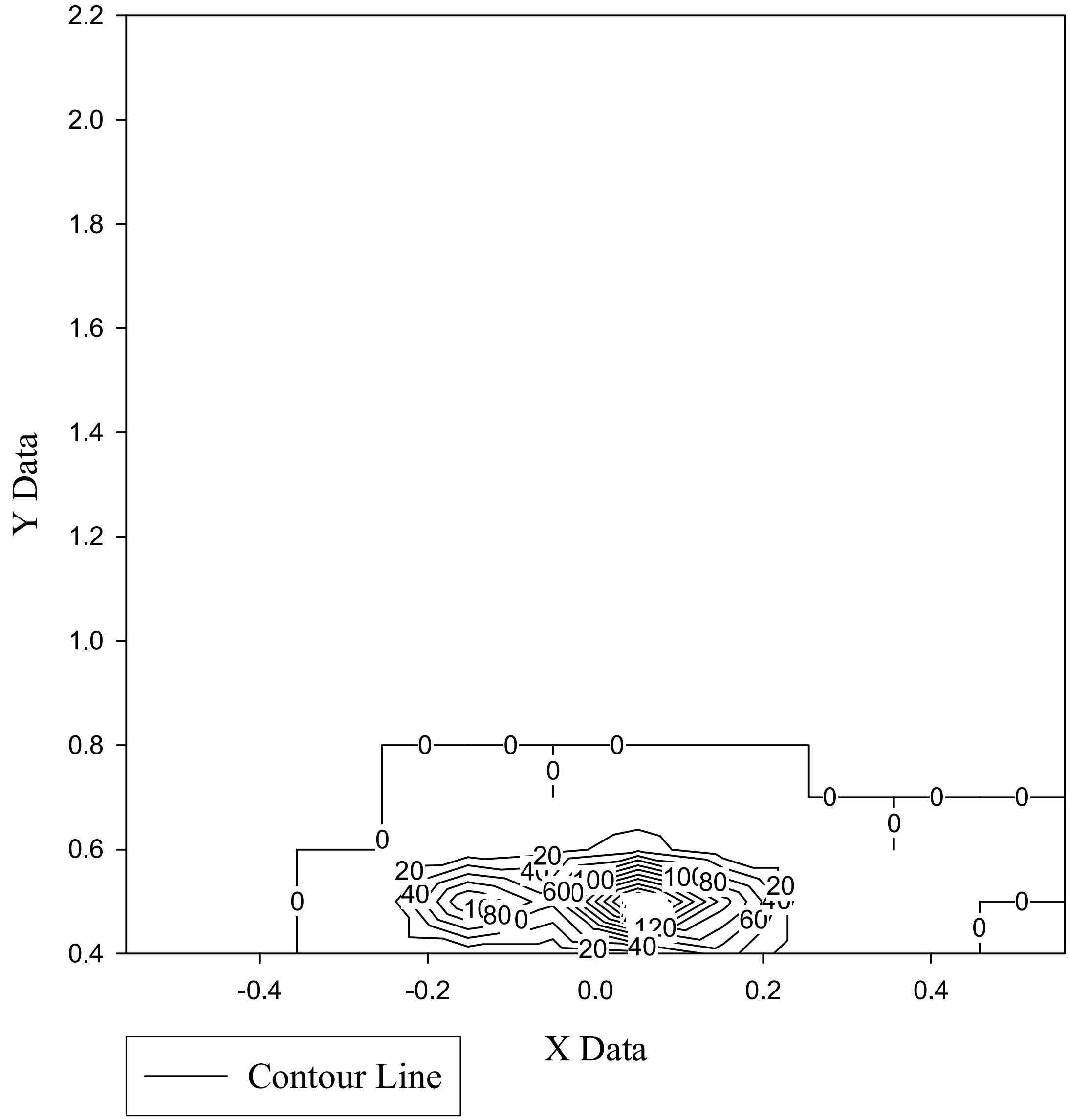
Test 31   15º   100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	3.0	3.0	11.7	48.5	0.4	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	125.4	65.1	256.5	109.4	0.4	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	1.1	11.4	32.2	1.6	0.1	0.0	0.3	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 671.1 g   114 %

All measurements in grams

Test 31 Adjusted Mass Distribution



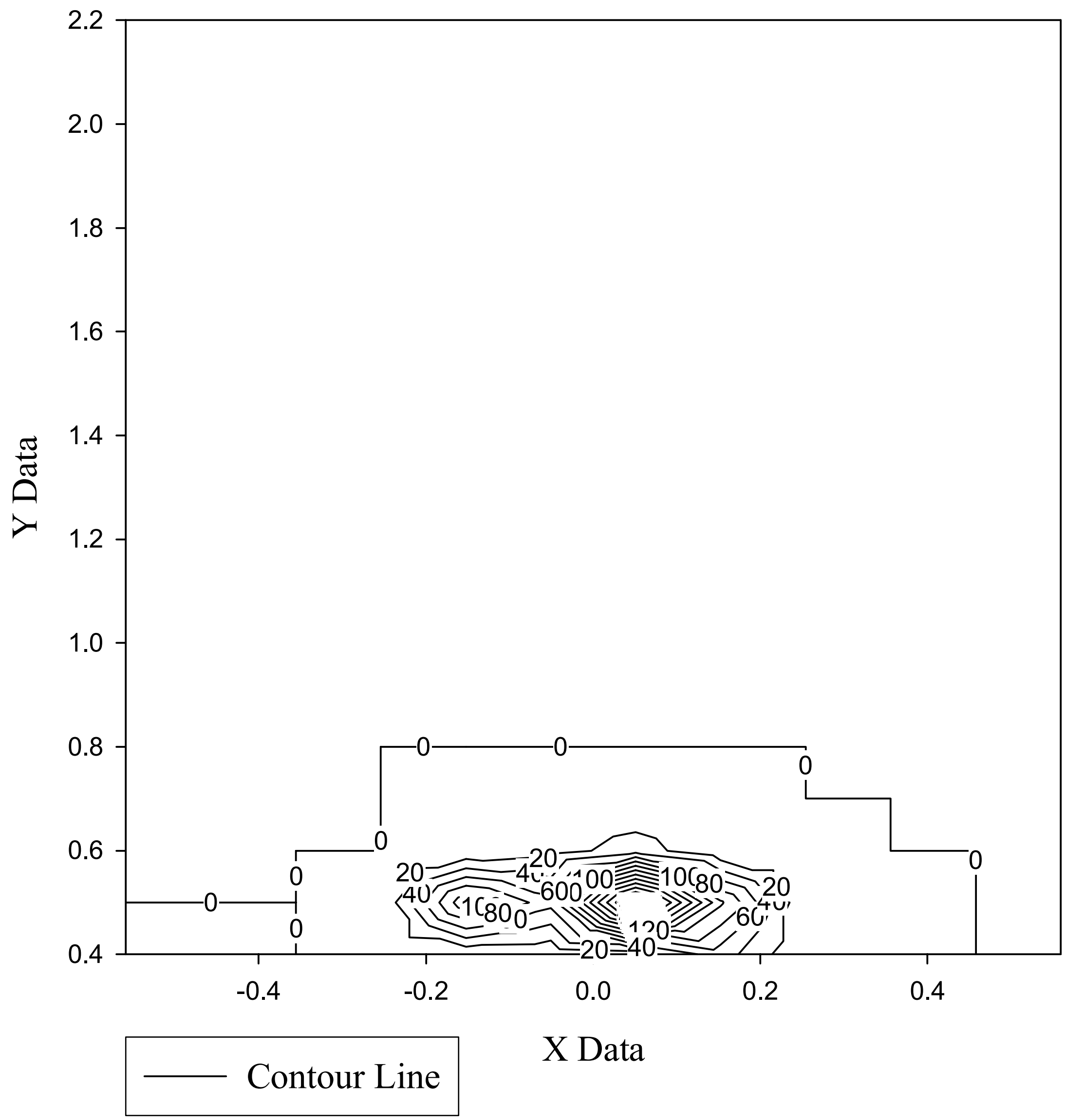
Test 32 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.1	0.1	0.0	0.0	4.0	2.6	10.2	50.3	0.3	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	117.1	67.2	268.0	103.8	0.3	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	0.9	9.9	31.0	1.3	0.1	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 668.2 g 113 %

All measurements in grams

Test 32 Adjusted Mass Distribution



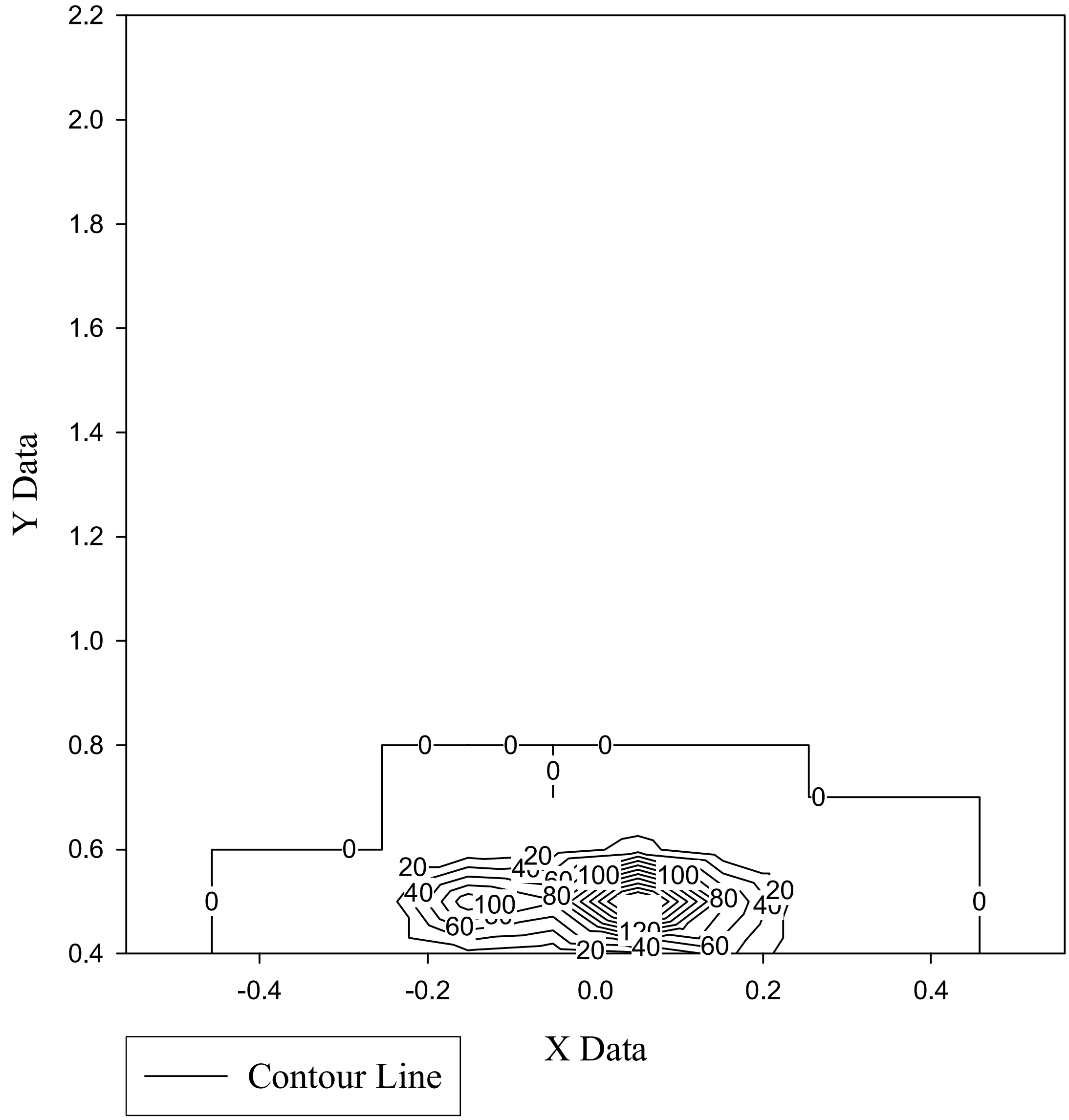
Test 33 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	13.7	5.1	16.7	47.3	0.3	0.1	0.0	0.0
0.50	0.0	0.0	0.1	0.1	115.8	82.7	263.3	85.2	0.3	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	0.6	9.2	26.9	1.0	0.1	0.1	0.0	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 669.4 g 113 %

All measurements in grams

Test 33 Adjusted Mass Distribution



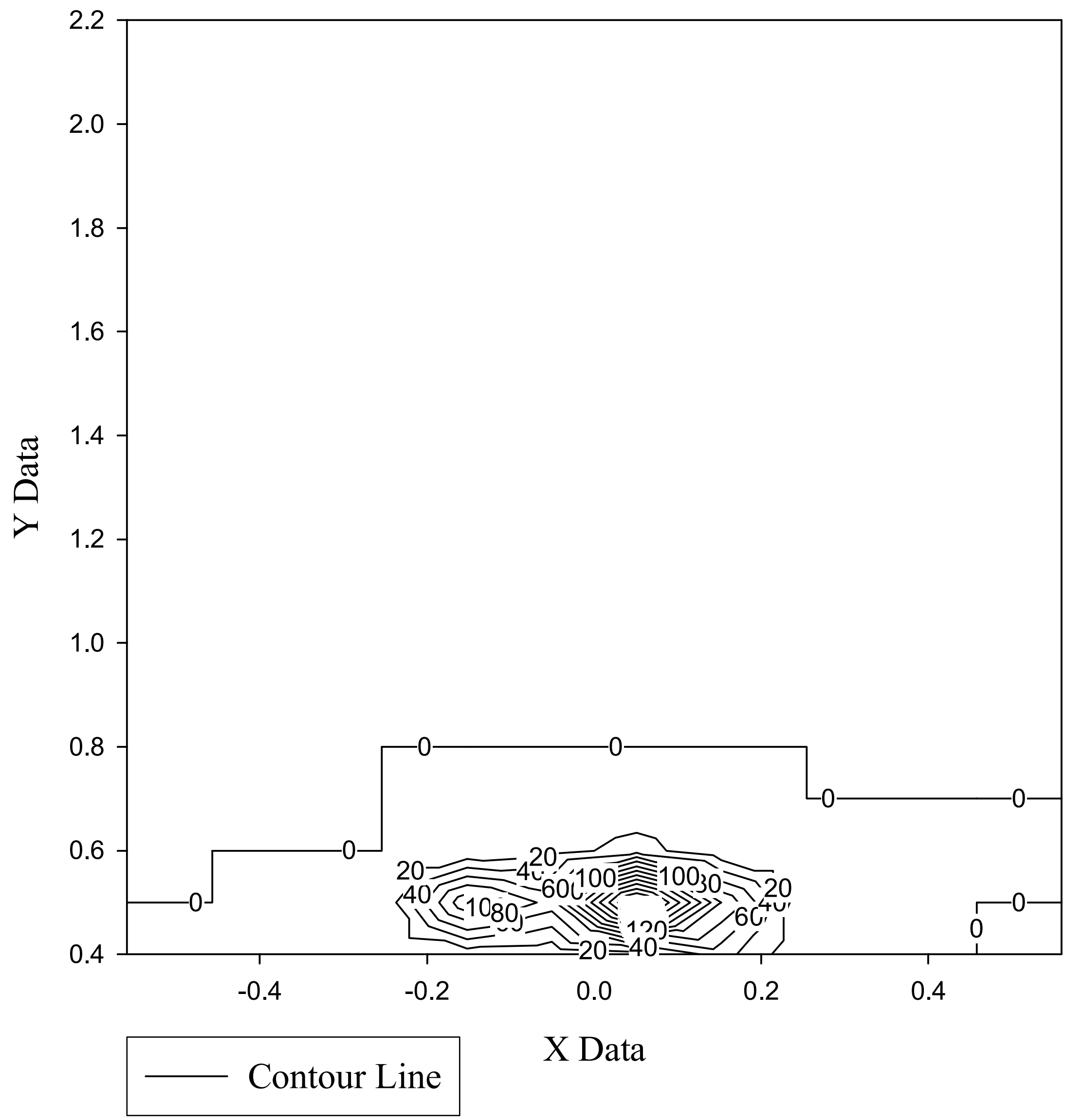
Avg 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	6.9	3.6	12.9	48.7	0.3	0.1	0.0	0.0
0.50	0.0	0.0	0.0	0.1	119.5	71.6	262.6	99.5	0.3	0.1	0.0	0.0
0.60	0.0	0.0	0.0	0.0	0.9	10.2	30.0	1.3	0.1	0.0	0.1	0.0
0.70	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total: 669.6 g 113 %

All measurements in grams

Test 31-33 Average Adjusted Mass Distribution



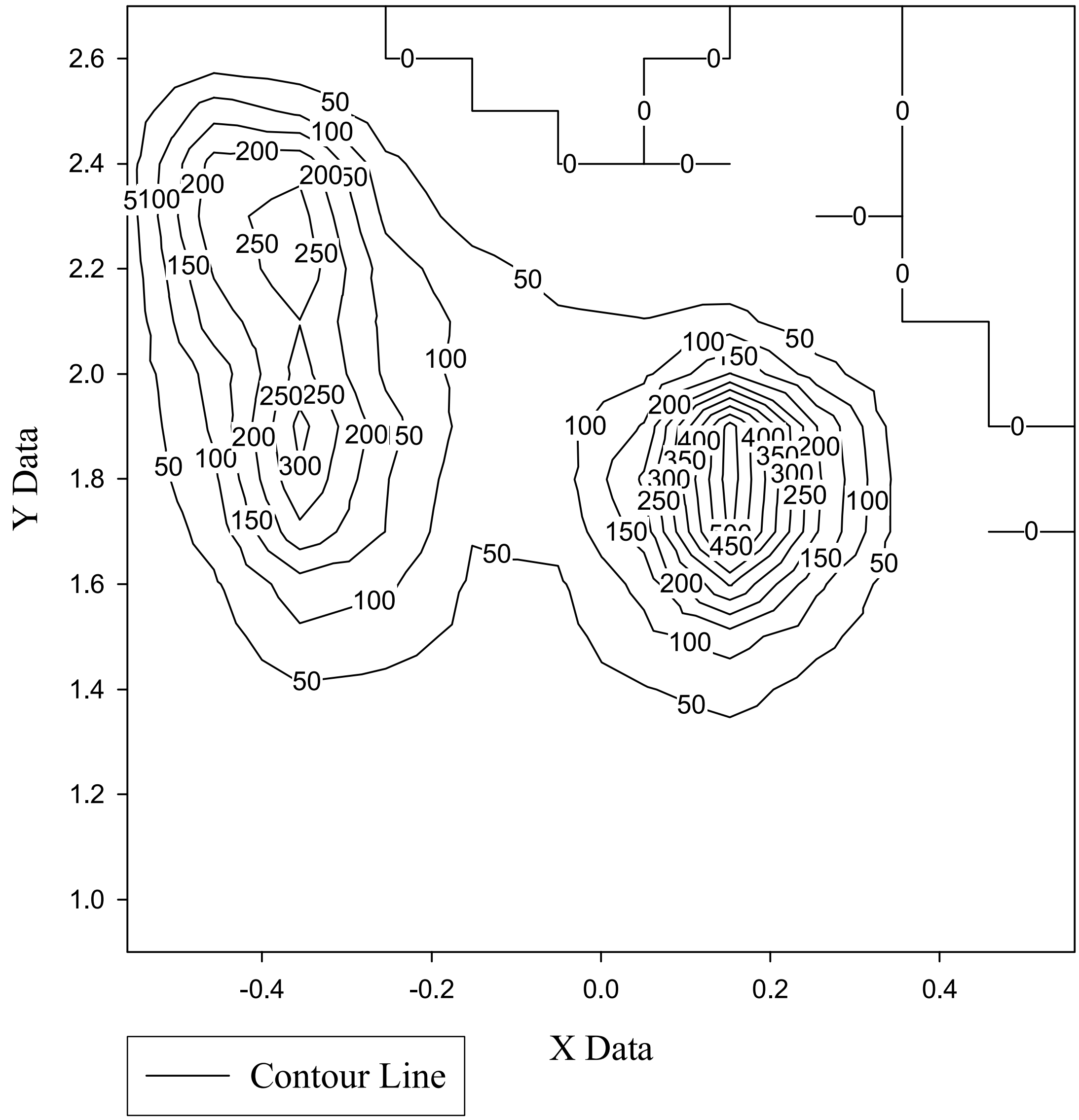
Appendix AH- Aspirated 0º Mass Flux Data

Test 3 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.9	1.9	2.8	5.6	5.6	3.8	2.8	2.8	2.8	0.9	0.0
1.00	0.9	1.9	1.9	4.7	5.6	6.6	6.6	4.7	4.7	1.9	0.9	0.9
1.10	0.0	1.9	4.7	6.6	9.4	9.4	9.4	10.3	9.4	3.8	0.9	0.0
1.20	0.9	2.8	11.3	10.3	10.3	20.6	19.7	13.1	15.0	5.6	0.9	0.0
1.30	0.9	8.4	17.8	19.7	17.8	19.7	21.6	33.8	21.6	10.3	2.8	0.9
1.40	3.8	18.8	44.1	36.6	23.4	32.8	46.9	68.5	31.9	13.1	1.9	0.0
1.50	3.8	26.3	90.0	70.3	36.6	32.8	84.4	122.8	63.8	18.8	1.9	0.9
1.60	4.7	43.1	128.5	109.7	43.1	43.1	115.3	305.7	110.6	19.7	2.8	0.9
1.70	3.8	68.5	237.2	149.1	52.5	62.8	173.5	512.9	203.5	24.4	0.0	0.0
1.80	10.3	90.0	295.4	152.8	66.6	75.0	208.2	529.8	211.0	25.3	1.9	0.9
1.90	11.3	107.8	316.0	168.8	78.8	76.0	154.7	522.3	201.6	14.1	0.0	0.0
2.00	16.9	118.2	268.2	141.6	80.6	66.6	88.1	202.5	73.1	5.6	0.0	0.0
2.10	14.1	176.3	248.5	136.9	87.2	57.2	51.6	68.5	12.2	0.0	0.0	0.0
2.20	18.8	205.4	287.9	123.8	67.5	33.8	26.3	12.2	0.9	0.0	0.0	0.0
2.30	26.3	237.2	269.1	89.1	27.2	6.6	5.6	1.9	0.0	0.0	0.0	0.0
2.40	29.1	219.4	236.3	61.9	10.3	0.0	0.0	0.0	0.9	0.0	0.0	0.0
2.50	15.9	128.5	89.1	11.3	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0
2.60	0.0	20.6	12.2	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
2.70	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 3 Mass Flux (g/m^2-s)

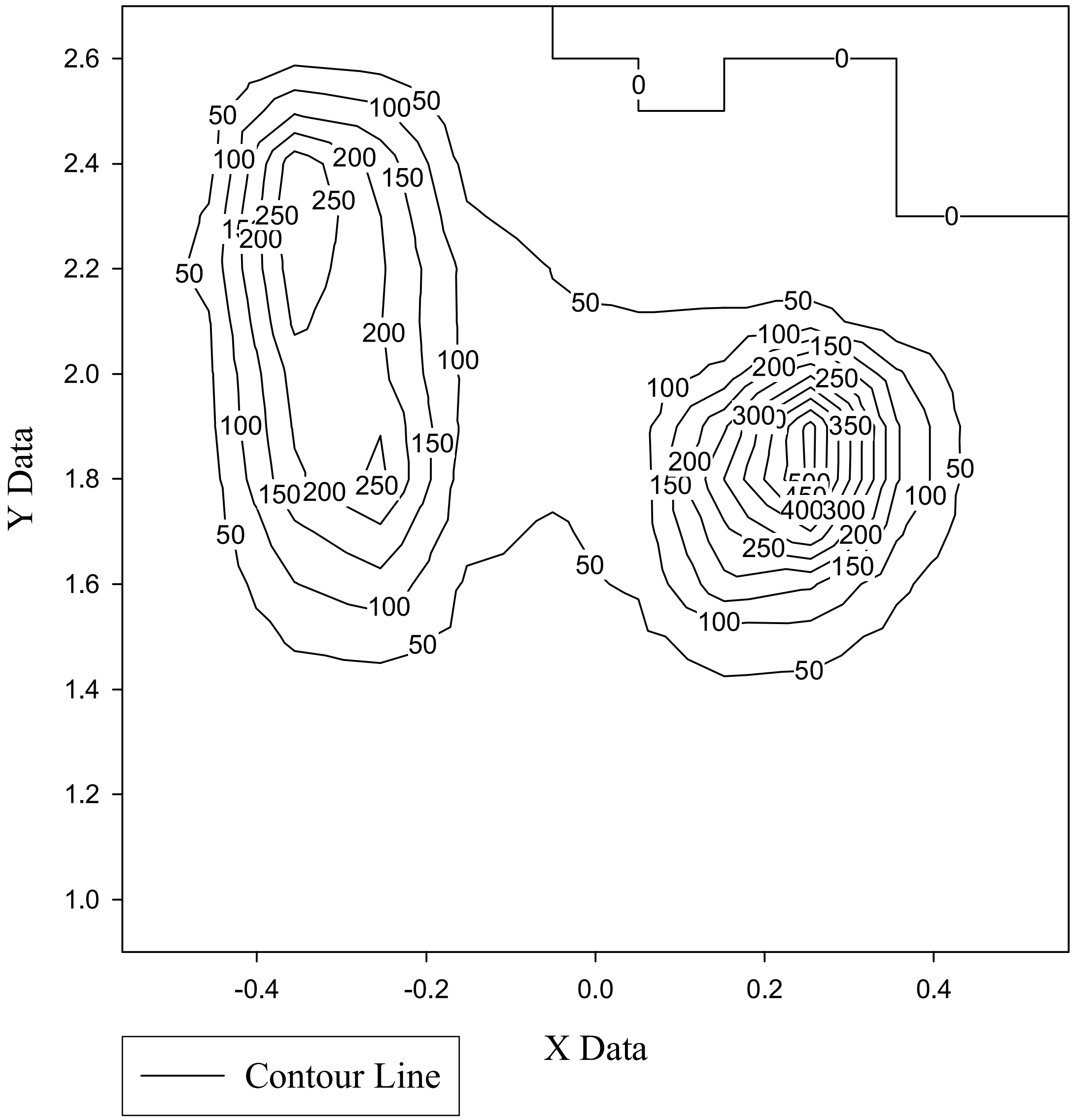


Test 4 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.9	0.9	0.9	2.8	4.7	3.8	2.8	2.8	1.9	0.9	0.0
1.00	0.0	0.9	1.9	3.8	3.8	5.6	3.8	3.8	3.8	2.8	0.9	0.9
1.10	0.9	1.9	2.8	3.8	6.6	7.5	7.5	6.6	5.6	3.8	0.9	0.0
1.20	0.9	1.9	4.7	5.6	7.5	12.2	13.1	14.1	10.3	5.6	5.6	0.9
1.30	0.9	2.8	14.1	17.8	13.1	17.8	19.7	23.4	21.6	7.5	2.8	0.9
1.40	0.9	5.6	30.9	30.9	24.4	23.4	30.0	42.2	36.6	15.0	4.7	1.9
1.50	2.8	12.2	57.2	69.4	37.5	28.1	39.4	73.1	75.0	34.7	6.6	2.8
1.60	1.9	10.3	98.5	133.2	43.1	41.3	54.4	186.6	157.5	60.0	9.4	0.9
1.70	0.9	22.5	138.8	190.4	62.8	44.1	68.5	237.2	348.8	108.8	12.2	0.0
1.80	4.7	28.1	191.3	261.6	71.3	60.0	69.4	301.0	515.7	154.7	13.1	0.0
1.90	3.8	37.5	206.3	247.6	84.4	61.0	75.0	241.9	520.4	155.7	12.2	0.0
2.00	1.9	40.3	219.4	211.0	87.2	69.4	63.8	115.3	293.5	109.7	2.8	0.0
2.10	0.9	45.9	260.7	202.5	86.3	55.3	53.4	56.3	73.1	15.0	1.9	0.0
2.20	0.9	65.6	280.4	207.2	85.3	48.8	33.8	31.9	15.0	3.8	0.9	0.0
2.30	1.9	55.3	301.0	200.7	56.3	27.2	11.3	7.5	1.9	0.0	0.0	0.0
2.40	0.0	33.8	283.2	181.0	34.7	8.4	0.9	0.9	0.9	0.0	0.0	0.0
2.50	0.0	25.3	142.5	113.5	12.2	0.9	0.0	0.0	0.9	0.0	0.0	0.0
2.60	0.9	7.5	36.6	23.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.70	0.0	0.9	2.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 4 Mass Flux (g/m^2-s)

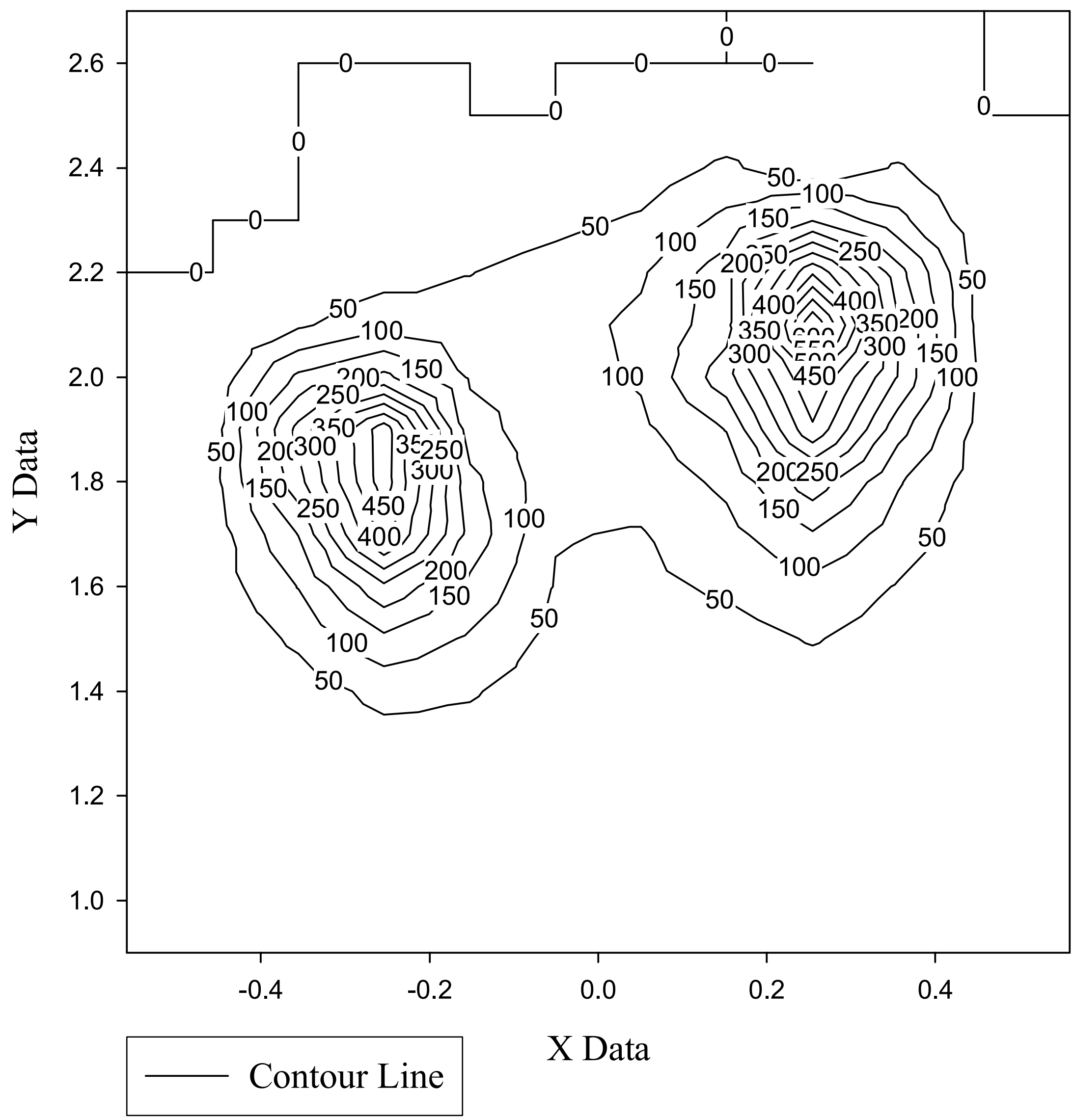


Test 5 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.0	0.9	1.9	2.8	1.9	3.8	3.8	2.8	1.9	5.6	0.9	0.0
1.00	0.0	0.9	2.8	3.8	4.7	4.7	5.6	4.7	5.6	2.8	0.9	0.9
1.10	0.9	2.8	4.7	6.6	7.5	8.4	8.4	5.6	5.6	2.8	0.9	0.0
1.20	0.9	1.9	7.5	11.3	15.0	14.1	10.3	9.4	10.3	3.8	0.9	0.0
1.30	0.0	4.7	18.8	31.9	33.8	19.7	15.9	15.0	15.9	9.4	2.8	0.0
1.40	0.0	6.6	25.3	64.7	54.4	24.4	21.6	20.6	26.3	18.8	2.8	0.9
1.50	0.9	10.3	60.0	138.8	92.8	35.6	30.0	31.9	53.4	29.1	6.6	0.9
1.60	0.9	21.6	102.2	240.1	138.8	46.9	39.4	57.2	84.4	46.9	11.3	1.9
1.70	0.9	20.6	151.9	422.0	181.9	52.5	46.9	84.4	145.3	76.9	11.3	0.0
1.80	0.9	32.8	232.6	479.2	165.0	64.7	69.4	110.6	229.7	105.0	20.6	4.7
1.90	0.0	25.3	267.2	481.0	121.0	65.6	89.1	151.9	391.0	168.8	25.3	2.8
2.00	0.0	12.2	161.3	213.8	93.8	78.8	106.0	229.7	452.0	246.6	31.9	1.9
2.10	0.0	2.8	42.2	87.2	67.5	83.5	109.7	178.2	651.7	255.1	21.6	1.9
2.20	0.0	0.0	1.9	27.2	48.8	69.4	93.8	180.0	442.6	219.4	21.6	0.0
2.30	0.0	0.0	0.0	3.8	20.6	36.6	56.3	112.5	199.7	114.4	11.3	0.0
2.40	0.0	0.0	0.0	0.9	3.8	8.4	22.5	60.0	8.4	55.3	3.8	0.0
2.50	0.0	0.0	0.0	0.9	0.0	0.0	2.8	12.2	15.9	9.4	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0

All measurements in g/m^2-s

Test 5 Mass Flux (g/m^2-s)

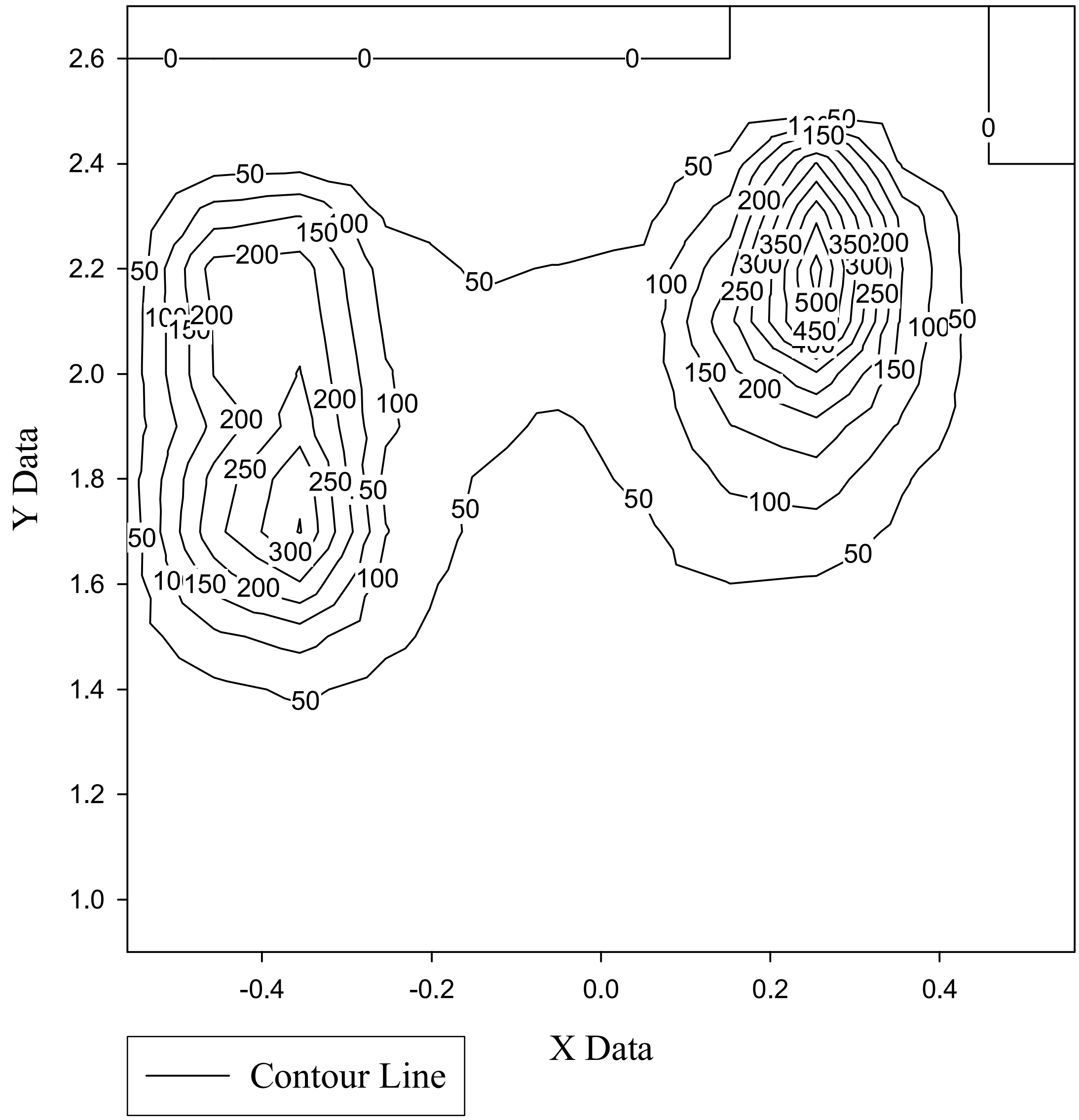


Test 6 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.9	1.9	3.8	3.8	2.8	8.4	6.6	3.8	1.9	1.9	0.9	0.0
1.00	0.9	2.8	5.6	4.7	5.6	12.2	15.0	6.6	3.8	1.9	0.9	0.9
1.10	1.9	4.7	7.5	10.3	8.4	18.8	7.5	6.6	7.5	3.8	0.9	0.9
1.20	3.8	10.3	16.9	12.2	13.1	13.1	12.2	7.5	5.6	3.8	0.9	0.9
1.30	8.4	21.6	29.1	22.5	15.9	16.9	13.1	15.0	11.3	6.6	2.8	0.9
1.40	11.3	38.4	57.2	35.6	24.4	18.8	18.8	23.4	14.1	11.3	4.7	0.9
1.50	23.4	89.1	119.1	60.0	30.9	29.1	29.1	32.8	18.8	15.9	6.6	0.9
1.60	20.6	166.0	245.7	76.0	32.8	32.8	40.3	49.7	45.0	27.2	9.4	1.9
1.70	18.8	234.4	353.5	102.2	43.1	35.6	43.1	79.7	78.8	40.3	11.3	1.9
1.80	25.3	216.6	338.5	87.2	49.7	40.3	55.3	107.8	128.5	54.4	10.3	1.9
1.90	18.8	162.2	275.7	107.8	57.2	45.9	60.0	148.2	181.0	91.9	15.0	1.9
2.00	19.7	201.6	252.2	104.1	53.4	59.1	67.5	183.8	292.6	123.8	12.2	0.0
2.10	17.8	203.5	237.2	90.0	62.8	53.4	63.8	237.2	488.5	139.7	10.3	0.0
2.20	10.3	220.4	224.1	76.9	45.9	51.6	61.0	188.5	521.4	151.0	3.8	0.0
2.30	0.9	128.5	151.0	44.1	33.8	31.9	37.5	124.7	439.8	133.2	1.9	0.0
2.40	0.0	26.3	30.9	11.3	11.3	13.1	20.6	63.8	303.8	44.1	0.0	0.0
2.50	0.0	1.9	2.8	1.9	1.9	2.8	1.9	9.4	35.6	8.4	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.9	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 6 Mass Flux (g/m^2-s)

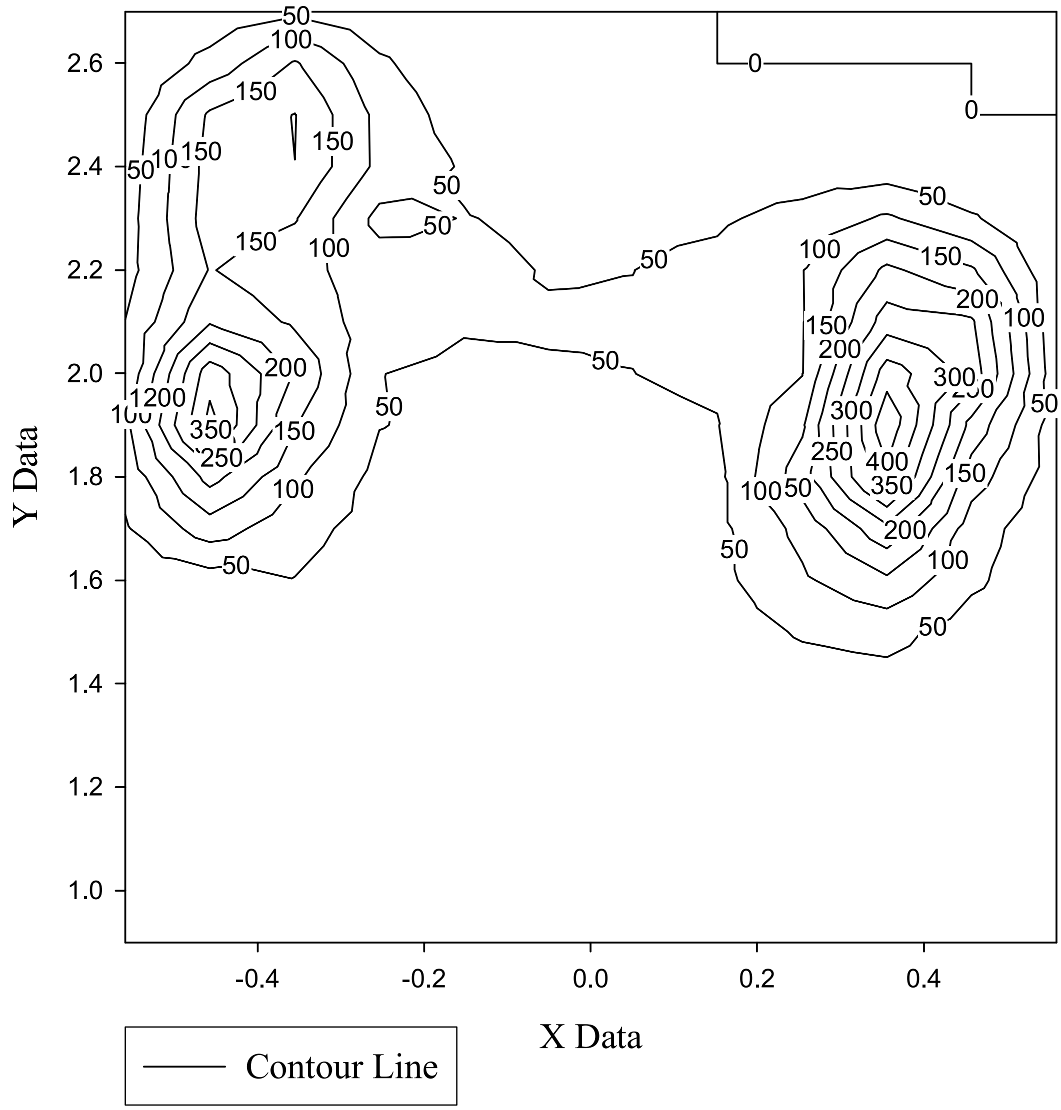


Test 7 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.9	0.9	1.9	0.9	2.8	24.4	1.9	1.9	1.9	1.9	0.9	0.9
1.00	0.0	0.9	1.9	2.8	3.8	9.4	2.8	1.9	3.8	2.8	0.9	0.9
1.10	0.9	1.9	2.8	3.8	5.6	11.3	4.7	4.7	3.8	3.8	2.8	0.9
1.20	1.9	2.8	4.7	5.6	7.5	16.9	8.4	7.5	5.6	5.6	3.8	1.9
1.30	1.9	6.6	8.4	7.5	8.4	13.1	12.2	8.4	15.9	17.8	6.6	3.8
1.40	5.6	13.1	16.9	13.1	13.1	14.1	12.2	15.0	28.1	32.8	18.8	3.8
1.50	11.3	31.9	21.6	15.9	17.8	17.8	18.8	23.4	55.3	66.6	26.3	11.3
1.60	19.7	27.2	48.8	23.4	22.5	30.9	26.3	36.6	91.9	141.6	60.0	10.3
1.70	45.0	125.7	66.6	30.9	25.3	8.4	29.1	36.6	115.3	237.2	74.1	13.1
1.80	62.8	218.5	107.8	35.6	30.9	30.9	32.8	37.5	178.2	386.3	124.7	23.4
1.90	89.1	366.6	153.8	51.6	37.5	36.6	41.3	47.8	141.6	439.8	183.8	22.5
2.00	57.2	331.9	195.0	50.6	42.2	46.9	49.7	57.2	98.5	377.9	282.2	17.8
2.10	50.6	194.1	141.6	69.4	53.4	53.4	52.5	61.0	96.6	273.8	258.8	8.4
2.20	30.9	152.8	114.4	76.9	61.0	47.8	49.7	61.0	97.5	211.0	157.5	2.8
2.30	28.1	175.4	153.8	34.7	51.6	42.2	42.2	44.1	64.7	107.8	56.3	0.0
2.40	22.5	168.8	199.7	87.2	45.0	22.5	19.7	27.2	25.3	22.5	1.9	0.0
2.50	14.1	158.5	201.6	86.3	24.4	7.5	6.6	7.5	5.6	0.9	0.0	0.0
2.60	0.0	66.6	155.7	59.1	9.4	1.9	0.9	0.0	0.0	0.0	0.0	0.0
2.70	0.0	15.0	41.3	12.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 7 Mass Flux (g/m^2-s)

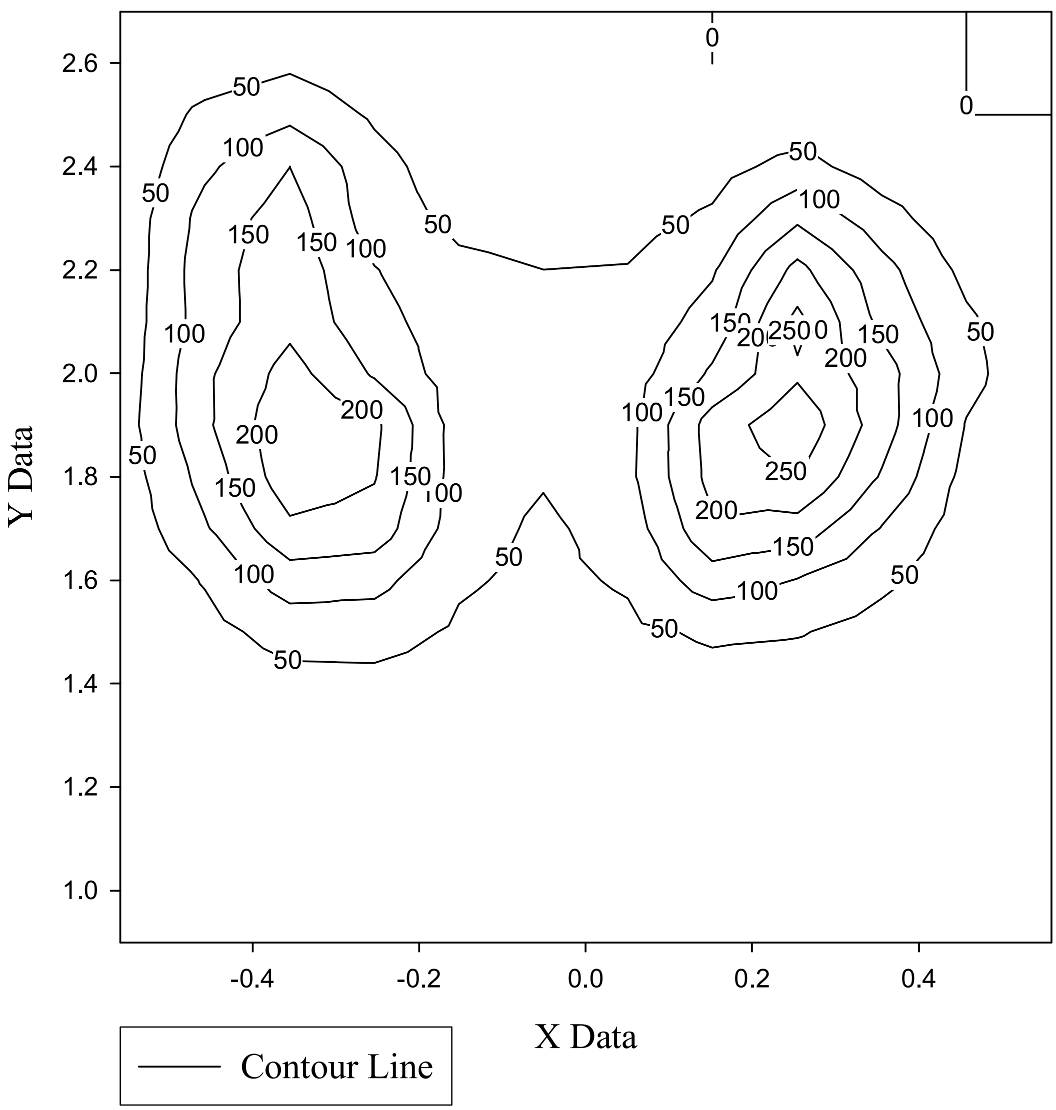


Avg 0º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.4	1.1	2.1	2.3	3.2	9.4	3.9	2.8	2.3	2.8	0.9	0.2
1.00	0.4	1.5	2.8	3.9	4.7	7.7	6.8	4.3	4.3	2.4	0.9	0.9
1.10	0.9	2.6	4.5	6.2	7.5	11.1	7.5	6.8	6.4	3.6	1.3	0.4
1.20	1.7	3.9	9.0	9.0	10.7	15.4	12.8	10.3	9.4	4.9	2.4	0.8
1.30	2.4	8.8	17.6	19.9	17.8	17.4	16.5	19.1	17.3	10.3	3.6	1.3
1.40	4.3	16.5	34.9	36.2	27.9	22.7	25.9	33.9	27.4	18.2	6.6	1.5
1.50	8.4	33.9	69.6	70.9	43.1	28.7	40.3	56.8	53.3	33.0	9.6	3.4
1.60	9.6	53.6	124.7	116.5	56.1	39.0	55.1	127.2	97.9	59.1	18.6	3.2
1.70	13.9	94.3	189.6	178.9	73.1	40.7	72.2	190.2	178.4	97.5	21.8	3.0
1.80	20.8	117.2	233.1	203.3	76.7	54.2	87.0	217.4	252.6	145.2	34.1	6.2
1.90	24.6	139.9	243.8	211.4	75.8	57.0	84.0	222.4	287.1	174.0	47.3	5.4
2.00	19.1	140.8	219.2	144.2	71.5	64.1	75.0	157.7	241.9	172.7	65.8	3.9
2.10	16.7	124.5	186.0	117.2	71.5	60.6	66.2	120.2	264.4	136.7	58.5	2.1
2.20	12.2	128.8	181.7	102.4	61.7	50.3	52.9	94.7	215.5	117.0	36.8	0.6
2.30	11.4	119.3	175.0	74.5	37.9	28.9	30.6	58.1	141.2	71.1	13.9	0.0
2.40	10.3	89.6	150.0	68.5	21.0	10.5	12.8	30.4	67.9	24.4	1.1	0.0
2.50	6.0	62.8	87.2	42.8	7.7	2.3	2.3	6.0	11.8	3.8	0.0	0.0
2.60	0.2	18.9	40.9	16.5	2.1	0.4	0.2	0.0	1.1	0.4	0.0	0.0
2.70	0.0	3.4	8.8	3.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0

All measurements in g/m^2-s

Test 3-7 Average Mass Flux (g/m^2-s)



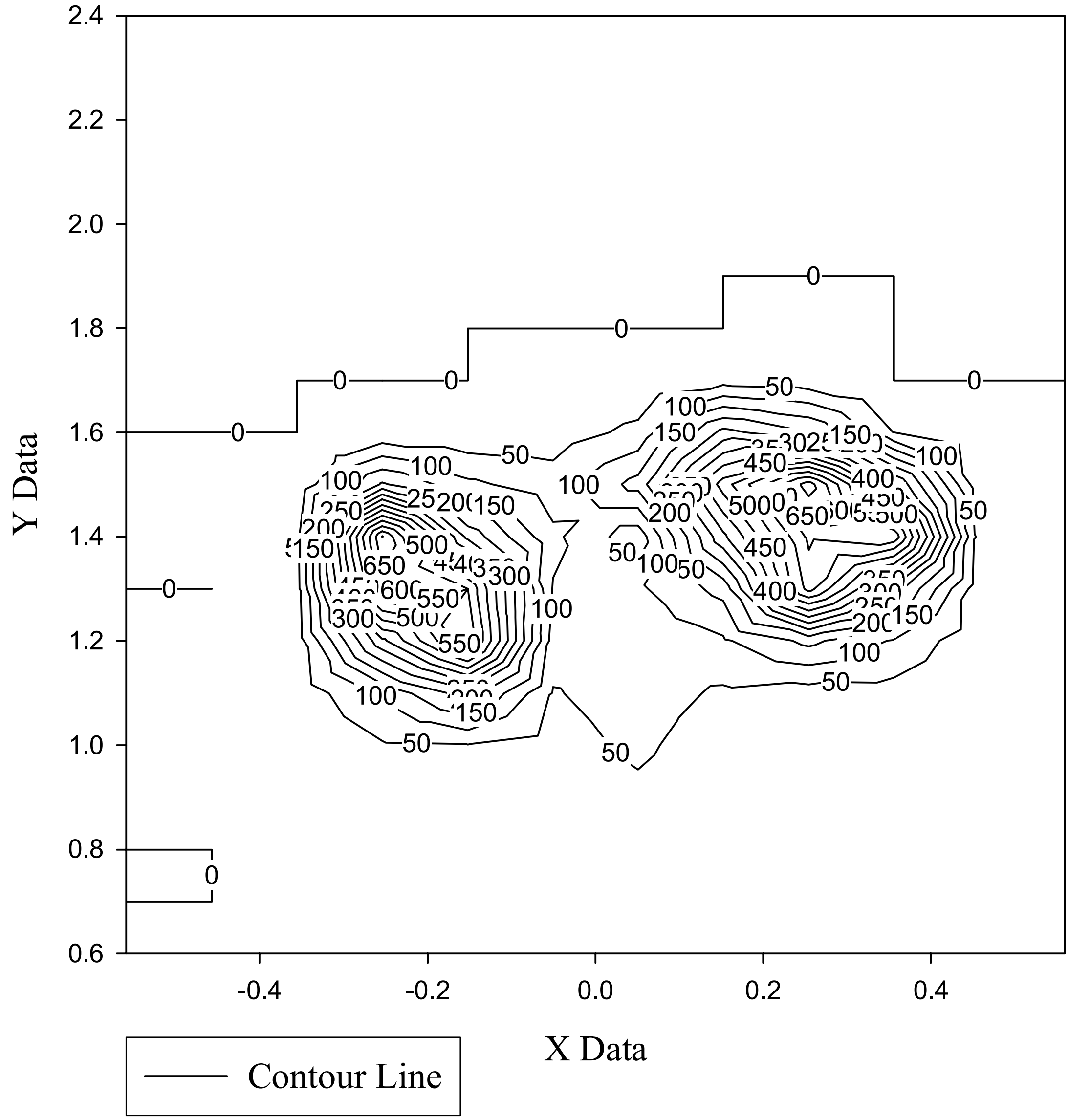
Appendix AI- Aspirated -15º Mass Flux Data

Test 10 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	1.4	1.4	1.4	1.4	2.8	9.8	4.2	1.4	1.4	1.4	0.0
0.70	0.0	0.0	1.4	2.8	2.8	8.4	9.8	5.6	4.2	2.8	1.4	0.0
0.80	0.0	0.0	2.8	11.3	8.4	8.4	18.3	7.0	7.0	4.2	1.4	1.4
0.90	0.0	1.4	5.6	11.3	16.9	19.7	38.0	12.7	12.7	5.6	0.0	1.4
1.00	1.4	1.4	7.0	45.0	47.8	29.5	60.5	19.7	15.5	15.5	4.2	1.4
1.10	0.0	1.4	14.1	109.7	226.5	46.4	73.1	42.2	28.1	30.9	5.6	1.4
1.20	0.0	1.4	25.3	337.6	590.8	76.0	66.1	92.8	163.2	94.2	11.3	1.4
1.30	0.0	0.0	32.4	618.9	550.0	97.1	91.4	167.4	569.7	278.5	15.5	1.4
1.40	0.0	1.4	38.0	700.5	284.1	111.1	18.3	337.6	610.4	635.8	23.9	0.0
1.50	0.0	1.4	5.6	206.8	111.1	71.7	168.8	474.0	725.8	355.9	14.1	0.0
1.60	0.0	0.0	0.0	8.4	8.4	23.9	63.3	267.2	202.5	49.2	1.4	0.0
1.70	0.0	0.0	0.0	0.0	0.0	1.4	7.0	29.5	21.1	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 10 Mass Flux (g/m^2-s)

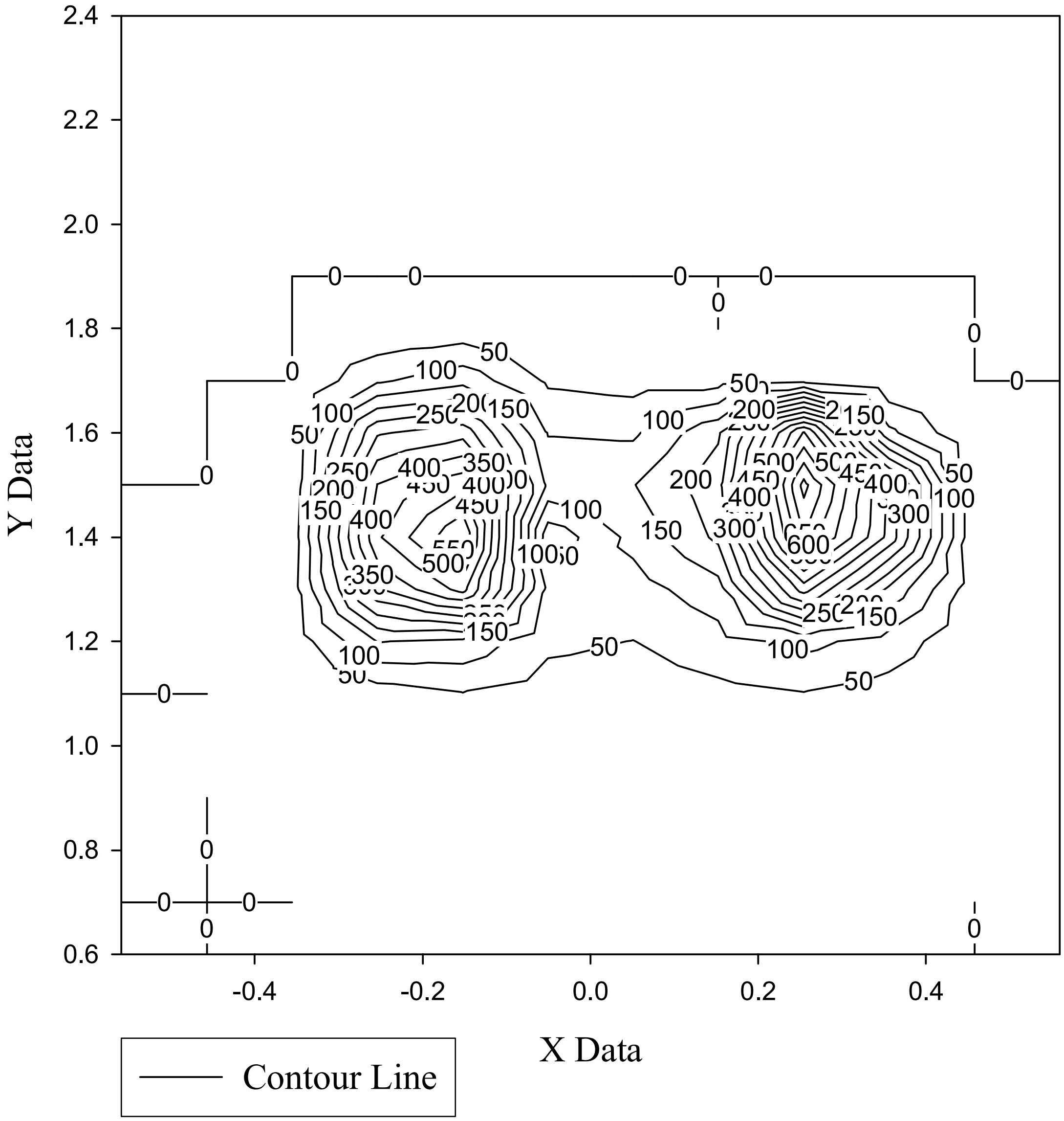


Test 11 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	1.4	1.4	1.4	2.8	4.2	1.4	1.4	1.4	0.0	0.0
0.70	0.0	0.0	0.0	2.8	1.4	4.2	2.8	2.8	2.8	1.4	0.0	1.4
0.80	1.4	0.0	1.4	4.2	5.6	4.2	7.0	5.6	5.6	2.8	1.4	0.0
0.90	1.4	0.0	1.4	4.2	7.0	8.4	11.3	9.8	8.4	2.8	1.4	0.0
1.00	0.0	1.4	4.2	14.1	15.5	18.3	19.7	19.7	16.9	8.4	2.8	1.4
1.10	0.0	0.0	9.8	25.3	47.8	30.9	26.7	36.6	47.8	30.9	4.2	0.0
1.20	0.0	1.4	18.3	151.9	139.2	59.1	49.2	80.2	115.3	77.4	11.3	2.8
1.30	0.0	1.4	26.7	344.6	468.4	85.8	78.8	129.4	422.0	188.5	18.3	1.4
1.40	0.0	1.4	21.1	443.1	597.8	14.1	115.3	211.0	648.4	384.0	8.4	0.0
1.50	0.0	0.0	11.3	400.9	485.3	139.2	147.7	232.1	717.3	391.0	8.4	0.0
1.60	0.0	0.0	5.6	294.0	330.5	97.1	91.4	191.3	555.6	112.5	1.4	0.0
1.70	0.0	0.0	0.0	92.8	133.6	42.2	30.9	29.5	42.2	7.0	0.0	0.0
1.80	0.0	0.0	0.0	7.0	16.9	5.6	1.4	0.0	1.4	1.4	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 11 Mass Flux (g/m^2-s)

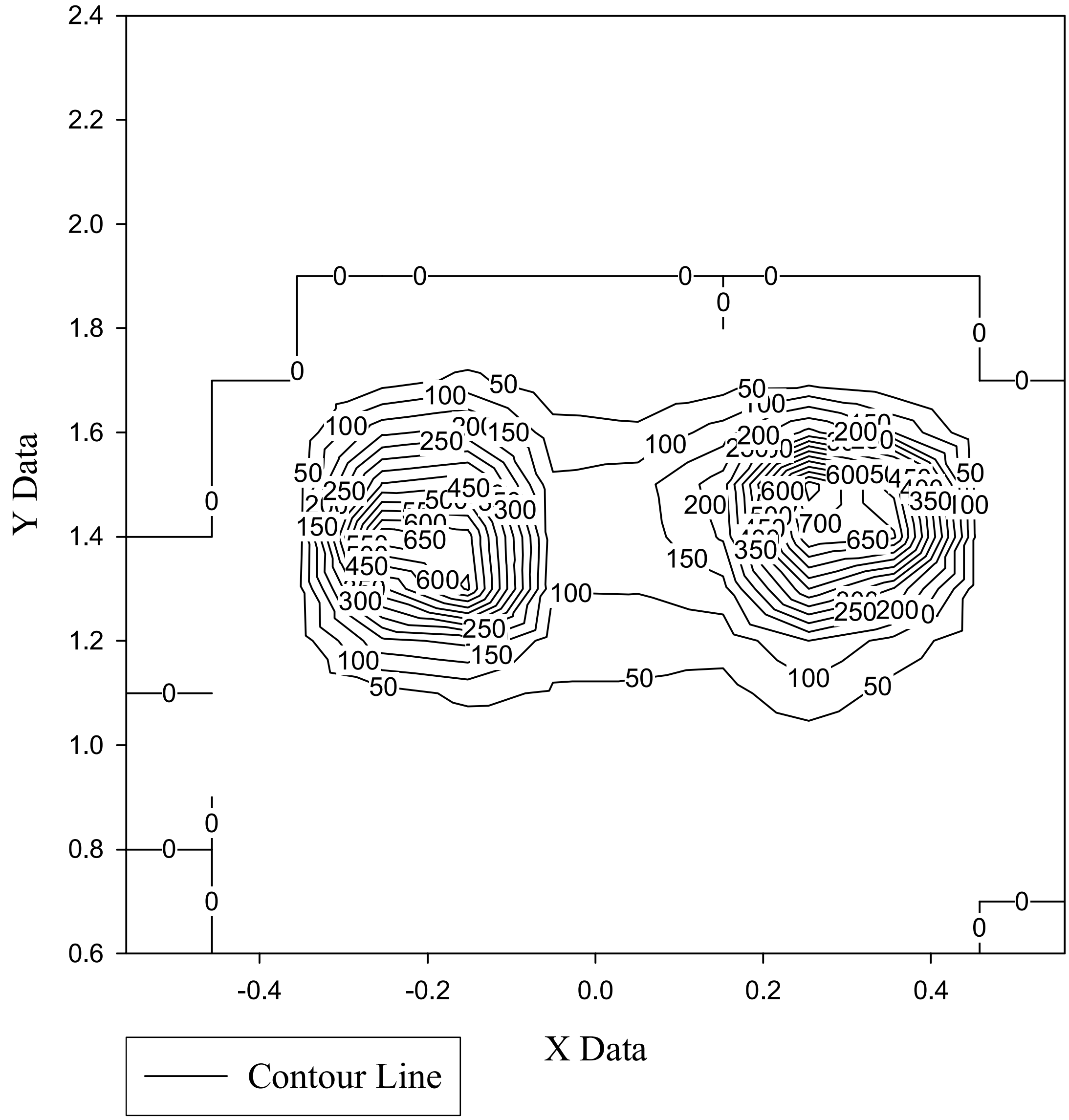


Test 12 -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.0	1.4	1.4	1.4	2.8	7.0	4.2	1.4	1.4	0.0	1.4
0.70	0.0	0.0	1.4	2.8	2.8	2.8	15.5	7.0	2.8	2.8	0.0	0.0
0.80	0.0	0.0	1.4	4.2	4.2	5.6	7.0	8.4	4.2	1.4	1.4	0.0
0.90	1.4	0.0	2.8	7.0	8.4	9.8	14.1	11.3	7.0	5.6	2.8	0.0
1.00	0.0	1.4	4.2	14.1	19.7	30.9	23.9	21.1	22.5	11.3	5.6	1.4
1.10	0.0	0.0	9.8	30.9	60.5	45.0	45.0	33.8	81.6	33.8	7.0	0.0
1.20	0.0	2.8	19.7	187.1	213.8	70.3	63.3	67.5	149.1	80.2	15.5	0.0
1.30	0.0	1.4	26.7	438.8	659.7	102.7	104.1	132.2	450.1	295.4	16.9	1.4
1.40	0.0	0.0	21.1	692.0	623.1	113.9	122.4	206.8	697.7	659.7	19.7	0.0
1.50	0.0	0.0	15.5	405.1	441.7	109.7	129.4	227.9	773.6	578.1	15.5	1.4
1.60	0.0	0.0	4.2	188.5	222.2	68.9	59.1	122.4	265.8	150.5	1.4	0.0
1.70	0.0	0.0	0.0	26.7	61.9	15.5	14.1	22.5	28.1	2.8	0.0	0.0
1.80	0.0	0.0	0.0	2.8	4.2	1.4	1.4	0.0	1.4	1.4	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 12 Mass Flux (g/m^2-s)

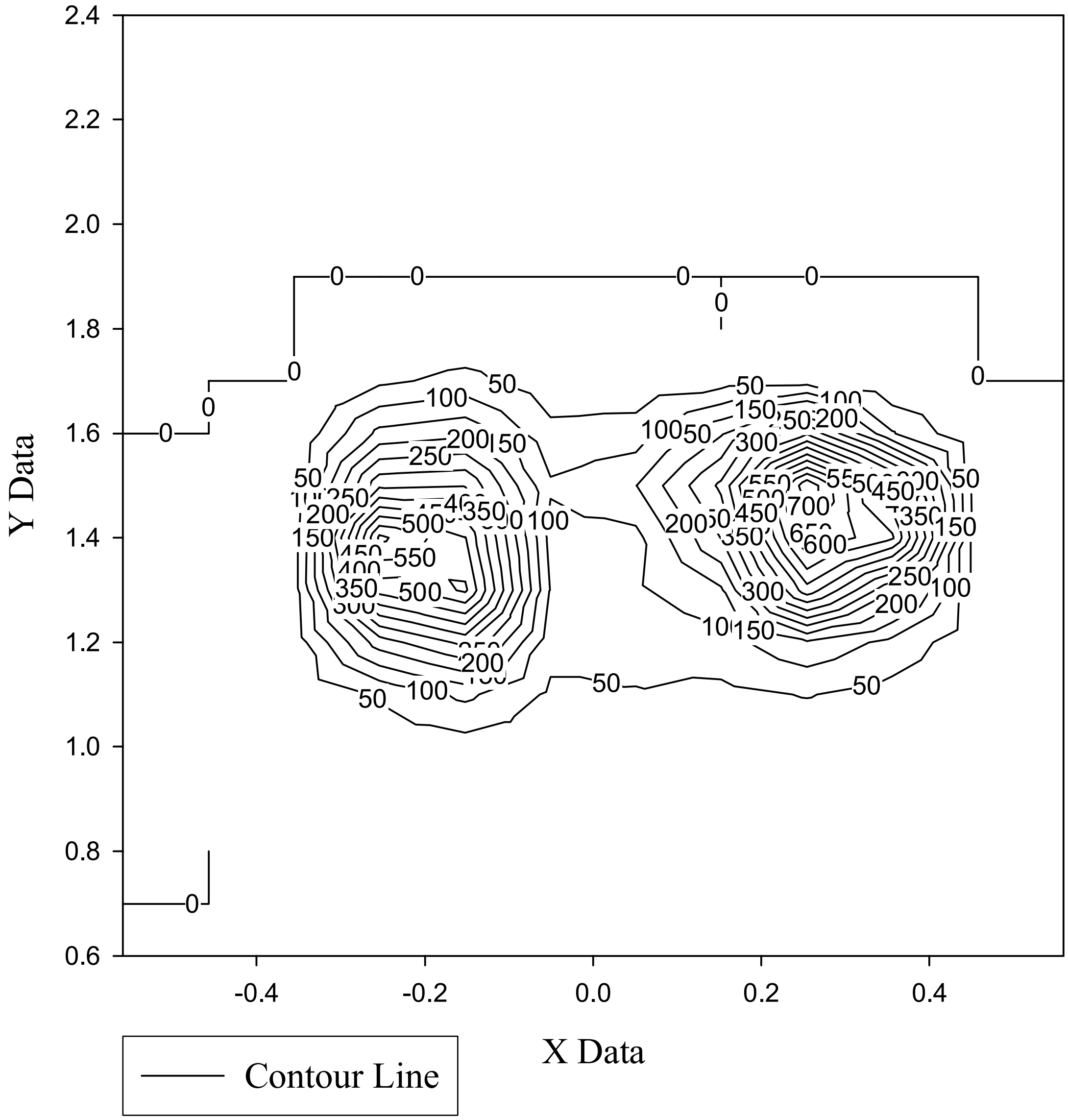


Avg -15º 100 psi asp 10 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.60	0.0	0.5	1.4	1.4	1.4	2.8	7.0	3.3	1.4	1.4	0.5	0.5
0.70	0.0	0.0	0.9	2.8	2.3	5.2	9.4	5.2	3.3	2.3	0.5	0.5
0.80	0.5	0.0	1.9	6.6	6.1	6.1	10.8	7.0	5.6	2.8	1.4	0.5
0.90	0.9	0.5	3.3	7.5	10.8	12.7	21.1	11.3	9.4	4.7	1.4	0.5
1.00	0.5	1.4	5.2	24.4	27.7	26.3	34.7	20.2	18.3	11.7	4.2	1.4
1.10	0.0	0.5	11.3	55.3	111.6	40.8	48.3	37.5	52.5	31.9	5.6	0.5
1.20	0.0	1.9	21.1	225.5	314.6	68.5	59.5	80.2	142.5	83.9	12.7	1.4
1.30	0.0	0.9	28.6	467.4	559.3	95.2	91.4	143.0	480.6	254.1	16.9	1.4
1.40	0.0	0.9	26.7	611.9	501.7	79.7	85.3	251.8	652.2	559.8	17.3	0.0
1.50	0.0	0.5	10.8	337.6	346.0	106.9	148.6	311.3	738.9	441.7	12.7	0.5
1.60	0.0	0.0	3.3	163.6	187.1	63.3	71.3	193.6	341.3	104.1	1.4	0.0
1.70	0.0	0.0	0.0	39.9	65.2	19.7	17.3	27.2	30.5	3.3	0.0	0.0
1.80	0.0	0.0	0.0	3.3	7.0	2.3	0.9	0.0	1.4	0.9	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 10-12 Average Mass Flux (g/m^2-s)



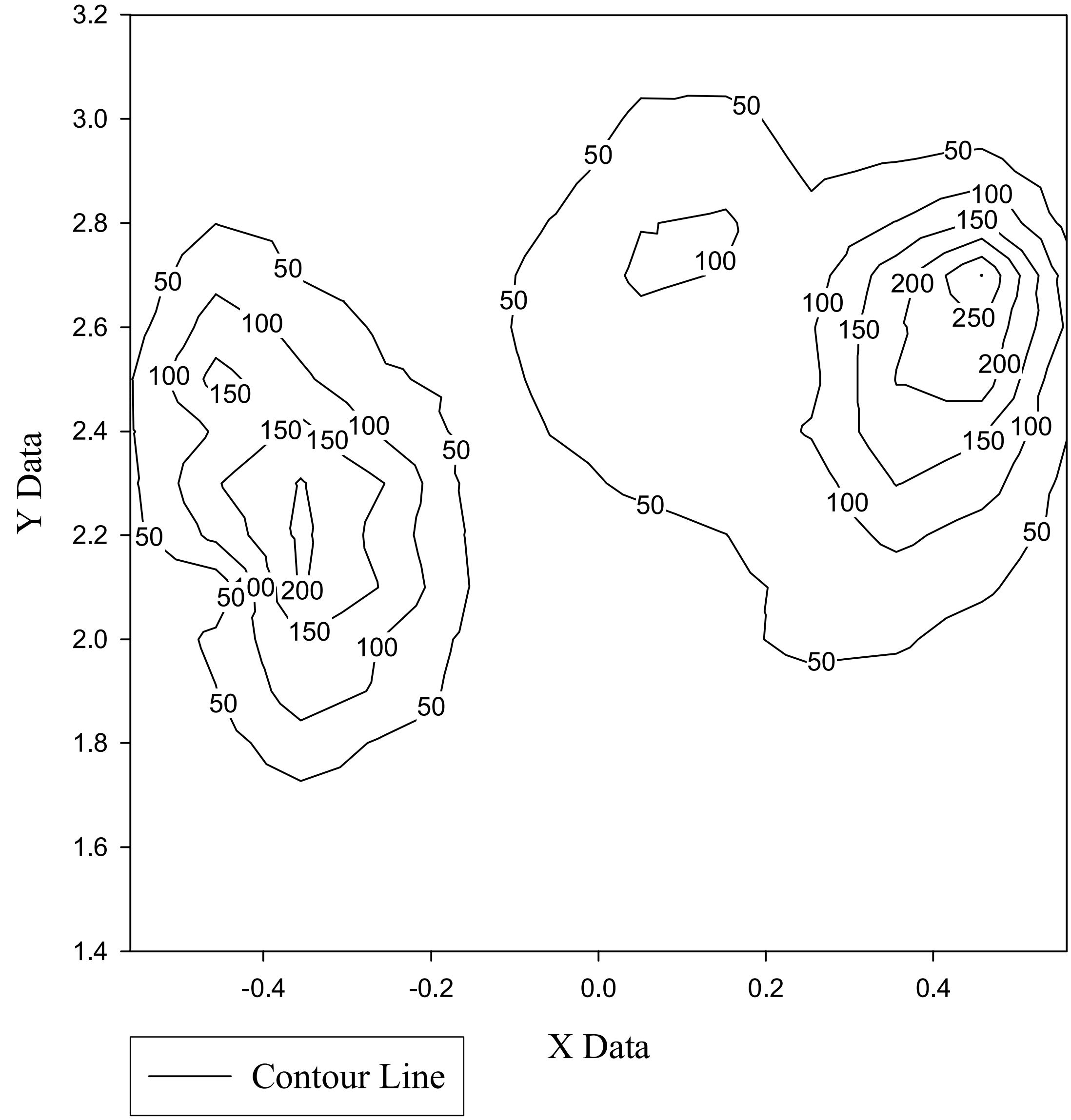
Appendix AJ- Aspirated 15º Mass Flux Data

Test 15 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.9	3.8	4.7	4.7	6.6	14.1	14.1	8.4	5.6	5.6	2.8	1.9
1.50	2.8	5.6	8.4	11.3	9.4	16.9	13.1	9.4	8.4	5.6	2.8	1.9
1.60	3.8	12.2	18.8	20.6	11.3	26.3	15.0	15.0	13.1	10.3	4.7	3.8
1.70	5.6	24.4	39.4	30.0	25.3	17.8	26.3	17.8	17.8	17.8	12.2	4.7
1.80	10.3	30.0	78.8	42.2	27.2	22.5	27.2	29.1	30.9	28.1	14.1	5.6
1.90	10.3	48.8	127.5	91.9	27.2	24.4	30.9	30.9	37.5	30.9	24.4	3.8
2.00	15.0	59.1	147.2	95.6	37.5	30.0	32.8	41.3	61.0	57.2	29.1	8.4
2.10	16.9	17.8	205.4	144.4	47.8	35.6	36.6	43.1	57.2	74.1	58.1	19.7
2.20	35.6	112.5	211.0	127.5	43.1	33.8	40.3	49.7	70.3	112.5	77.8	32.8
2.30	41.3	146.3	203.5	149.1	33.8	42.2	55.3	63.8	77.8	151.9	122.8	37.5
2.40	46.9	105.0	164.1	89.1	35.6	51.6	61.0	70.3	104.1	185.7	158.5	52.5
2.50	47.8	167.8	108.8	54.4	39.4	56.3	66.6	77.8	88.1	201.6	229.7	53.4
2.60	29.1	124.7	83.5	40.3	40.3	61.0	88.1	76.9	95.6	193.2	248.5	92.8
2.70	15.9	86.3	46.9	30.0	30.9	67.5	107.8	97.5	76.9	180.0	301.0	76.9
2.80	9.4	49.7	38.4	7.5	23.4	53.4	98.5	106.0	61.0	102.2	158.5	35.6
2.90	7.5	19.7	16.9	8.4	15.0	35.6	73.1	84.4	43.1	56.3	71.3	16.9
3.00	0.9	0.9	3.8	4.7	10.3	24.4	57.2	66.6	27.2	22.5	22.5	2.8
3.10	0.0	1.9	1.9	0.9	3.8	11.3	39.4	29.1	11.3	2.8	1.9	0.0
3.20	0.0	0.0	0.0	0.0	0.0	0.9	14.1	10.3	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 15 Mass Flux (g/m^2-s)

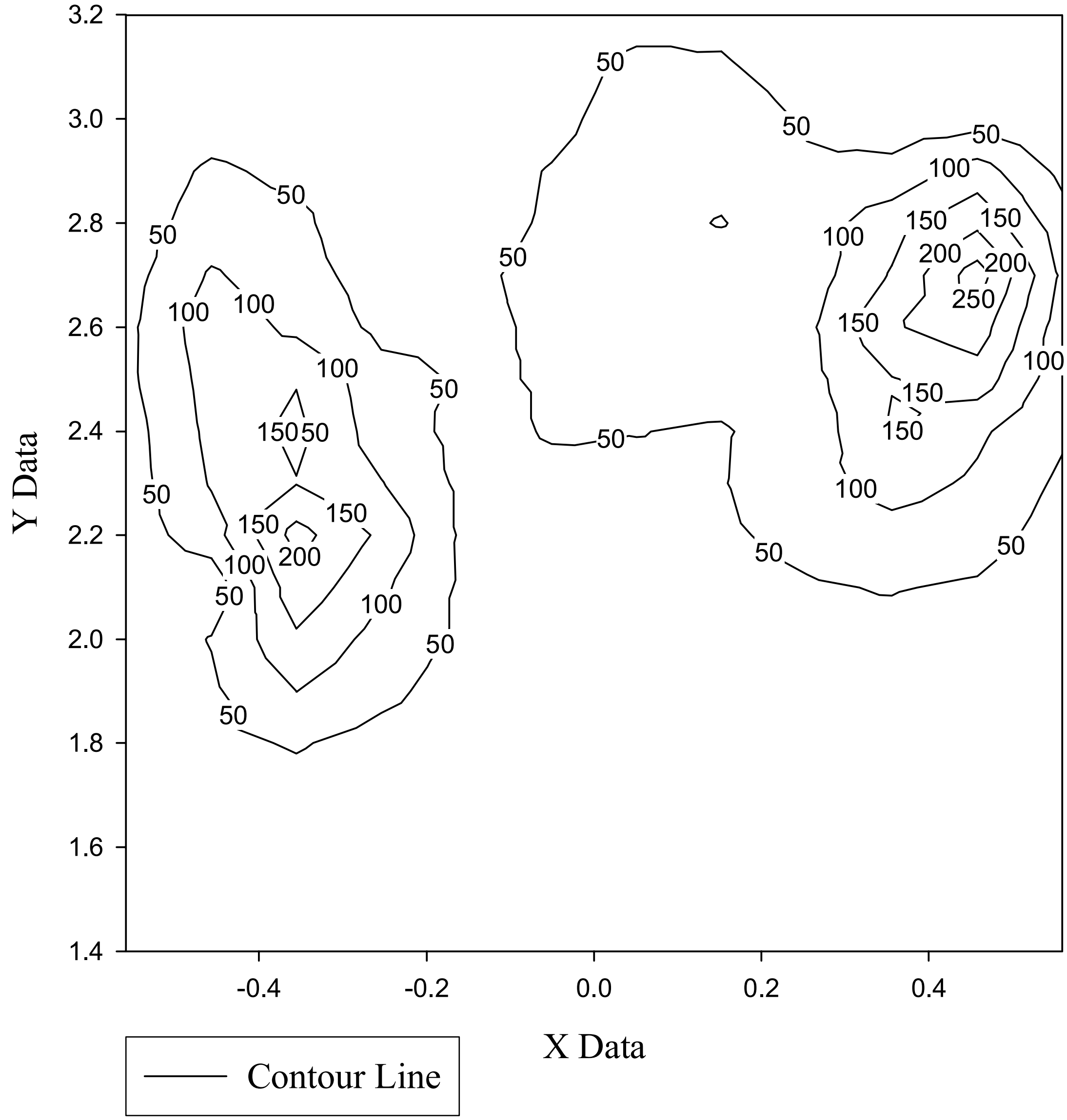


Test 16 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	1.9	3.8	4.7	3.8	8.4	7.5	7.5	6.6	4.7	3.8	1.9	0.9
1.50	2.8	5.6	9.4	9.4	10.3	13.1	9.4	7.5	5.6	5.6	2.8	1.9
1.60	3.8	8.4	17.8	14.1	11.3	13.1	10.3	11.3	9.4	10.3	4.7	1.9
1.70	9.4	15.0	31.9	19.7	14.1	15.9	16.9	13.1	15.0	12.2	8.4	2.8
1.80	7.5	38.4	54.4	31.9	20.6	18.8	16.9	23.4	23.4	23.4	12.2	4.7
1.90	10.3	42.2	100.3	62.8	25.3	26.3	23.4	23.4	22.5	31.9	18.8	6.6
2.00	14.1	52.5	141.6	80.6	38.4	27.2	29.1	31.9	40.3	37.5	21.6	13.1
2.10	13.1	15.0	181.9	108.8	38.4	33.8	33.8	35.6	45.9	52.5	44.1	14.1
2.20	22.5	77.8	218.5	139.7	37.5	32.8	36.6	43.1	62.8	80.6	72.2	27.2
2.30	25.3	104.1	148.2	102.2	36.6	39.4	45.0	47.8	78.8	121.0	91.9	41.3
2.40	28.1	112.5	161.3	75.0	34.7	53.4	50.6	46.9	67.5	155.7	108.8	57.2
2.50	38.4	119.1	147.2	66.6	44.1	53.4	63.8	63.8	84.4	147.2	177.2	69.4
2.60	37.5	130.3	89.1	37.5	41.3	56.3	76.0	70.3	88.1	195.0	226.9	72.2
2.70	30.0	106.0	69.4	28.1	41.3	62.8	79.7	73.1	72.2	154.7	275.7	90.0
2.80	26.3	71.3	61.9	6.6	30.0	56.3	86.3	102.2	72.2	130.3	187.5	69.4
2.90	18.8	58.1	38.4	19.7	23.4	53.4	84.4	87.2	58.1	63.8	123.8	37.5
3.00	0.9	26.3	17.8	14.1	14.1	32.8	80.6	81.6	44.1	22.5	27.2	12.2
3.10	1.9	8.4	4.7	4.7	11.3	15.0	69.4	56.3	26.3	15.0	3.8	1.9
3.20	0.0	0.9	0.0	0.0	1.9	7.5	20.6	35.6	7.5	0.9	0.9	0.9

All measurements in g/m^2-s

Test 16 Mass Flux (g/m^2-s)

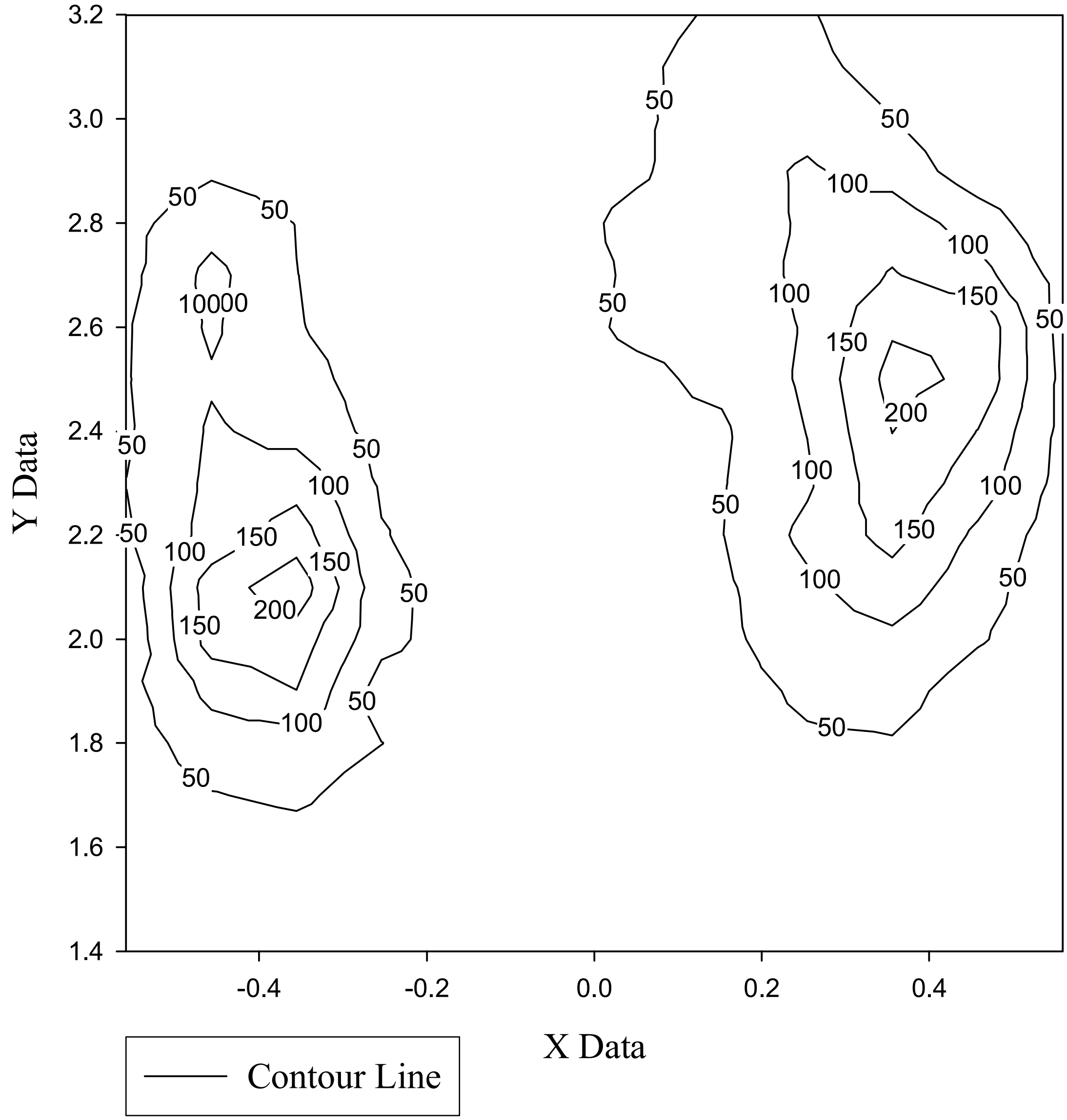


Test 18 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	3.8	6.6	7.5	6.6	8.4	8.4	7.5	8.4	7.5	7.5	3.8	1.9
1.50	7.5	11.3	12.2	14.1	12.2	13.1	11.3	12.2	13.1	12.2	5.6	1.9
1.60	7.5	25.3	30.9	20.6	15.0	15.0	15.9	15.0	17.8	15.0	8.4	3.8
1.70	21.6	47.8	58.1	28.1	15.0	18.8	15.9	17.8	23.4	28.1	19.7	4.7
1.80	25.3	76.0	76.0	50.6	18.8	17.8	21.6	29.1	44.1	46.9	23.4	8.4
1.90	30.9	113.5	149.1	27.2	19.7	19.7	20.6	30.9	58.1	67.5	27.2	4.7
2.00	8.4	171.6	177.2	64.7	21.6	19.7	24.4	38.4	78.8	90.0	54.4	21.6
2.10	19.7	175.4	231.6	66.6	22.5	24.4	30.9	41.3	90.0	128.5	69.4	16.9
2.20	44.1	117.2	175.4	53.4	19.7	22.5	30.9	48.8	113.5	166.0	90.0	20.6
2.30	50.6	109.7	131.3	43.1	28.1	32.8	37.5	46.9	92.8	186.6	126.6	31.9
2.40	44.1	106.0	83.5	34.7	23.4	29.1	40.3	43.1	101.3	200.7	149.1	36.6
2.50	46.9	95.6	65.6	30.0	27.2	31.9	41.3	59.1	108.8	216.6	189.4	36.6
2.60	45.9	106.9	52.5	29.1	25.3	34.7	57.2	61.9	105.0	194.1	193.2	30.9
2.70	35.6	114.4	50.6	25.3	20.6	30.9	56.3	72.2	110.6	153.8	120.0	29.1
2.80	34.7	81.6	48.8	18.8	17.8	27.2	64.7	76.0	106.0	129.4	76.9	9.4
2.90	18.8	43.1	30.0	14.1	11.3	23.4	43.1	80.6	106.0	80.6	23.4	0.0
3.00	0.9	14.1	17.8	5.6	4.7	14.1	43.1	70.3	85.3	51.6	8.4	0.0
3.10	0.0	3.8	5.6	3.8	3.8	9.4	36.6	80.6	64.7	30.0	1.9	0.0
3.20	0.0	0.0	0.0	0.0	0.0	2.8	26.3	60.0	55.3	12.2	0.0	0.0

All measurements in g/m^2-s

Test 18 Mass Flux (g/m^2-s)

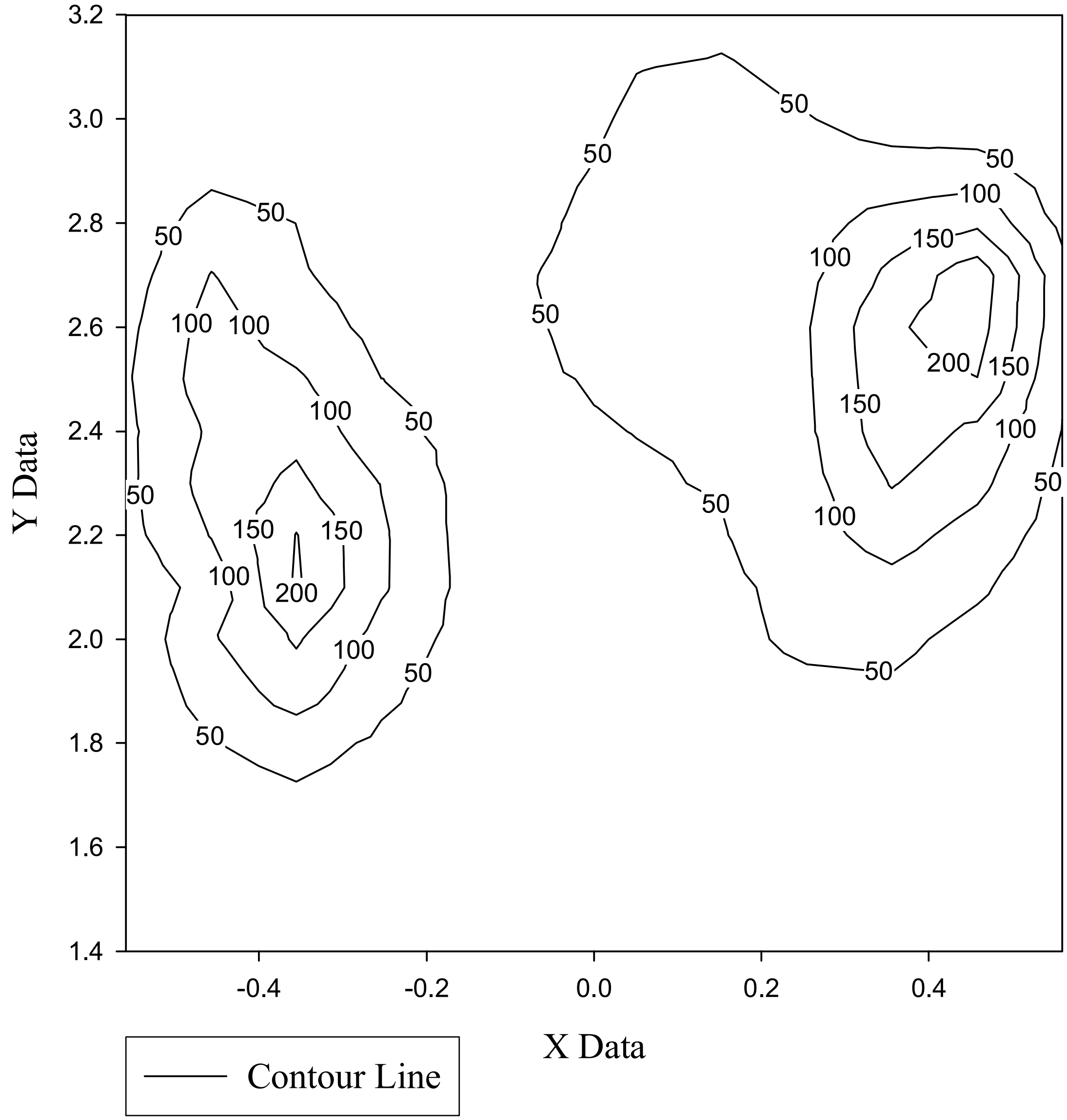


Avg 15º 100 psi asp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	2.2	4.7	5.6	5.0	7.8	10.0	9.7	7.8	5.9	5.6	2.8	1.6
1.50	4.4	7.5	10.0	11.6	10.6	14.4	11.3	9.7	9.1	7.8	3.8	1.9
1.60	5.0	15.3	22.5	18.4	12.5	18.1	13.8	13.8	13.4	11.9	5.9	3.1
1.70	12.2	29.1	43.1	25.9	18.1	17.5	19.7	16.3	18.8	19.4	13.4	4.1
1.80	14.4	48.1	69.7	41.6	22.2	19.7	21.9	27.2	32.8	32.8	16.6	6.3
1.90	17.2	68.1	125.7	60.6	24.1	23.4	25.0	28.4	39.4	43.4	23.4	5.0
2.00	12.5	94.4	155.3	80.3	32.5	25.6	28.8	37.2	60.0	61.6	35.0	14.4
2.10	16.6	69.4	206.3	106.6	36.3	31.3	33.8	40.0	64.4	85.0	57.2	16.9
2.20	34.1	102.5	201.6	106.9	33.4	29.7	35.9	47.2	82.2	119.7	80.0	26.9
2.30	39.1	120.0	161.0	98.1	32.8	38.1	45.9	52.8	83.1	153.2	113.8	36.9
2.40	39.7	107.8	136.3	66.3	31.3	44.7	50.6	53.4	91.0	180.7	138.8	48.8
2.50	44.4	127.5	107.2	50.3	36.9	47.2	57.2	66.9	93.8	188.5	198.8	53.1
2.60	37.5	120.7	75.0	35.6	35.6	50.6	73.8	69.7	96.3	194.1	222.9	65.3
2.70	27.2	102.2	55.6	27.8	30.9	53.8	81.3	81.0	86.6	162.8	232.2	65.3
2.80	23.4	67.5	49.7	10.9	23.8	45.6	83.1	94.7	79.7	120.7	141.0	38.1
2.90	15.0	40.3	28.4	14.1	16.6	37.5	66.9	84.1	69.1	66.9	72.8	18.1
3.00	0.9	13.8	13.1	8.1	9.7	23.8	60.3	72.8	52.2	32.2	19.4	5.0
3.10	0.6	4.7	4.1	3.1	6.3	11.9	48.4	55.3	34.1	15.9	2.5	0.6
3.20	0.0	0.3	0.0	0.0	0.6	3.8	20.3	35.3	20.9	4.4	0.3	0.3

All measurements in g/m^2-s

Test 15-18 Average Mass Flux (g/m^2-s)



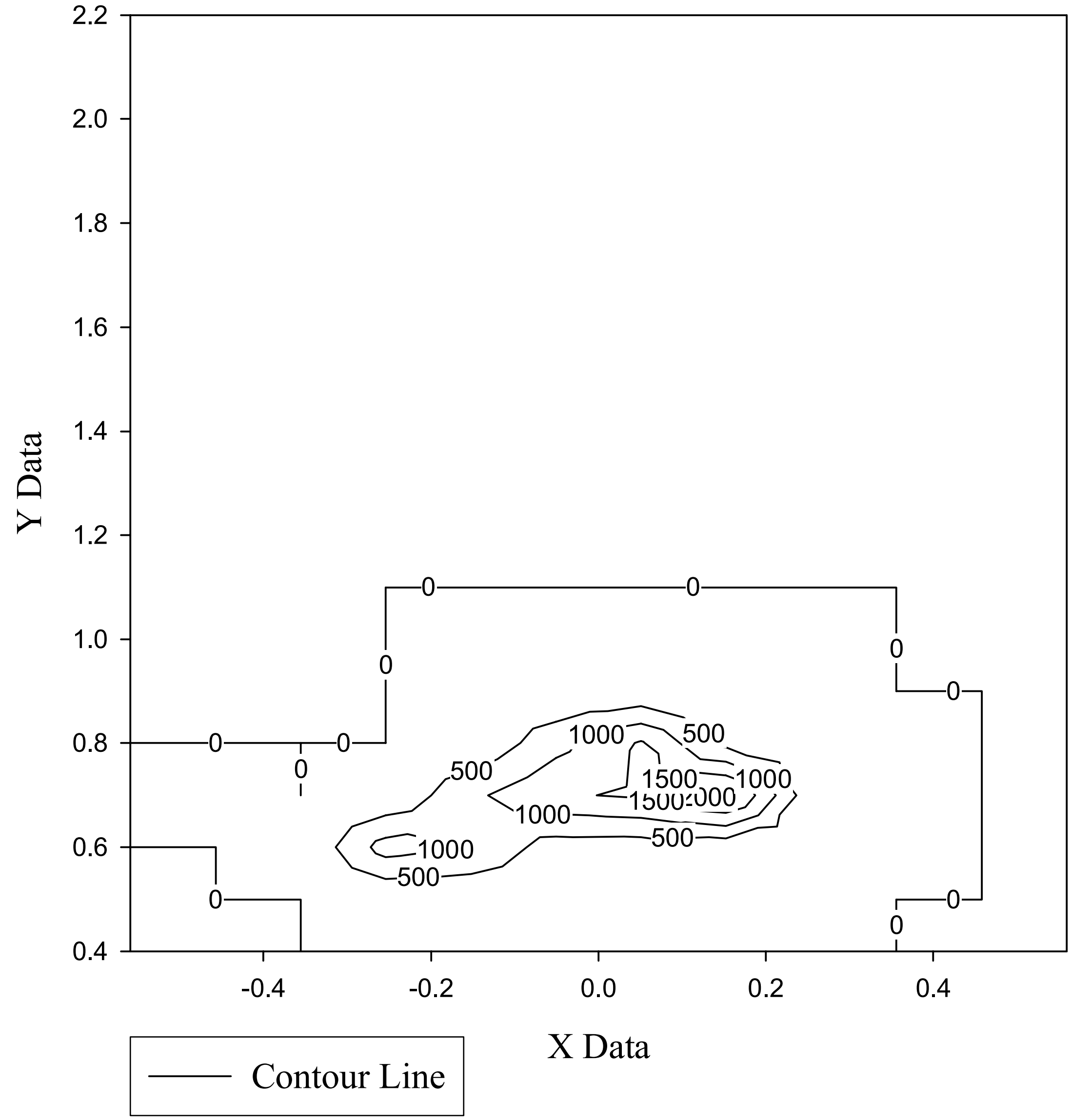
Appendix AK- Nonaspirated 0º Mass Flux Data

Test 23 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	2.8	22.5	8.4	5.6	2.8	2.8	0.0	0.0	0.0
0.50	0.0	0.0	0.0	50.6	45.0	56.3	50.6	25.3	2.8	0.0	0.0	0.0
0.60	0.0	0.0	2.8	1218.1	976.2	250.4	244.7	140.7	8.4	2.8	0.0	0.0
0.70	0.0	2.8	0.0	53.4	891.8	1431.9	1575.3	2208.3	146.3	2.8	0.0	0.0
0.80	0.0	0.0	0.0	0.0	36.6	832.7	1555.7	340.4	5.6	2.8	0.0	0.0
0.90	0.0	0.0	0.0	0.0	2.8	36.6	73.1	14.1	5.6	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	2.8	2.8	5.6	2.8	2.8	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 23 Mass Flux (g/m^2-s)

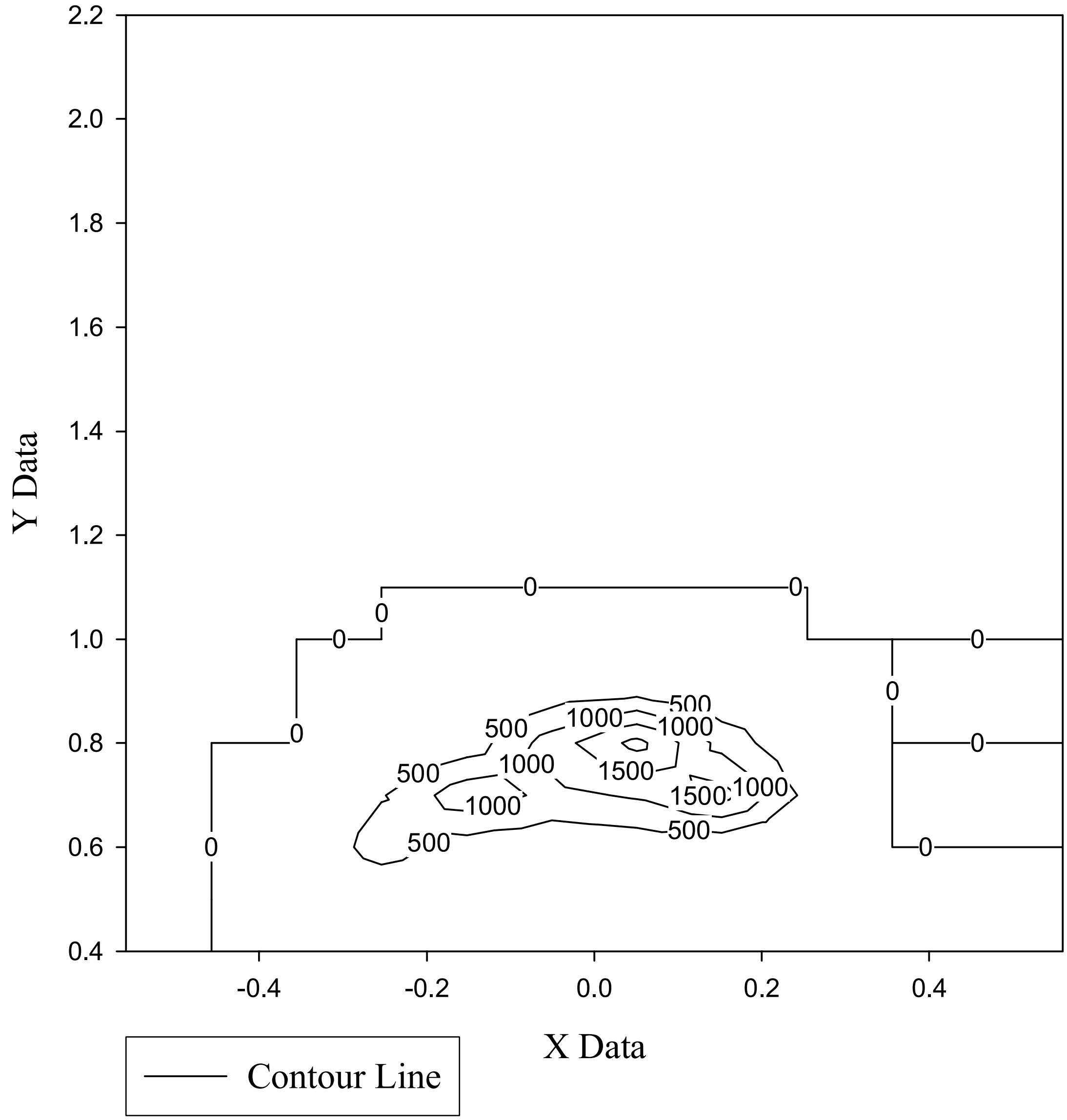


Test 24 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	2.8	2.8	2.8	11.3	5.6	2.8	2.8	0.0	0.0	0.0
0.50	0.0	0.0	2.8	5.6	5.6	19.7	25.3	11.3	8.4	2.8	2.8	0.0
0.60	0.0	0.0	2.8	742.7	244.7	123.8	160.3	33.8	14.1	0.0	0.0	0.0
0.70	0.0	0.0	2.8	461.4	1336.2	852.4	1066.2	1693.5	340.4	0.0	0.0	0.0
0.80	0.0	0.0	0.0	8.4	194.1	1246.2	2163.3	824.2	5.6	0.0	0.0	0.0
0.90	0.0	0.0	0.0	2.8	8.4	174.4	309.4	39.4	2.8	0.0	2.8	0.0
1.00	0.0	0.0	0.0	0.0	2.8	11.3	14.1	5.6	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 24 Mass Flux (g/m^2-s)

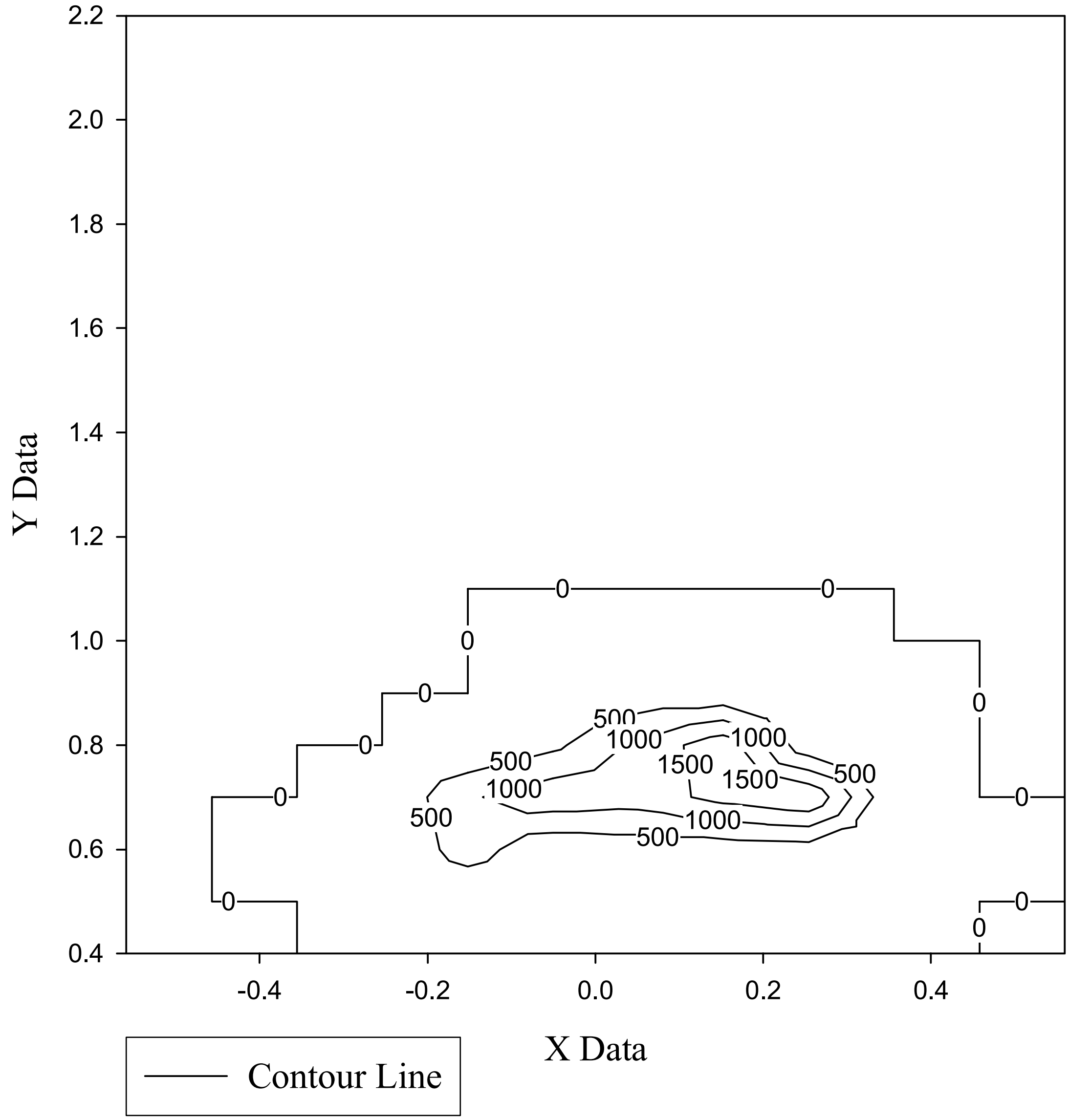


Test 25 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	2.8	8.4	16.9	8.4	5.6	2.8	0.0	0.0
0.50	0.0	0.0	0.0	2.8	8.4	19.7	39.4	39.4	11.3	2.8	0.0	0.0
0.60	0.0	0.0	2.8	11.3	737.0	104.1	216.6	222.2	267.2	2.8	2.8	0.0
0.70	0.0	0.0	0.0	33.8	928.3	1341.9	1235.0	1662.6	1957.9	33.8	0.0	0.0
0.80	0.0	0.0	0.0	0.0	14.1	382.6	1119.6	1828.5	115.3	2.8	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	19.7	101.3	104.1	8.4	2.8	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	2.8	8.4	11.3	2.8	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 25 Mass Flux (g/m^2-s)

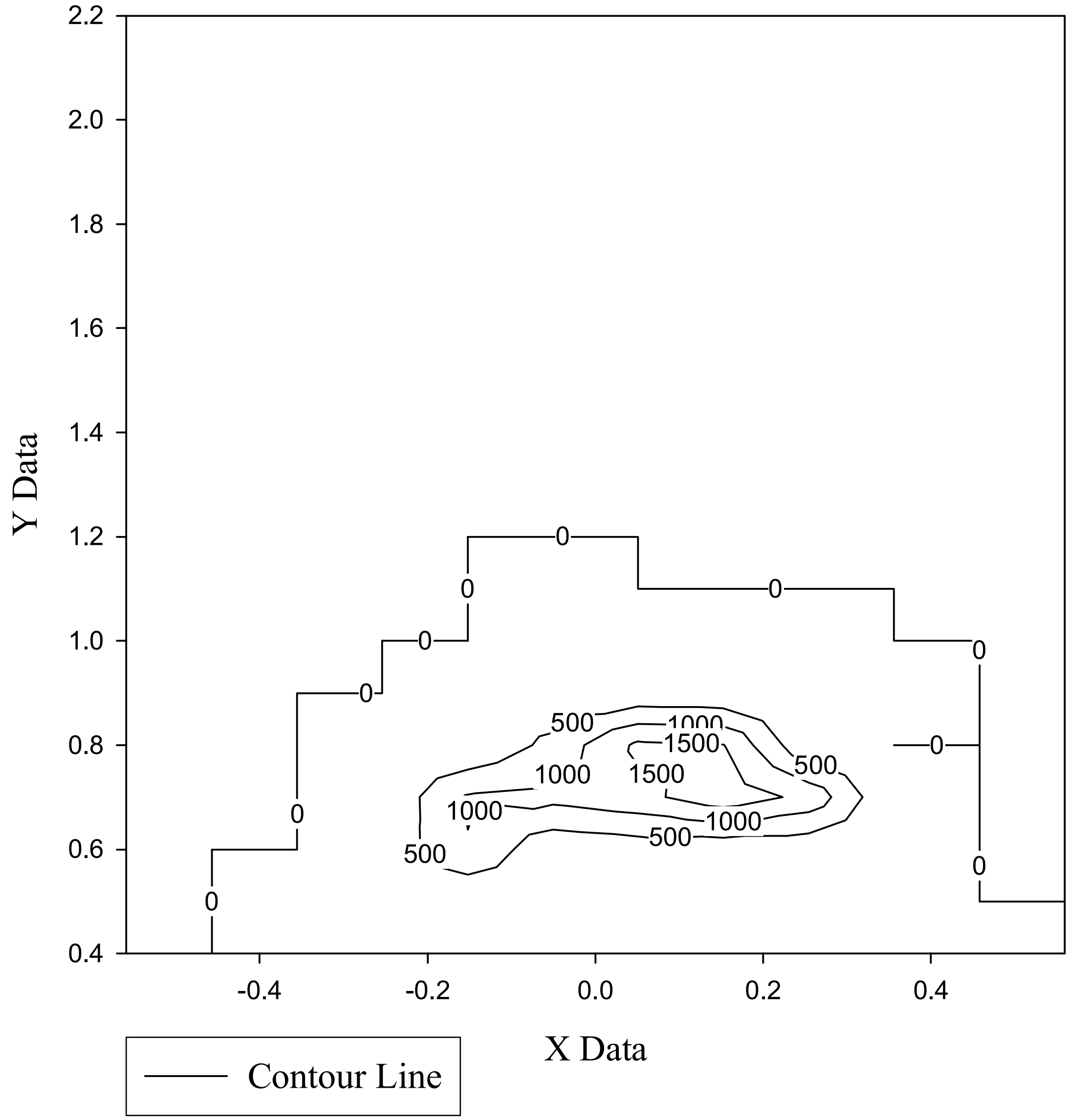


Test 26 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	2.8	0.0	5.6	8.4	22.5	2.8	0.0	0.0	2.8	0.0
0.50	0.0	0.0	2.8	2.8	2.8	22.5	39.4	25.3	5.6	2.8	0.0	0.0
0.60	0.0	0.0	0.0	123.8	967.7	98.5	219.4	121.0	129.4	8.4	0.0	0.0
0.70	0.0	0.0	0.0	76.0	1052.1	1150.6	1344.7	1822.9	1355.9	8.4	0.0	0.0
0.80	0.0	0.0	0.0	2.8	16.9	652.6	1597.8	1513.5	56.3	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	2.8	22.5	118.2	95.6	11.3	2.8	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	2.8	8.4	8.4	5.6	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 26 Mass Flux (g/m^2-s)

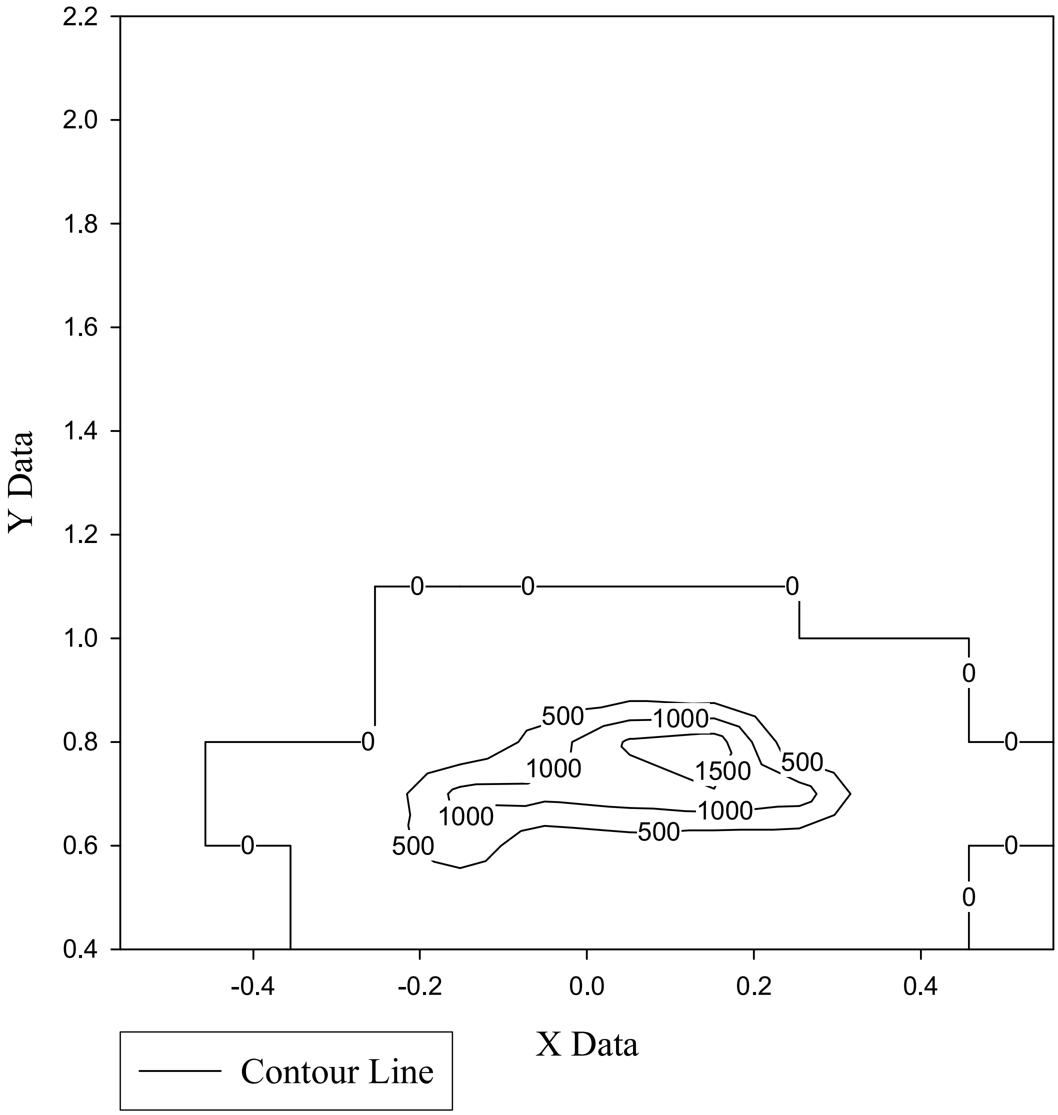


Test 27 0º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	2.8	2.8	5.6	0.0	0.0	0.0	0.0	0.0
0.50	0.0	0.0	0.0	2.8	2.8	30.9	25.3	16.9	5.6	2.8	0.0	0.0
0.60	0.0	0.0	0.0	208.2	874.9	95.6	227.9	101.3	118.2	2.8	0.0	0.0
0.70	0.0	0.0	2.8	118.2	1142.1	1156.2	1294.0	1471.3	1265.9	5.6	2.8	0.0
0.80	0.0	0.0	0.0	0.0	14.1	725.8	1569.7	1761.0	47.8	2.8	0.0	0.0
0.90	0.0	0.0	0.0	0.0	2.8	50.6	211.0	70.3	5.6	2.8	0.0	0.0
1.00	0.0	0.0	0.0	0.0	2.8	5.6	14.1	8.4	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 27 Mass Flux (g/m^2-s)

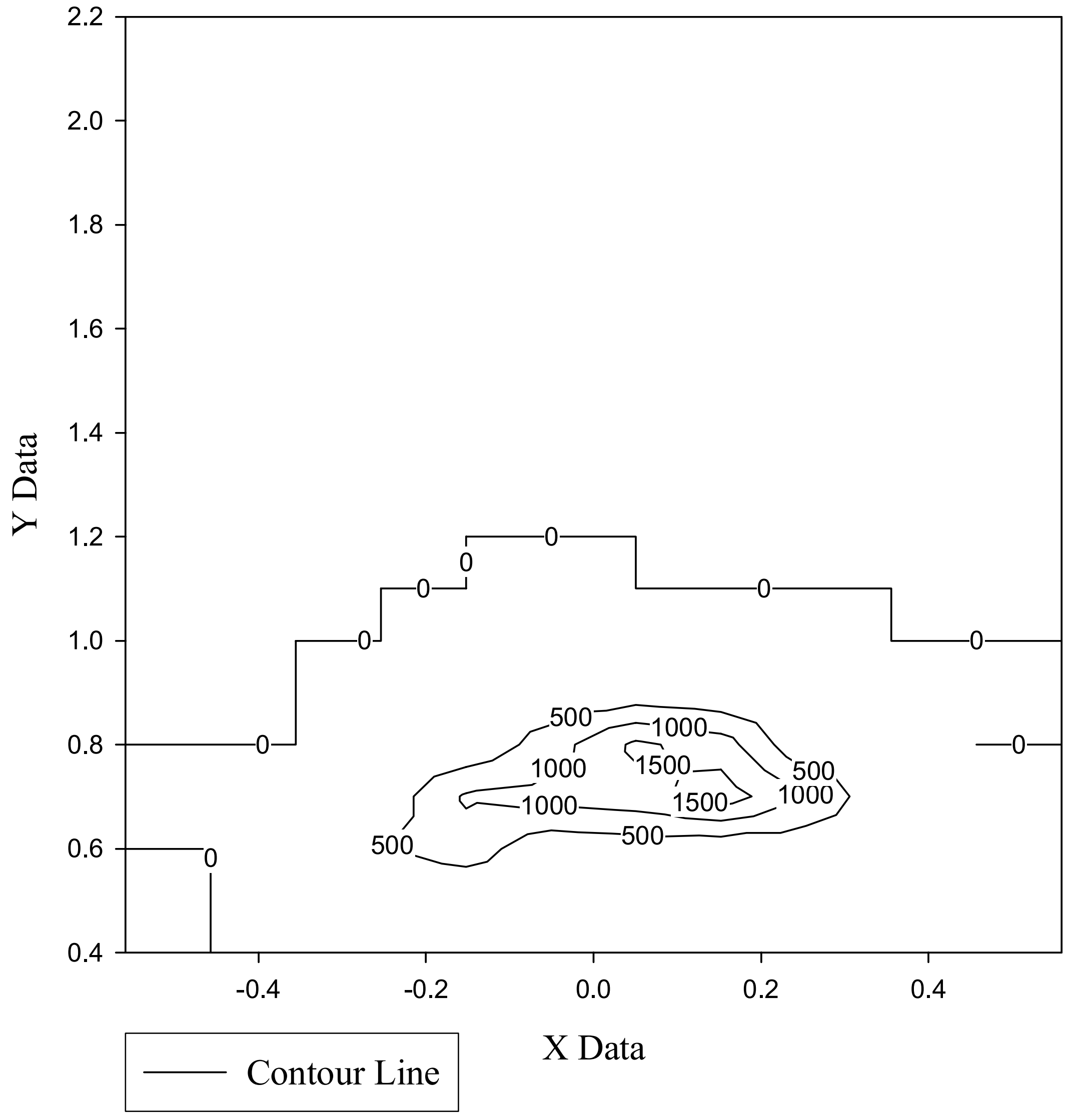


Avg 0º 100 psi nonasp 15 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
1.40	0.0	0.0	1.7	1.1	7.9	9.0	14.6	3.9	2.3	0.6	1.1	0.0
1.50	0.0	0.0	1.7	12.9	12.9	28.1	38.8	25.3	6.8	2.3	0.6	0.0
1.60	0.0	0.0	1.7	443.9	778.7	135.0	212.1	127.7	109.7	4.5	0.6	0.0
1.70	0.0	0.6	0.6	140.1	1052.1	1185.4	1313.2	1842.0	1031.3	10.7	0.0	0.0
1.80	0.0	0.0	0.0	2.8	55.7	753.4	1606.9	1204.0	47.8	1.1	0.0	0.0
1.90	0.0	0.0	0.0	0.6	3.4	55.1	144.0	69.8	7.9	1.7	0.6	0.0
2.00	0.0	0.0	0.0	0.0	1.1	4.5	9.0	7.3	3.4	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 23-27 Average Mass Flux (g/m^2-s)



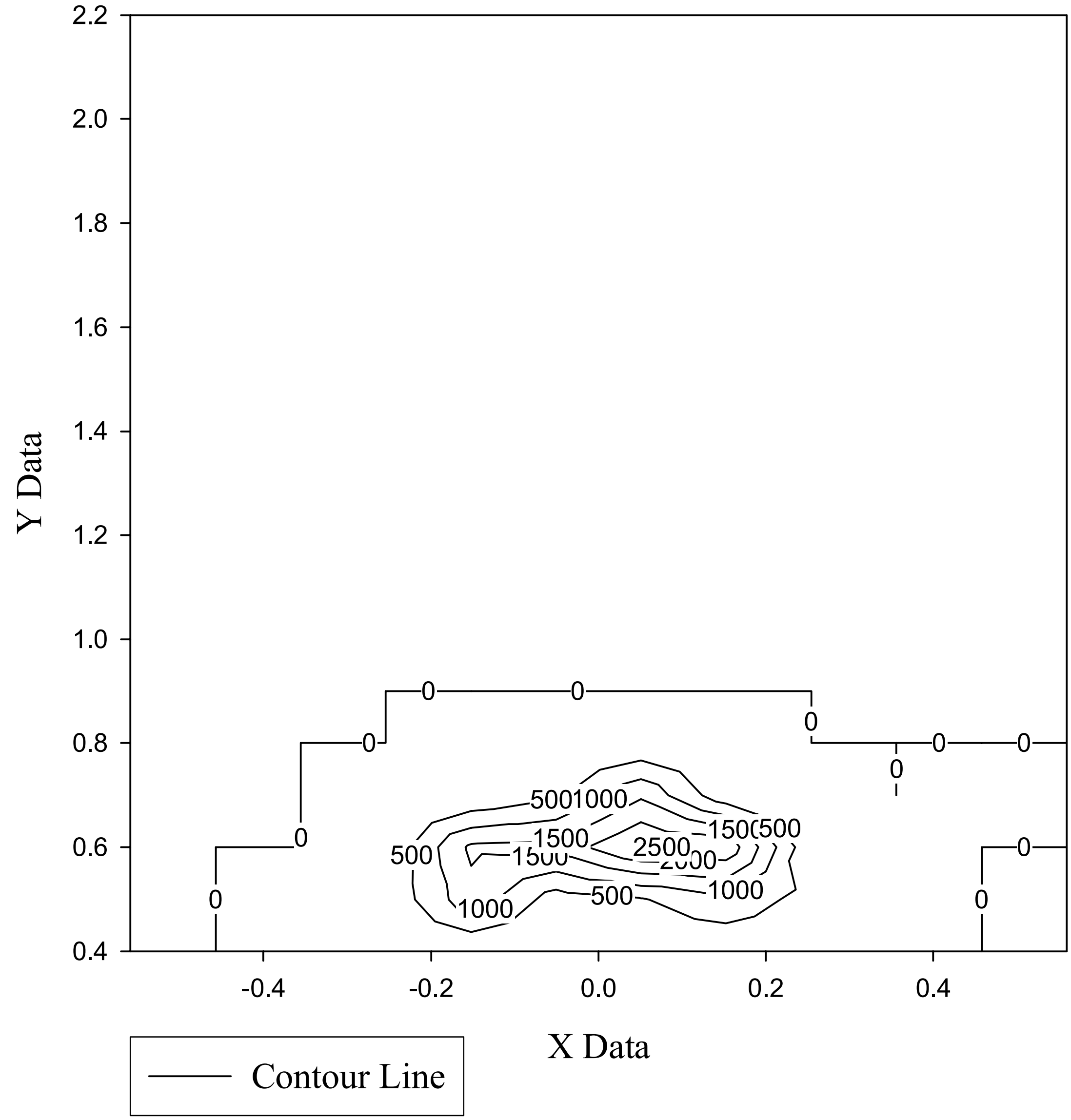
Appendix AL- Nonaspirated -15º Mass Flux Data

Test 28 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	8.4	33.8	67.5	19.7	14.1	2.8	0.0	0.0
0.50	0.0	0.0	2.8	78.8	1327.8	241.9	458.5	900.2	270.1	2.8	0.0	0.0
0.60	0.0	0.0	0.0	53.4	1597.8	1662.6	2559.9	2368.6	64.7	2.8	0.0	0.0
0.70	0.0	0.0	0.0	2.8	16.9	402.3	1409.4	140.7	5.6	0.0	2.8	0.0
0.80	0.0	0.0	0.0	0.0	5.6	14.1	56.3	11.3	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 28 Mass Flux (g/m^2-s)

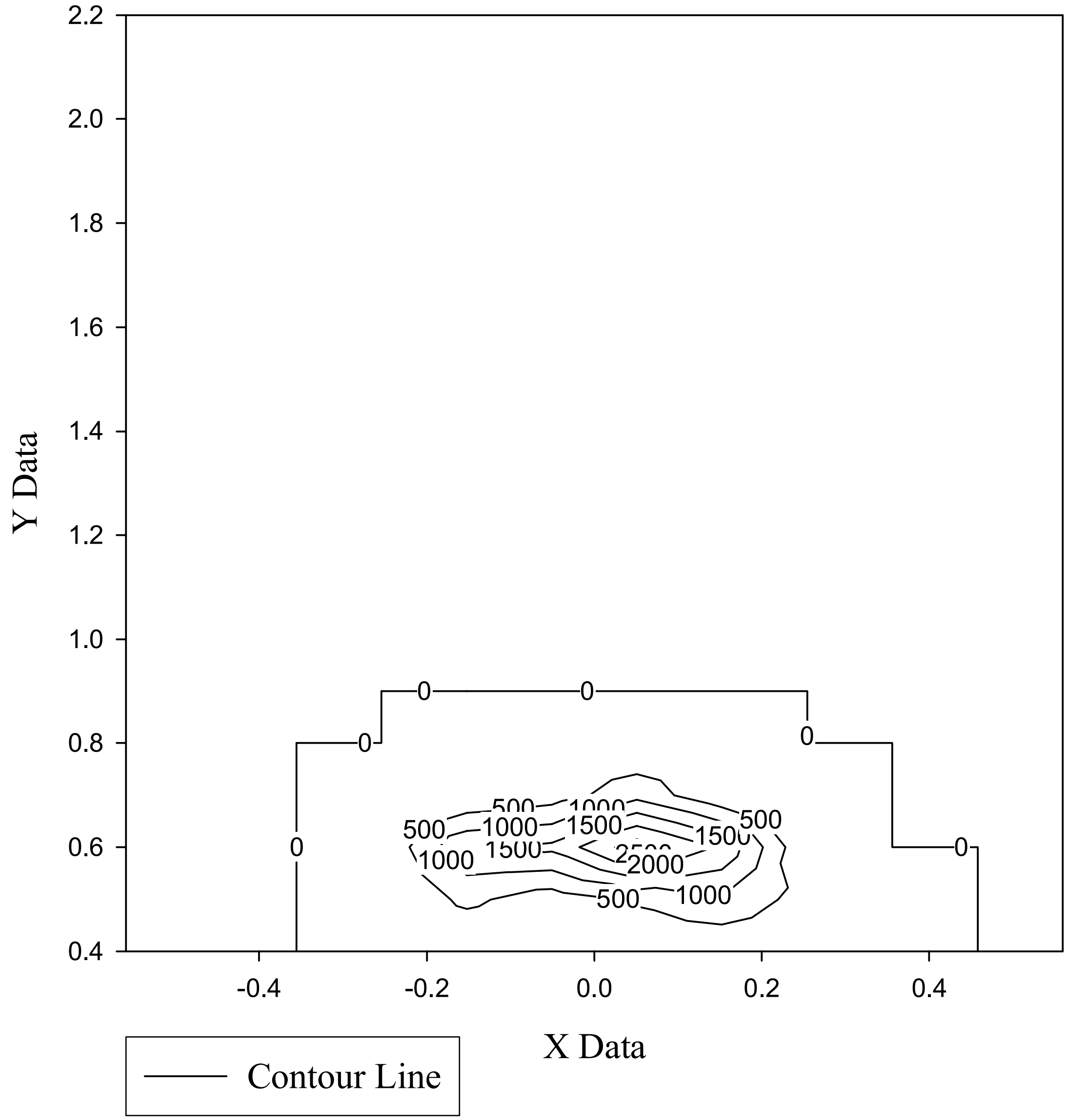


Test 29 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	2.8	33.8	70.3	30.9	2.8	0.0	0.0	0.0
0.50	0.0	0.0	0.0	22.5	610.4	216.6	568.2	948.0	267.2	2.8	0.0	0.0
0.60	0.0	0.0	0.0	28.1	1462.8	1611.9	2810.3	1910.1	16.9	0.0	0.0	0.0
0.70	0.0	0.0	0.0	2.8	8.4	244.7	824.2	90.0	5.6	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	2.8	14.1	33.8	8.4	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 29 Mass Flux (g/m^2-s)

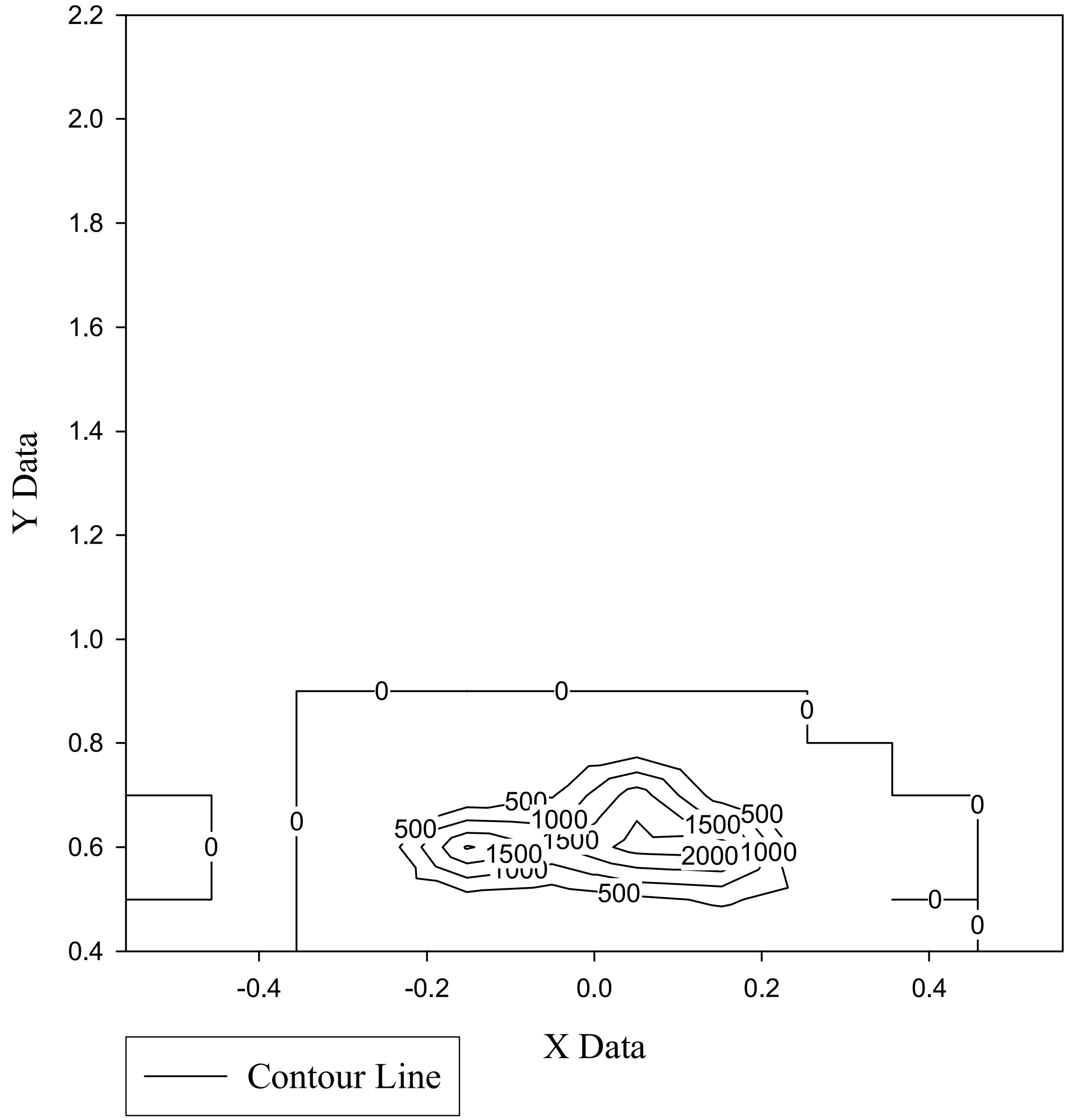


Test 30 -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	2.8	19.7	25.3	19.7	2.8	2.8	0.0	0.0
0.50	0.0	0.0	0.0	28.1	253.2	129.4	379.8	576.7	264.4	0.0	0.0	0.0
0.60	2.8	0.0	0.0	84.4	2056.4	1423.4	2225.2	2303.9	39.4	2.8	0.0	0.0
0.70	0.0	0.0	0.0	2.8	28.1	455.7	1775.1	199.7	2.8	0.0	0.0	0.0
0.80	0.0	0.0	0.0	2.8	2.8	16.9	36.6	11.3	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 30 Mass Flux (g/m^2-s)

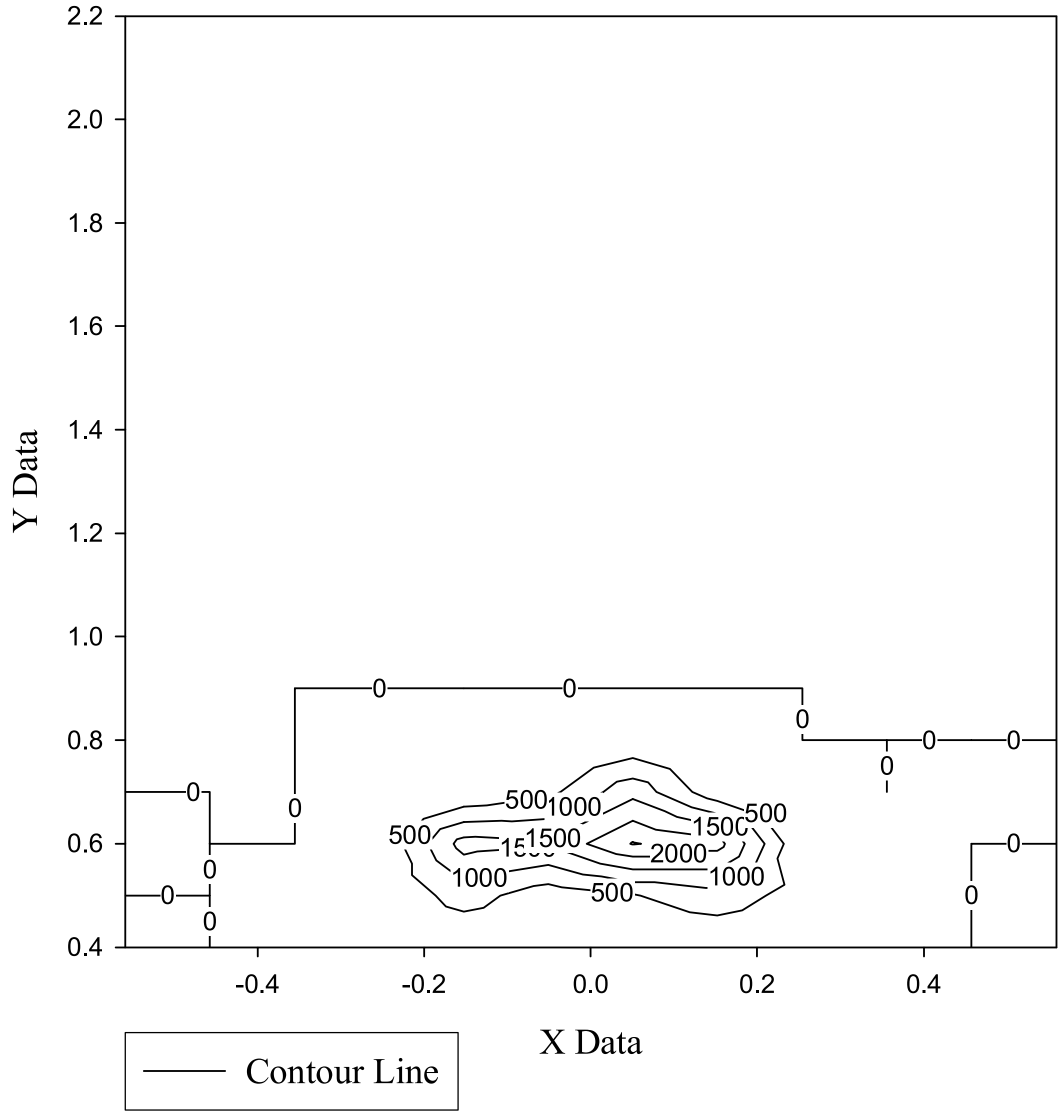


Avg -15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	4.7	29.1	54.4	23.4	6.6	1.9	0.0	0.0
0.50	0.0	0.0	0.9	43.1	730.5	196.0	468.9	808.3	267.2	1.9	0.0	0.0
0.60	0.9	0.0	0.0	55.3	1705.7	1566.0	2531.8	2194.2	40.3	1.9	0.0	0.0
0.70	0.0	0.0	0.0	2.8	17.8	367.6	1336.2	143.5	4.7	0.0	0.9	0.0
0.80	0.0	0.0	0.0	0.9	3.8	15.0	42.2	10.3	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 28-30 Average Mass Flux (g/m^2-s)



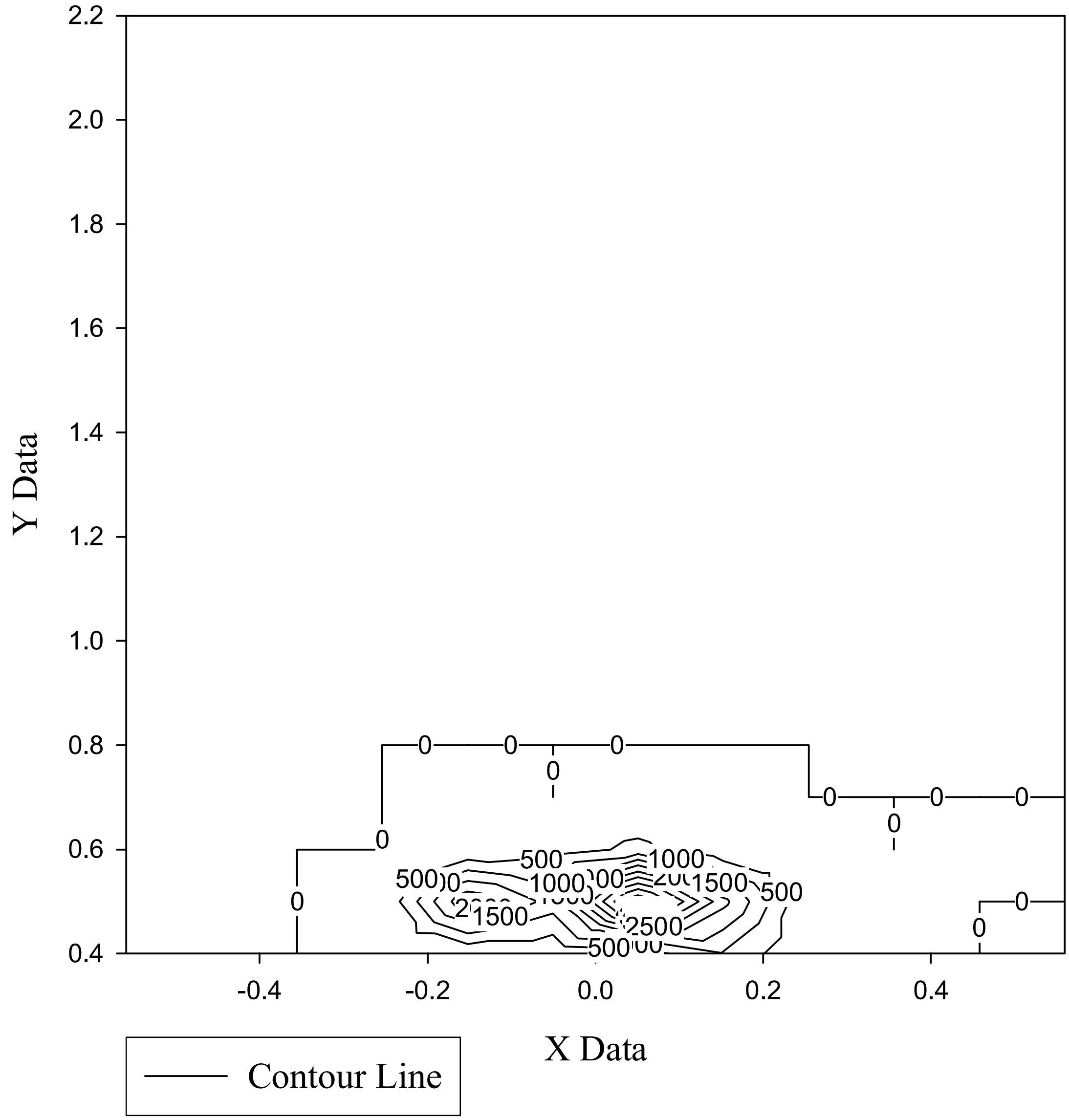
Appendix AM- Nonaspirated 15º Mass Flux Data

Test 31 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	59.1	59.1	230.7	953.6	8.4	2.8	0.0	0.0
0.50	0.0	0.0	0.0	2.8	2467.1	1280.0	5046.7	2152.0	8.4	2.8	0.0	0.0
0.60	0.0	0.0	0.0	0.0	22.5	225.0	633.0	30.9	2.8	0.0	5.6	0.0
0.70	0.0	0.0	0.0	0.0	2.8	0.0	2.8	2.8	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 31 Mass Flux (g/m^2-s)

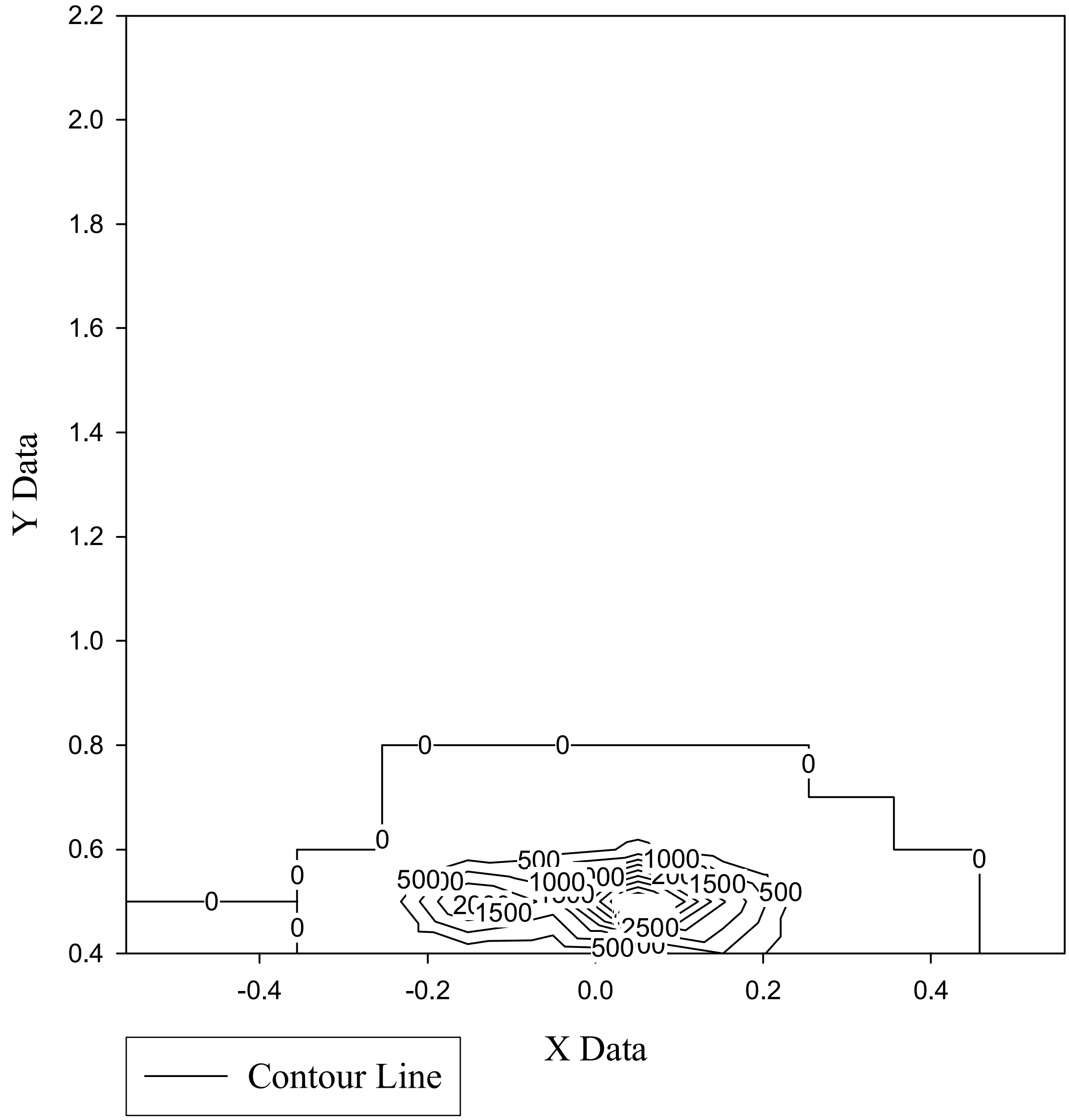


Test 32 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	2.8	2.8	0.0	0.0	78.8	50.6	199.7	990.2	5.6	2.8	0.0	0.0
0.50	0.0	0.0	0.0	2.8	2303.9	1322.2	5271.8	2042.3	5.6	2.8	0.0	0.0
0.60	0.0	0.0	0.0	0.0	16.9	194.1	610.4	25.3	2.8	0.0	0.0	0.0
0.70	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 32 Mass Flux (g/m^2-s)

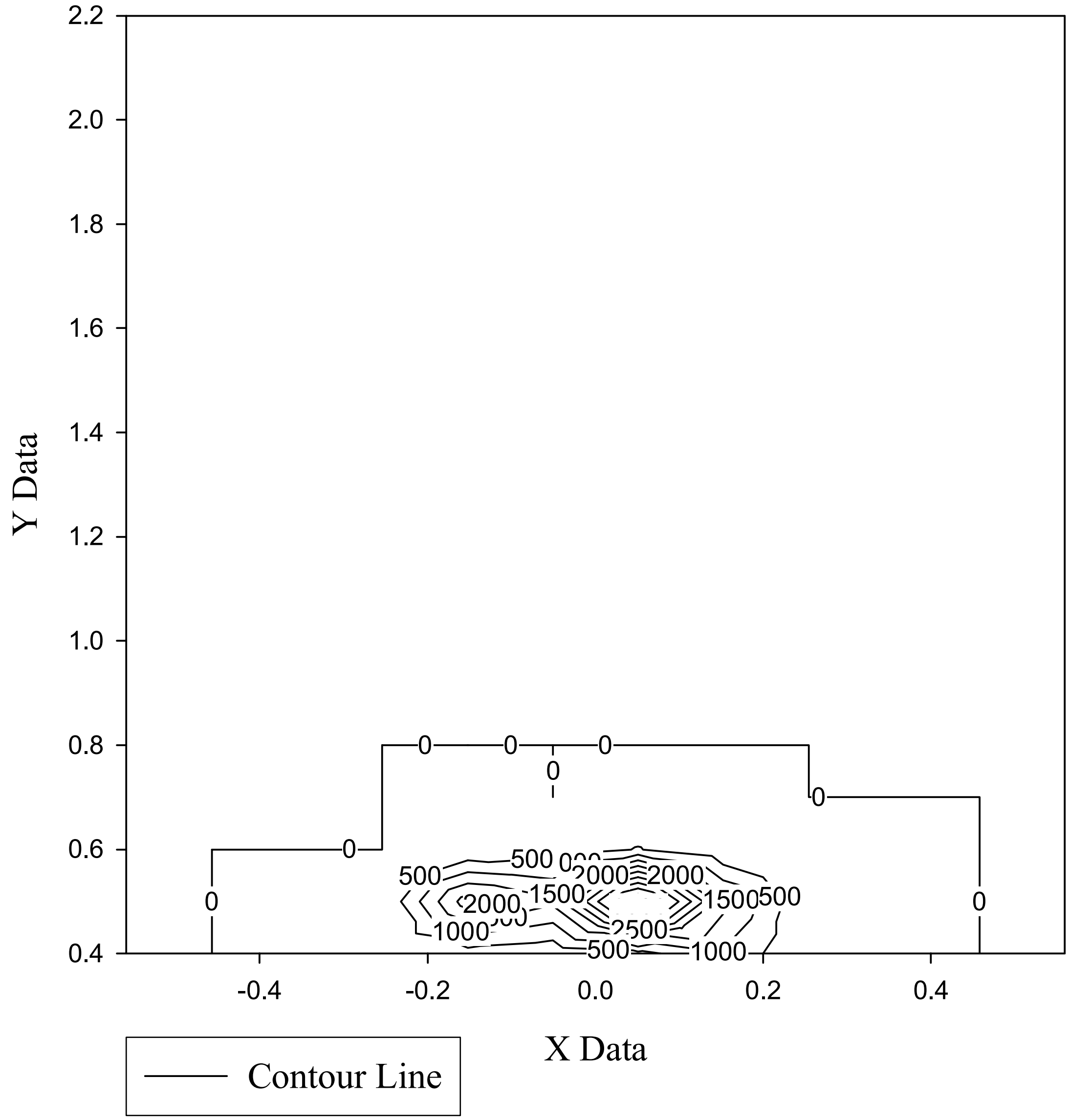


Test 33 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.0	0.0	0.0	0.0	270.1	101.3	329.1	931.1	5.6	2.8	0.0	0.0
0.50	0.0	0.0	2.8	2.8	2278.6	1626.0	5178.9	1676.6	5.6	2.8	0.0	0.0
0.60	0.0	0.0	0.0	0.0	11.3	180.0	528.9	19.7	2.8	2.8	0.0	0.0
0.70	0.0	0.0	0.0	0.0	2.8	0.0	2.8	2.8	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

Test 33 Mass Flux (g/m^2-s)

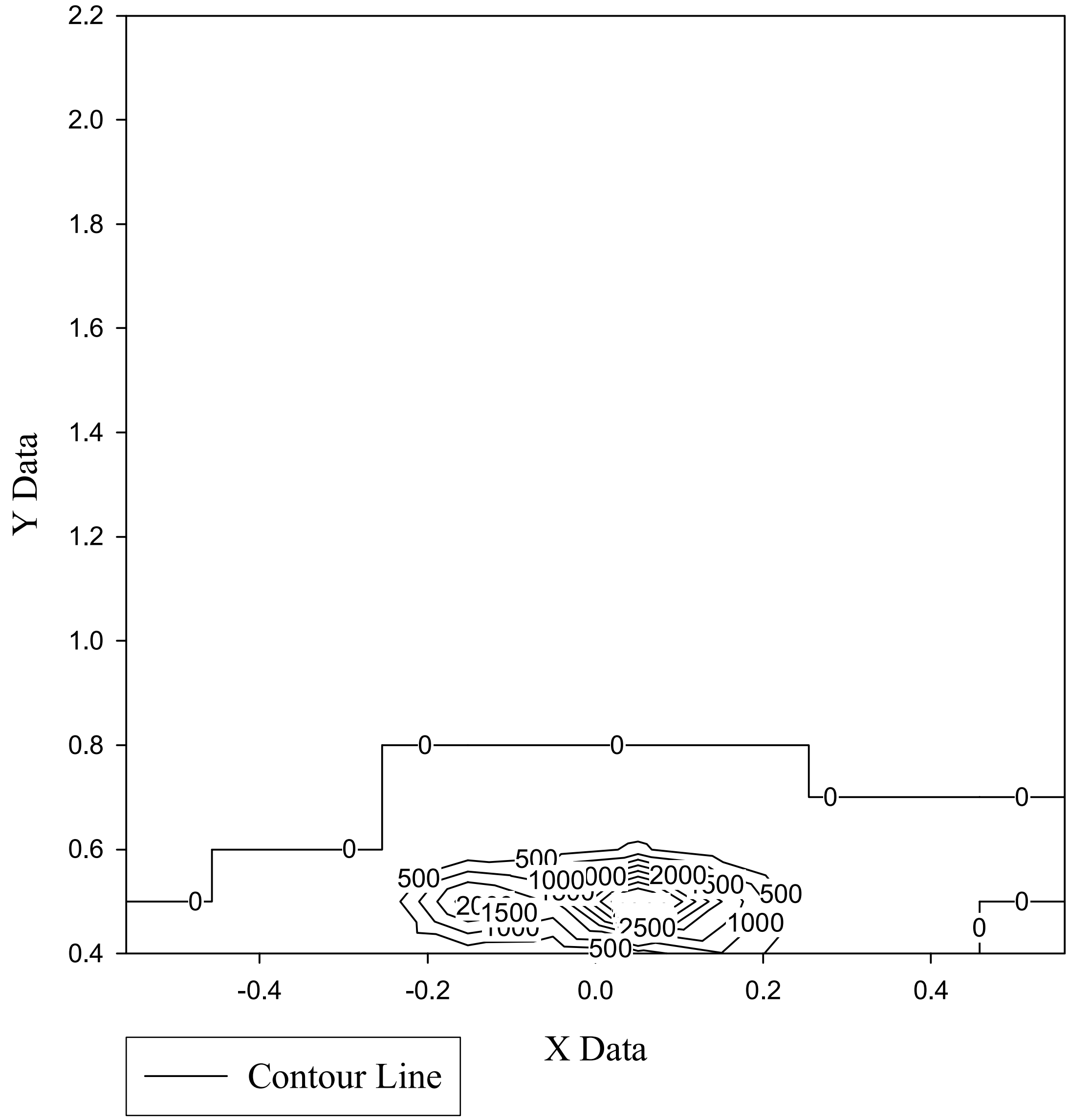


Avg 15º 100 psi nonasp 5 s

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.40	0.9	0.9	0.0	0.0	136.0	70.3	253.2	958.3	6.6	2.8	0.0	0.0
0.50	0.0	0.0	0.9	2.8	2349.9	1409.4	5165.8	1957.0	6.6	2.8	0.0	0.0
0.60	0.0	0.0	0.0	0.0	16.9	199.7	590.8	25.3	2.8	0.9	1.9	0.0
0.70	0.0	0.0	0.0	0.0	2.8	0.9	2.8	2.8	0.0	0.0	0.0	0.0
0.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All measurements in g/m^2-s

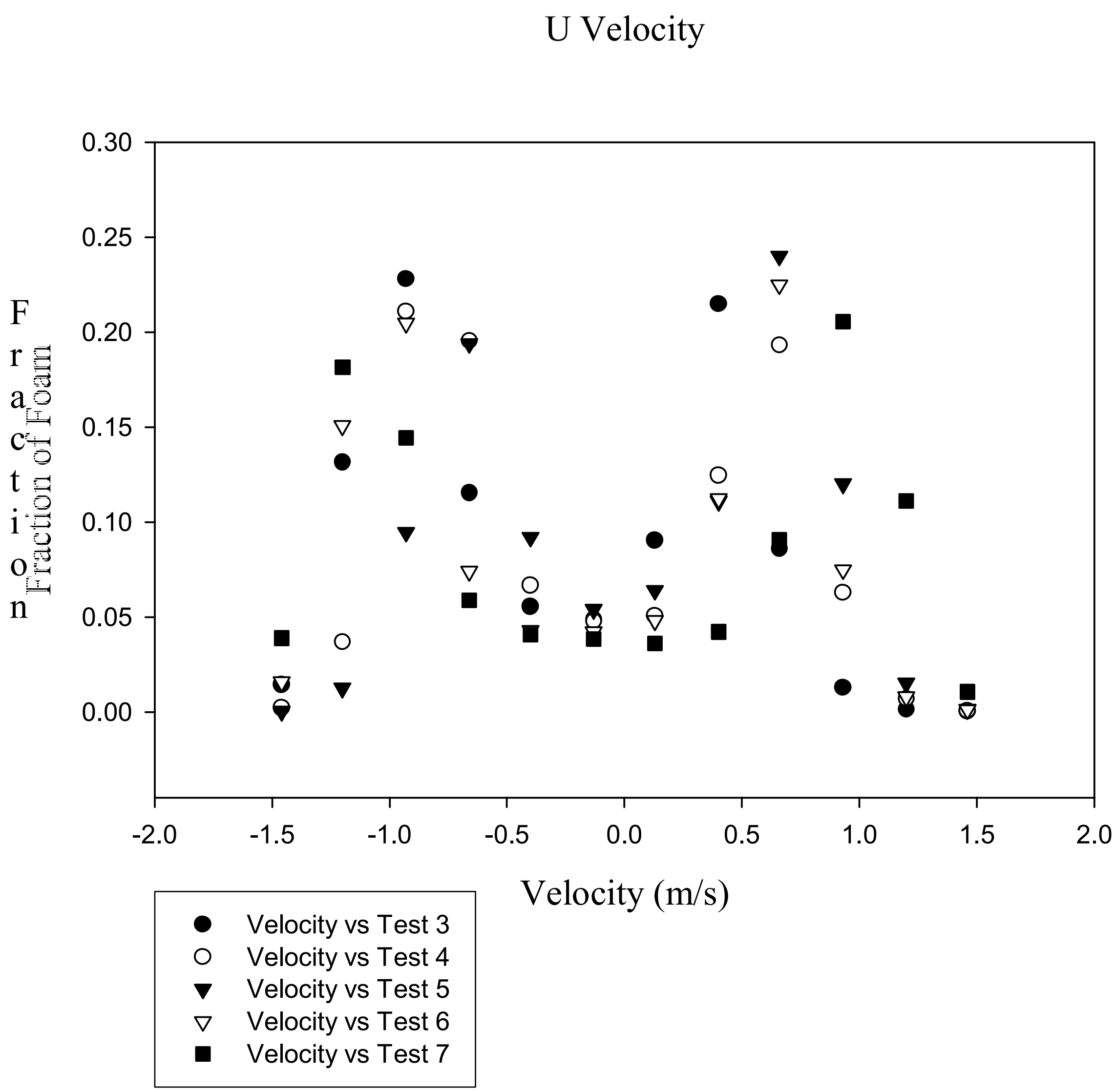
Test 31-33 Average Mass Flux (g/m^2-s)



Appendix AN- Collected Mass Fractions Per Row and Column

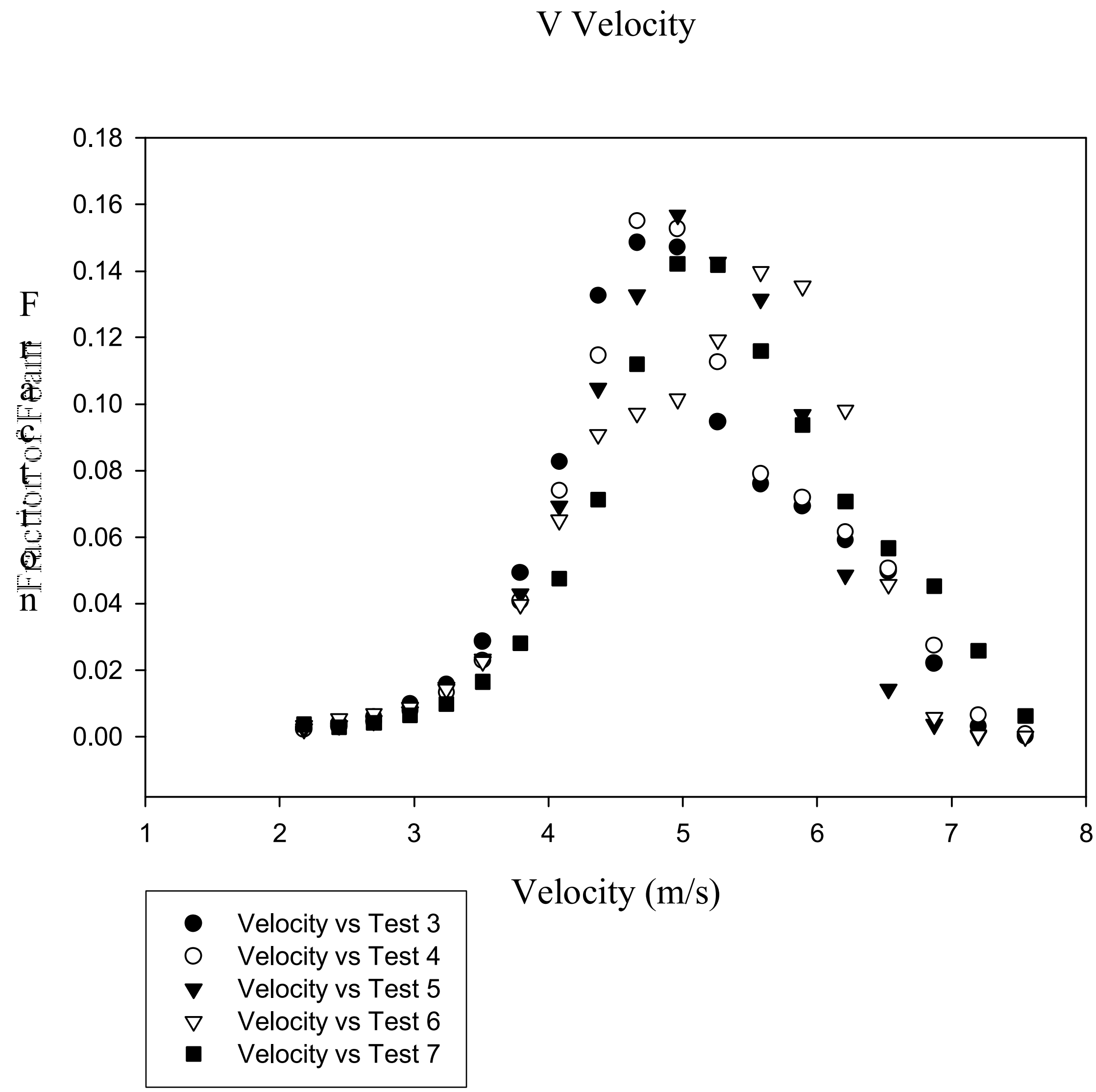
Fraction of Mass in Each Row

Row	Fraction
1	0.000
2	0.000
3	0.001
4	0.004
5	0.010
6	0.021
7	0.042
8	0.074
9	0.112
10	0.144
11	0.160
12	0.150
13	0.118
14	0.078
15	0.042
16	0.019
17	0.007
18	0.002
19	0.000


U Velocity
Fraction of Foam
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Velocity (m/s)
Velocity vs Test 3
Velocity vs Test 4
Velocity vs Test 5
Velocity vs Test 6
Velocity vs Test 7

Fraction of Mass in Each Column

Column	Fraction
1	0.008
2	0.092
3	0.248
4	0.132
5	0.016
6	0.001
7	0.021
8	0.160
9	0.240
10	0.075
11	0.005
12	0.000


V Velocity
Fraction of Fan
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1
2
3
4
5
6
7
8
Velocity (m/s)
Velocity vs Test 3
Velocity vs Test 4
Velocity vs Test 5
Velocity vs Test 6
Velocity vs Test 7

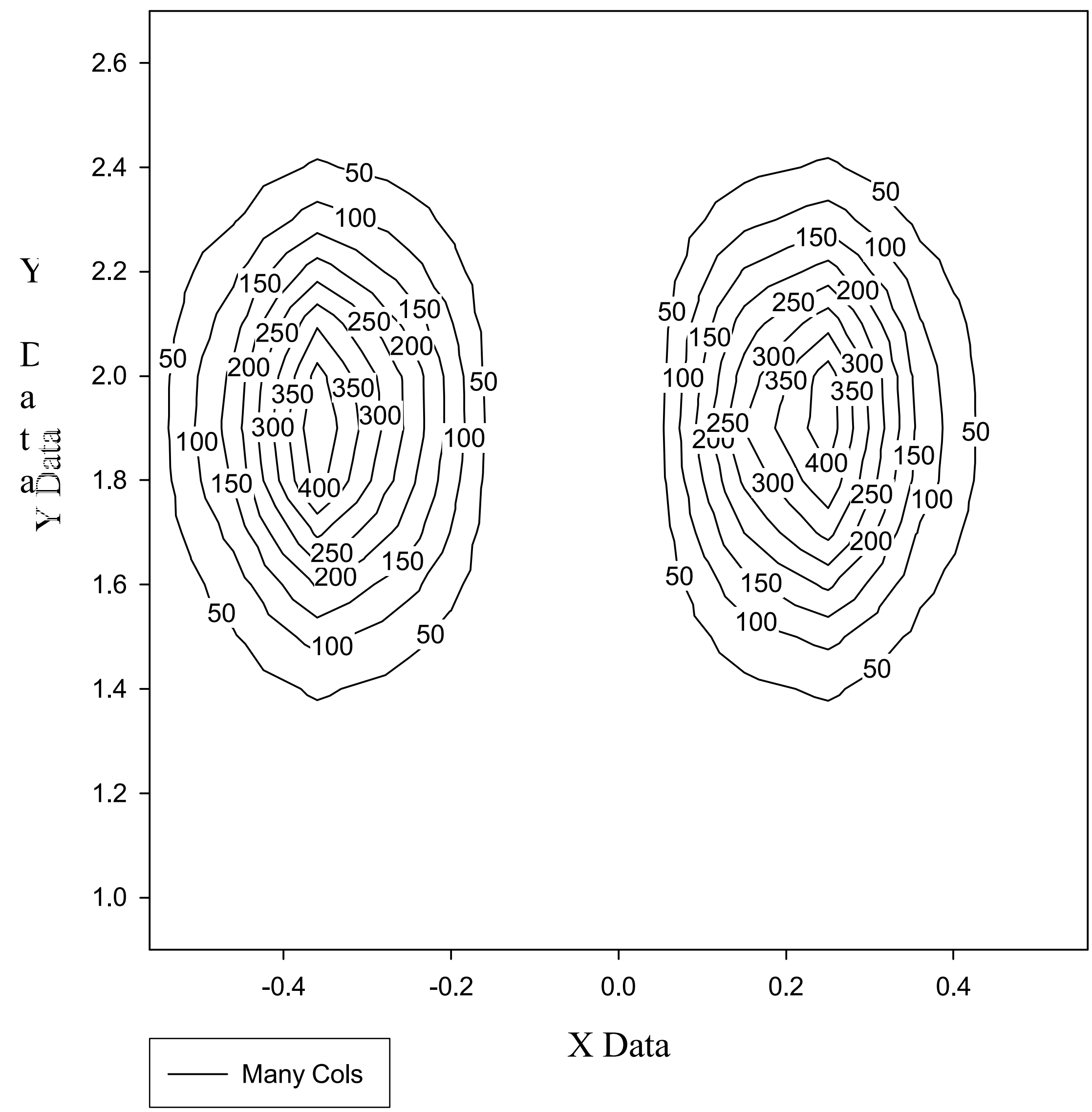
Appendix AO- Aspirated 0º Predicted Mass Flux

Avg 0º 100 psi asp

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.01	0.11	0.31	0.17	0.02	0.00	0.02	0.20	0.31	0.09	0.01	0.00
1.00	0.04	0.43	1.10	0.58	0.07	0.00	0.10	0.71	1.07	0.33	0.02	0.00
1.10	0.12	1.35	3.46	1.85	0.22	0.02	0.33	2.24	3.36	1.04	0.07	0.00
1.20	0.31	3.90	10.51	5.34	0.63	0.04	0.91	6.49	9.73	3.16	0.19	0.00
1.30	0.87	9.90	26.63	14.19	1.60	0.11	2.31	16.46	25.85	8.02	0.49	0.01
1.40	1.92	23.13	56.45	31.50	3.71	0.24	5.13	38.30	57.39	17.00	1.15	0.02
1.50	3.82	45.88	117.59	62.63	7.39	0.48	10.20	76.15	114.11	35.42	2.28	0.03
1.60	6.71	72.96	206.18	115.30	12.95	0.85	17.89	133.53	210.09	62.10	3.63	0.06
1.70	10.09	115.28	310.25	173.50	19.49	1.27	26.92	200.92	316.13	93.44	5.74	0.09
1.80	13.03	156.32	420.69	213.38	25.17	1.72	36.51	259.47	388.81	126.71	7.78	0.11
1.90	14.46	173.39	444.40	236.69	29.31	1.91	40.49	302.20	431.27	133.85	8.63	0.13
2.00	14.41	163.29	418.52	234.05	26.29	1.72	36.32	271.05	426.46	126.06	8.13	0.13
2.10	10.66	127.89	344.18	183.31	21.62	1.41	29.87	222.90	334.01	103.66	6.37	0.09
2.20	7.83	88.96	227.44	121.13	15.04	0.93	19.74	155.05	220.72	68.50	4.43	0.07
2.30	3.82	45.88	123.47	69.22	8.16	0.51	10.71	84.17	126.12	37.19	2.28	0.03
2.40	1.92	21.76	55.64	31.19	3.50	0.23	4.83	36.12	56.84	16.76	1.08	0.02
2.50	0.67	7.61	19.45	10.91	1.29	0.08	1.69	13.26	19.87	5.86	0.38	0.01
2.60	0.19	2.24	6.04	3.06	0.40	0.02	0.52	4.12	5.57	1.82	0.11	0.00
2.70	0.04	0.50	1.33	0.71	0.08	0.00	0.11	0.86	1.29	0.40	0.02	0.00

All measurements in g/m^2-s

Test 3-7 Gaussian Mass Flux (g/m^2-s)



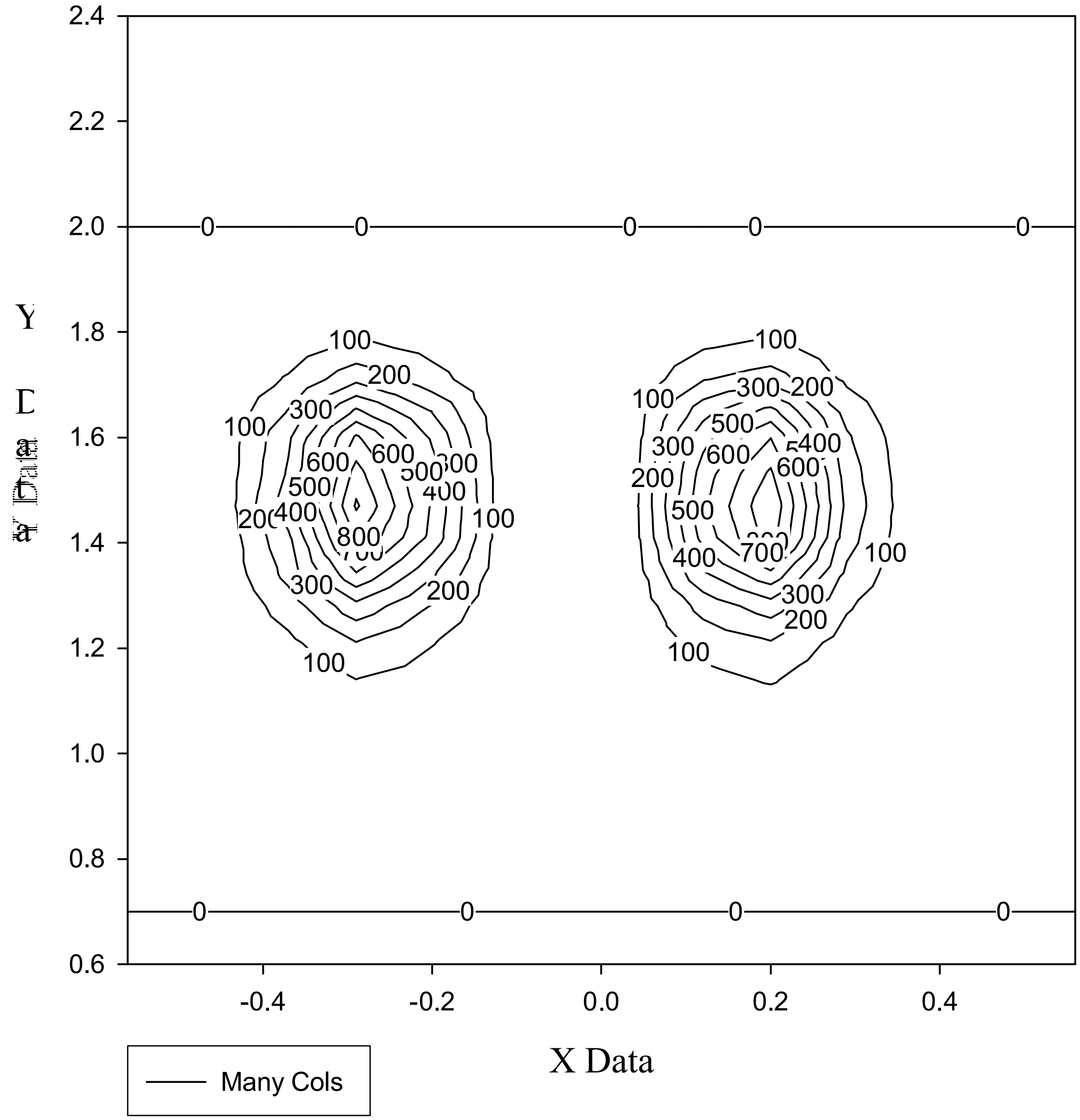
Appendix AP- Aspirated -15º Predicted Mass Flux

Avg -15º 100 psi asp

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.01	0.18	0.48	0.24	0.03	0.00	0.04	0.29	0.43	0.15	0.01	0.00
1.00	0.05	0.63	1.70	0.90	0.11	0.01	0.14	1.10	1.65	0.51	0.03	0.00
1.10	0.17	1.99	5.35	3.05	0.36	0.02	0.46	3.71	5.56	1.61	0.10	0.00
1.20	0.54	6.51	16.59	8.25	1.03	0.06	1.34	10.58	15.02	5.00	0.32	0.00
1.30	1.38	16.49	44.39	23.64	2.47	0.18	3.85	25.42	43.08	13.37	0.82	0.01
1.40	3.05	36.63	98.57	59.86	6.67	0.44	9.21	68.75	109.07	29.69	1.82	0.03
1.50	6.83	77.11	195.98	104.38	13.26	0.92	19.39	136.68	190.19	59.03	3.84	0.06
1.60	12.90	145.59	370.06	193.78	22.86	1.49	31.57	235.63	353.09	111.46	7.25	0.11
1.70	19.41	232.78	589.61	314.02	37.04	2.42	51.17	381.85	572.19	177.59	11.59	0.17
1.80	22.28	282.93	809.01	466.78	51.82	3.38	71.58	534.21	850.53	243.67	14.09	0.20
1.90	30.12	361.22	914.95	487.29	56.37	3.68	77.87	581.15	887.91	275.58	17.98	0.26
2.00	28.36	314.02	845.10	450.09	53.09	3.46	73.34	547.31	820.12	254.54	15.63	0.25
2.10	25.39	284.20	717.04	381.89	45.04	2.94	62.23	464.37	695.85	215.97	14.15	0.22
2.20	16.78	204.88	516.91	293.66	34.64	2.12	44.86	357.08	535.08	155.69	10.20	0.15
2.30	8.69	111.22	274.37	137.00	18.80	1.23	25.98	193.84	249.62	82.64	5.54	0.08
2.40	4.48	50.12	126.45	71.84	9.08	0.55	11.71	93.59	130.90	38.09	2.50	0.04
2.50	1.57	18.77	51.87	25.12	3.17	0.19	4.09	32.72	45.76	15.62	0.93	0.01
2.60	0.46	5.54	14.90	7.94	0.94	0.06	1.21	9.65	14.46	4.49	0.28	0.00
2.70	0.09	1.12	2.81	1.93	0.23	0.01	0.31	2.34	3.51	0.85	0.06	0.00

All measurements in g/m^2-s

Test 10-12 Gaussian Mass Flux (g/m^2-s)



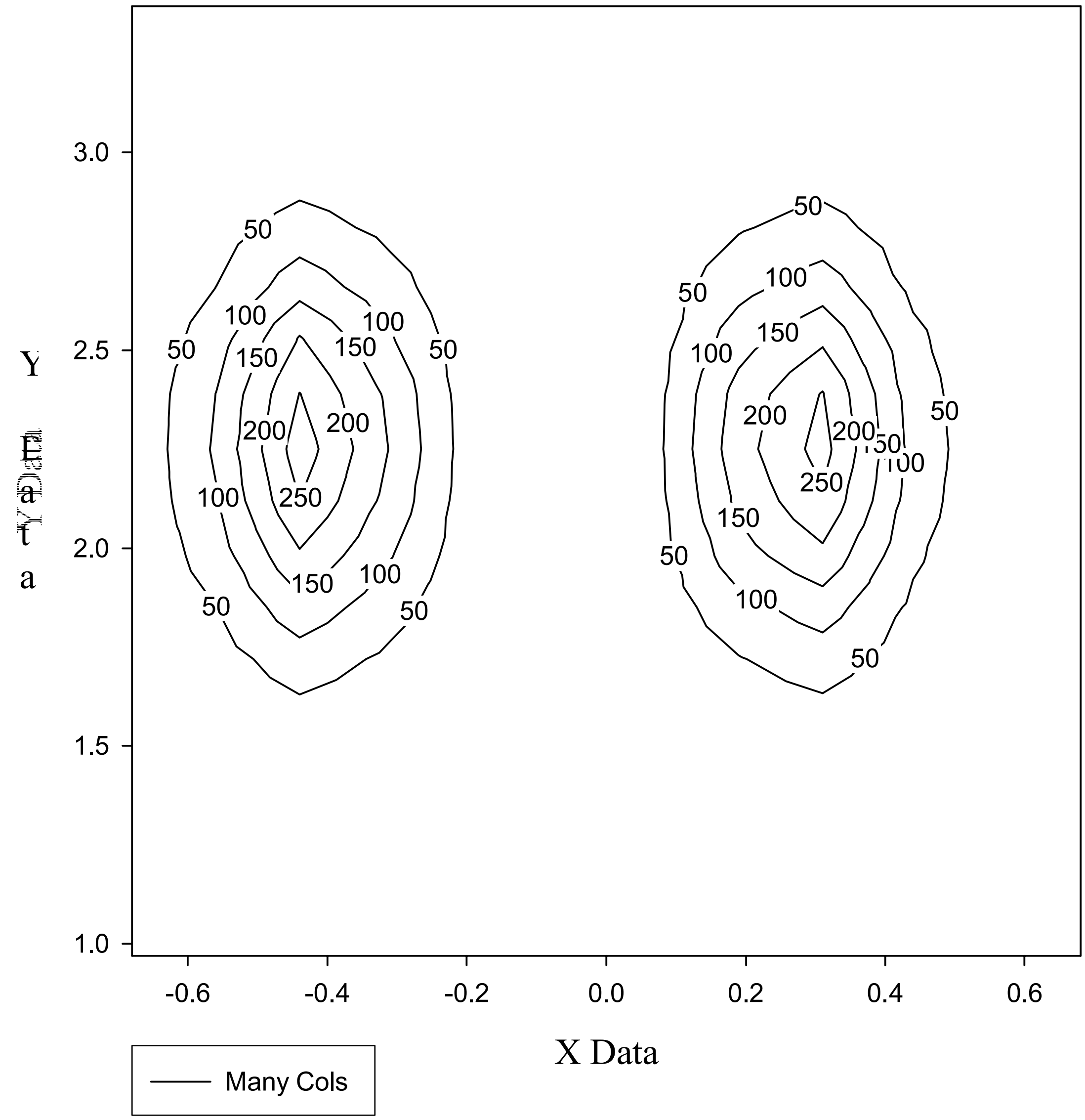
Appendix AQ- Aspirated 15º Predicted Mass Flux

Avg 15º 100 psi asp

Dist. (m)	-0.56	-0.46	-0.36	-0.25	-0.15	-0.05	0.05	0.15	0.25	0.36	0.46	0.56
0.90	0.01	0.09	0.24	0.13	0.01	0.00	0.02	0.15	0.23	0.07	0.00	0.00
1.00	0.03	0.31	0.84	0.45	0.05	0.00	0.07	0.52	0.81	0.25	0.02	0.00
1.10	0.09	0.98	2.44	1.35	0.16	0.01	0.22	1.65	2.47	0.73	0.05	0.00
1.20	0.23	2.62	7.06	3.77	0.44	0.03	0.61	4.57	6.86	2.13	0.13	0.00
1.30	0.58	6.65	17.90	9.93	1.12	0.07	1.49	11.59	18.09	5.39	0.33	0.01
1.40	1.23	15.38	38.21	21.17	2.50	0.16	3.45	25.74	38.57	11.51	0.77	0.01
1.50	2.45	29.41	75.98	40.47	4.60	0.31	6.59	47.38	73.73	22.88	1.46	0.02
1.60	4.30	49.65	133.22	68.33	8.06	0.53	11.13	83.08	124.50	40.13	2.47	0.04
1.70	6.23	74.72	193.04	102.81	12.59	0.82	17.40	129.83	187.34	58.14	3.72	0.05
1.80	8.04	96.49	249.30	132.77	15.66	1.02	21.63	161.45	241.93	75.09	4.80	0.07
1.90	8.92	107.03	276.52	147.27	17.37	1.13	24.00	179.08	268.35	83.29	5.33	0.08
2.00	8.10	100.80	251.11	138.69	16.36	1.03	21.79	168.65	252.72	75.63	5.02	0.07
2.10	6.35	76.12	203.96	104.75	12.35	0.81	17.07	127.37	190.86	61.43	3.79	0.06
2.20	4.19	50.30	129.97	69.22	8.16	0.55	11.70	84.17	126.12	39.14	2.50	0.04
2.30	2.36	27.31	70.55	37.58	4.43	0.29	6.12	45.69	68.47	21.25	1.36	0.02
2.40	1.03	11.81	31.79	17.64	2.00	0.13	2.76	20.59	32.14	9.58	0.59	0.01
2.50	0.35	4.13	10.73	6.17	0.70	0.05	0.96	7.20	11.24	3.23	0.21	0.00
2.60	0.11	1.18	3.28	1.76	0.20	0.01	0.27	2.05	3.20	0.99	0.06	0.00
2.70	0.02	0.26	0.75	0.37	0.04	0.00	0.06	0.44	0.68	0.23	0.01	0.00

All measurements in g/m^2-s

Test 15-18 Gaussian Mass Flux (g/m^2-s)



References

1. Perrson, Bror; Lonnermark, Anders; Persson Henry; Mulligan, Dave; Lancia, Antonio; Demichela, Micaela; FOAMSPEX Large Scale Foam Application- Modelling of Foam Spread and Extinguishment; SP Swedish National Testing and Research Institute SP Report 2001:13.
2. MIL-F-24385F; Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate for Fresh and Sea Water (1992).
3. Sthamer, Richard, "The History of Fire Chemistry". Available at http://www.sthamer.de/html/history.htm. Last viewed on August 25, 2004.
4. Fitzgerald, Paul; Mawhinney, John R.; Slye, Orville H. (Bud) Jr.; "Water-Based Fire Suppression". In Richardson, J. Kenneth, P. Eng., Editor, History of Fire Protection Engineering, National Fire Protection Association, Inc., Quincy, MA, 2003.
5. NFPA 11 Low Expansion Foam and Combined Agent System, National Fire Protection Association, Inc., Quincy, MA, 1988.
6. http://www.haifire.com/download/aetwc-2001/darwin.pdf. Last viewed on April 15, 2004.

7. Sheinson, R. S.; Williams, B. A.; Green, C.; Fleming, J. W.; Anleitner, R.; Ayers, S.; Maranghides, A.; Barylski, D.; “Future of Aqueous Film Forming Foam (AFFF): Performance Requirements and Parameters” Halon Options Technical Working Conference, 12th. Proceedings. April 30-May 2, 2002, Albuquerque, NM, Gann, R. G.; Reneke, P. A., Editors, 2002; pp.1-6. Available at: http://fire.nist.gov/bfrlpubs/fire02/PDF/f02130.pdf. Last viewed June 18, 2003.

8. http://www.fireworld.com/magazine/afff_2.htm. Last viewed on April 15, 2004.

9. Hague, David R.; “The Future of AFFF”. Available at: http://www.nfpa.org/NFPAJournal/onlineexclusive/exclusive0902/exclusive0902.asp. Last viewed August 25, 2004.