AN ABSTRACT OF THE THESIS OF

Ronald W. Buckingham for the degree of Master of Science in Mechanical Engineering presented on March 2, 1993
Title: An Experimental Study on the Use of Inclusion Trapping Devices for Investment Casting

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Abstract approved ______________________
Dr. Lorin R. Davis

A problem facing the casting industry is inclusions in the finished parts. The inclusions can be sand from the molds, oxides or other impurities in the metal charge. Inclusions lead to costly part repairing or reworking.

A study was done to try and find inclusion trapping devices that could be placed in the gating system. The experiments consisted of pouring water and suitable inclusion models into clear, full scale, plastic molds. The fills were video taped for later analysis. The efficiency of the trapping device was determined from the end location of the inclusions. No work was done on other anti-inclusion methods such as ceramic filters, bottom pour ladles, chemical additives, etc.

The research showed that a swirl chamber which used centrifugal force to separate inclusions worked quite well if set up correctly. The optimum setup was a vertical swirl chamber with a well. The inlet passage was choked and located below the exit passage. It also worked much better than any setup which tried to use buoyancy for separation.

The large volume of the swirl chamber may be objectionable. However, properly shaped inserts, such as an ice-cream cone shape, can be put into the chamber to reduce fill volume while still maintaining good efficiency and fills.

The efficiencies of the chambers behave as expected; faster pours are less efficient and bigger chambers (for a constant size mold) are more efficient. The use of outlet chokes may or may not improve separation efficiency, but will improve the filling of the part cavity.

An Experimental Study on the Use of Inclusion Trapping Devices for Investment Casting

By

Ronald W. Buckingham

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I. INTRODUCTION

A problem facing the casting industry is inclusions in the finished parts. The inclusions can be sand from the molds, oxides or other impurities in the metal charge. Inclusions lead to costly part repairing or reworking.

Many schemes for reducing inclusions in the part exist, including ceramic filters, bottom pour ladles, improved tundish designs, chemical additives, etc. However, the work done here was on devices that can be placed somewhere in the runner system to stop or separate the inclusions before they reach the part cavity.

INVESTMENT CASTING

Investment casting, sometimes called the lost wax process, attained industrial importance at the end of WW II for making rocket components and jet turbine blades from materials that are not readily machinable. A wax pattern of the desired part is constructed and attached to wax runners, gates and a downsprue and tundish. It is then dipped in a slurry and coated with sand. After this sets, the mold is heated, melting out the wax, leaving a hard ceramic mold. This is then preheated and filled with the desired metal.

Although this form of casting is complex and expensive, very intricate shapes can be cast, thin sections (0.015") can be made and tolerances can be kept to 0.005"-0.010"[1].

One important way that investment casting differs from sand casting is that the harder ceramic shell allows faster pouring rates. The faster pour rates are required to fill the smaller and more intricate parts of the mold cavity usually found in investment casting. These higher fluid velocities can lead to problems such as cold shots, cold shuts, nofill and ceramic wash.

A cold shot occurs when a portion of the metal flow separates from the main flow, then solidifies and won't properly fuse back with the rest of the material. A cold shut is when two separate flows solidify and come together. They do not fuse properly leaving a lap line. Nofill is when a section of the mold does not get filled due to trapped gases or early solidification of the metal flow. Ceramic wash occurs when the fluid flow erodes the mold walls. This leads to inclusions in the metal flow and changes the shape of the mold[2]. Besides ceramic wash, inclusions or other impurities can be present in the original metal charge.

The purpose of this project was to find ways using flow control devices in the gating system to remove or trap inclusions before they got into the part cavity.

INCLUSIONS ENCOUNTERED IN INVESTMENT CASTING

A summary of inclusions that are encountered in investment casting was provided by Precision Castparts Corporation (PCC). For this experiment their alloys were divided into two groups; titanium alloys which have "heavy" inclusions and Ni-, Fe-, and Co-base alloys that have "light" inclusions.

Titanium alloys have a density of 4.5 g/cm^3 and the two common inclusion types have densities of 9.9 and 5.0 g/cm^3, giving inclusions that are heavier than the alloy. The composition of these inclusions is not known since this information is proprietary.

Ni-, Fe-, and Co-base alloys have higher densities than titanium, 7.8-9 g/cm^3. The common types of inclusions found are alumina, silica, mullite and oxides. These have densities ranging from 2.3 to 3.96 g/cm^3, giving inclusions that are lighter than the alloy. A detailed list of these inclusions is given in the appendix.

PREVIOUS WORK

The study of investment casting has already been done at OSU in cooperation with PCC and the Oregon Metals Initiative (OMI). The work consisted of video taping water as it filled clear plastic or resin molds. Work was done in the area of flow modeling for centrifugal casting[3]. This is where the molds are rotated at high speeds while they are being filled to increase the "gravity" and fill the parts quicker. Another study looked at the use of flow control devices to minimize turbulence and poor filling characteristics[4]. These include waves, flow separation, splashing, flow reversal, bubbles and pumping of the fluid. The flow control devices were various shaped chokes in the gates and downsprue, wells, runner extensions and different shaped downsprues and runners. A numerical score was given to each pour based on the number and severity of bad fill characteristics.

Other smaller projects have also been done. A filling technique was studied in which the mold tilted along with the crucible. The idea was to reduce turbulence in the downsprue much in the same way one tilts a glass and pours down the side from a bottle[5].

PCC has made clear resin molds of some production molds in which they were experiencing fill problems. These were sent to OSU for study.

A literature search was done at the beginning of the project. Much information was found on inclusions such as their chemical composition, where inclusoons comes from, and how to control them using bottom pour ladles, chemical additives, ceramic filters, or different foundry procedures.[6,7,8,9,10,11,12]

Very little information was found on inclusion traps, and all of the traps found were for sand casting, not investment casting. Most of these traps used buoyancy to trap inclusions. Usually, the gate connecting the part cavity to the runner was smaller than the runner and attached low. The mechanism is the runner will fill and light inclusions will float to the top of it. Clean metal then goes into the gate. There were various shapes of this type of trap. Figure 1 shows a schematic of how these traps work[13].

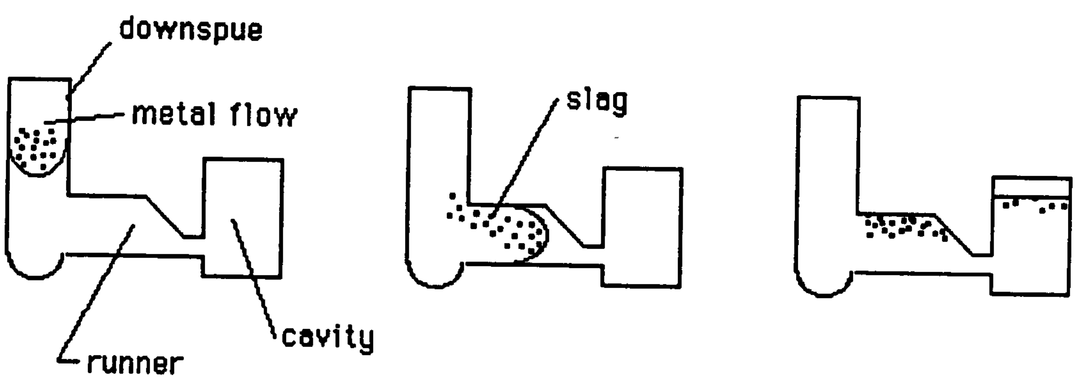

Figure 1. Typical buoyancy trap for sand casting

There seems to be only two commonly used traps that use centrifugal force. The mechanism by which this works is relatively simple. Fluid enters a cylindrical vertical chamber tangentially causing a swirl to form. A resultant centrifugal force pushes the lighter inclusions toward the center, and clean fluid is taken off the outside. Heavier inclusions sink to the bottom.

The first commonly found swirl chamber was used in sand casting. Since sand cast parts cannot have undercuts (unless premade cores are used) the top of the inlet runner and the bottom of the exit runner are in the same plane. Figure 2 shows a typical swirl chamber used in sand casting[14,15].

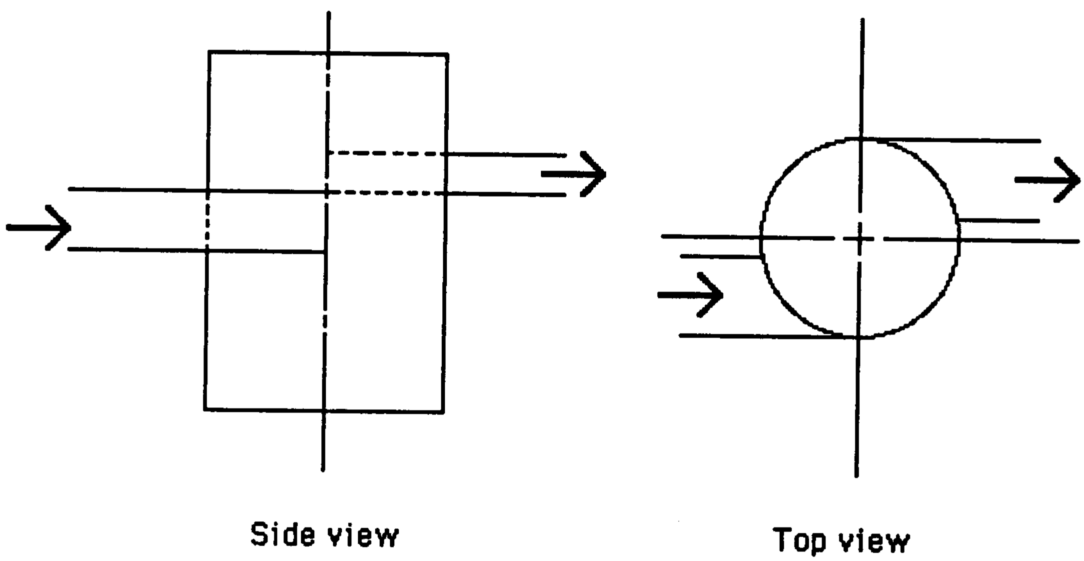

Figure 2. Typical swirl chamber for sand casting

The other centrifugal trap was a prefabricated "whirlgate." This consisted of a central, vertical sprue channel surrounded by a spiral runner. The gating system insert (figure 3) is assembled from individual, premade ceramic flights stacked on top of each other. This insert is then placed at the bottom of the downsprue as shown in figure 4. The lighter inclusions are forced to the center and caught on the bottom of the inserts[16,17].

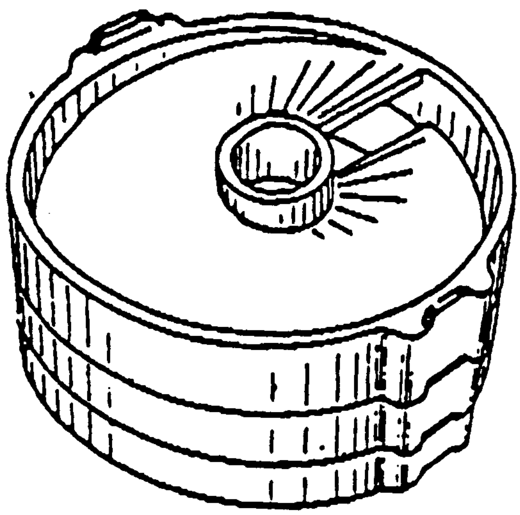

Figure 3. Gating system insert

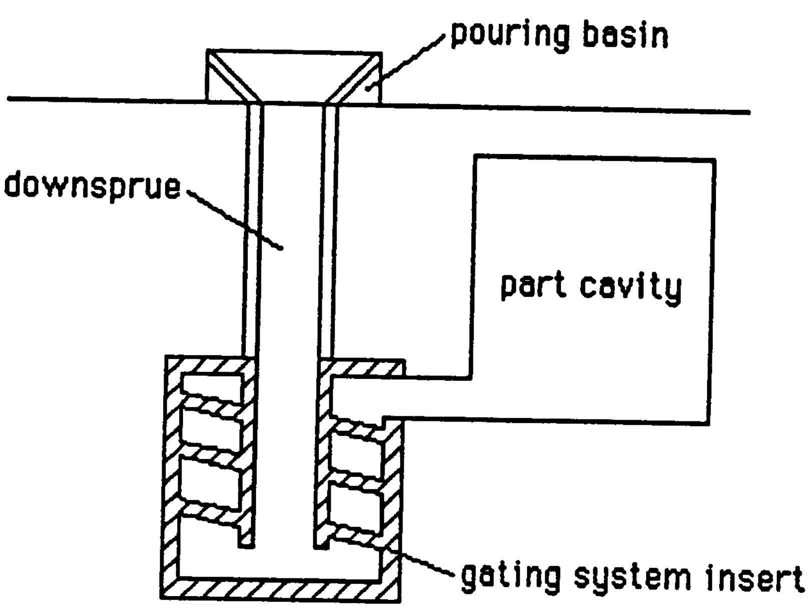

Figure 4. Gating system insert positioned in the mold

II. EXPERIMENTAL WORK

OVERALL SETUP

The casting process during this study was modeled by full size clear plastic molds and water. The fills were recorded with a video camera for analysis later. The use of water to model molten metal has already been largely justified by previous work done at OSU.[18]

Water was chosen as the working fluid because it is safe, inexpensive, easy to photograph, and has a viscosity value that is similar to molten titanium. Unfortunately, water has the drawback that its surface tension and density vary significantly from most molten metals.

All modeling in this system was done in full scale due to the variety of flows present in the mold. To have a properly scaled down model, one must maintain consistency between the model and the full scale version with respect to the Reynolds number, Froude number and Weber number. This requires either three different-sized models or a full sized model.

The Reynolds and Froude numbers were satisfied rather well because of the similarity between the viscosity of water and a molten alloy like titanium. However, the Weber number deviated greatly for the model because of the differences between the densities and surface tensions of water and molten metal.

The idea of using water to model metal was tested earlier at OSU[19]. A Pyrex mold was filled and videotaped first with water, then with a low melting solder under similar conditions. The results showed that the splashing and turbulence for the metal was less than for the water. This was attributed to the larger surface tension forces in the molten metal. However, after the initial splashing, the fills were very similar.

The effect of vacuum vs. ambient pours was also investigated[20]. Much of PCC's parts are poured in a vacuum to reduce oxidation. A vacuum chamber was constructed to compare different pairs of pours, one being poured in the vacuum and one being poured at ambient pressure. The results showed that there was little difference in the fluid flow and recommended that future tests be made at ambient pressure for simplicity.

INCLUSION MODELS

After a meeting with PCC engineers in April of 1991, emphasis shifted from heavy inclusions to light ones. They felt that this was the more important problem at present. They were still interested in heavy inclusions for titanium castings, however.

From the summary of inclusions supplied by PCC, a list was made of possible inclusion models. This list is given in the appendix. The studies have mainly centered around four inclusion models.

Light Inclusions

3mm cubic wood beads, s.g. = 0.5 - 0.6

5mm round wood beads, s.g. = 0.6 - 0.7

Heavy inclusions

3mm acetate balls, s.g. = 1.2

6mm glass balls, s.g. = 2

The 3mm size was the biggest that PCC was interested in. The bigger particles were sometimes used for better visibility on the videocamera.

The use of many small particles was considered since this would give much better statistical results and be closer to the size that PCC wanted to study. However, they were messy to use and required filtering of the water after each run to determine where various particles went. Some runs were made with cork particles, bubble alumina, sandblasting medium and silica to check the results of the larger inclusion models.

EQUIPMENT

Most of the major equipment for studying inclusions was already in place, thanks to the previous work of Sewell and Miller. This included the crucible stand, hydraulic crucible controls, small mold stand, LSBO table (large mold stand), video camera, VCR, lighting and fixtures, video monitor, previous molds and parts, various extra plexiglass material and an assortment of tools.

The crucible stand shown in figure 5 was a large structure built from steel I beams and square tubing by PCC. It had adjustable height and could support two types of crucibles; a tilting bucket type and a bottom pour type.

The tilting bucket had a maximum volume of 9.7 liters and was used with the small molds. It was operated by the hydraulic crucible control. This used an electronically driven hydraulic pump to pressurize hydraulic oil. This activated a hydraulic cylinder connected to the crucible which would tip it. The hydraulic fluid was controlled by a needle valve. Adjusting this needle valve would then give pour rates that could be repeated. Three pour rates were used, slow (S), medium (M) and fast (F). For a pour volume of two liters, this corresponded to pour times of about 4 seconds, 2.5 seconds and 1.5 seconds respectively.

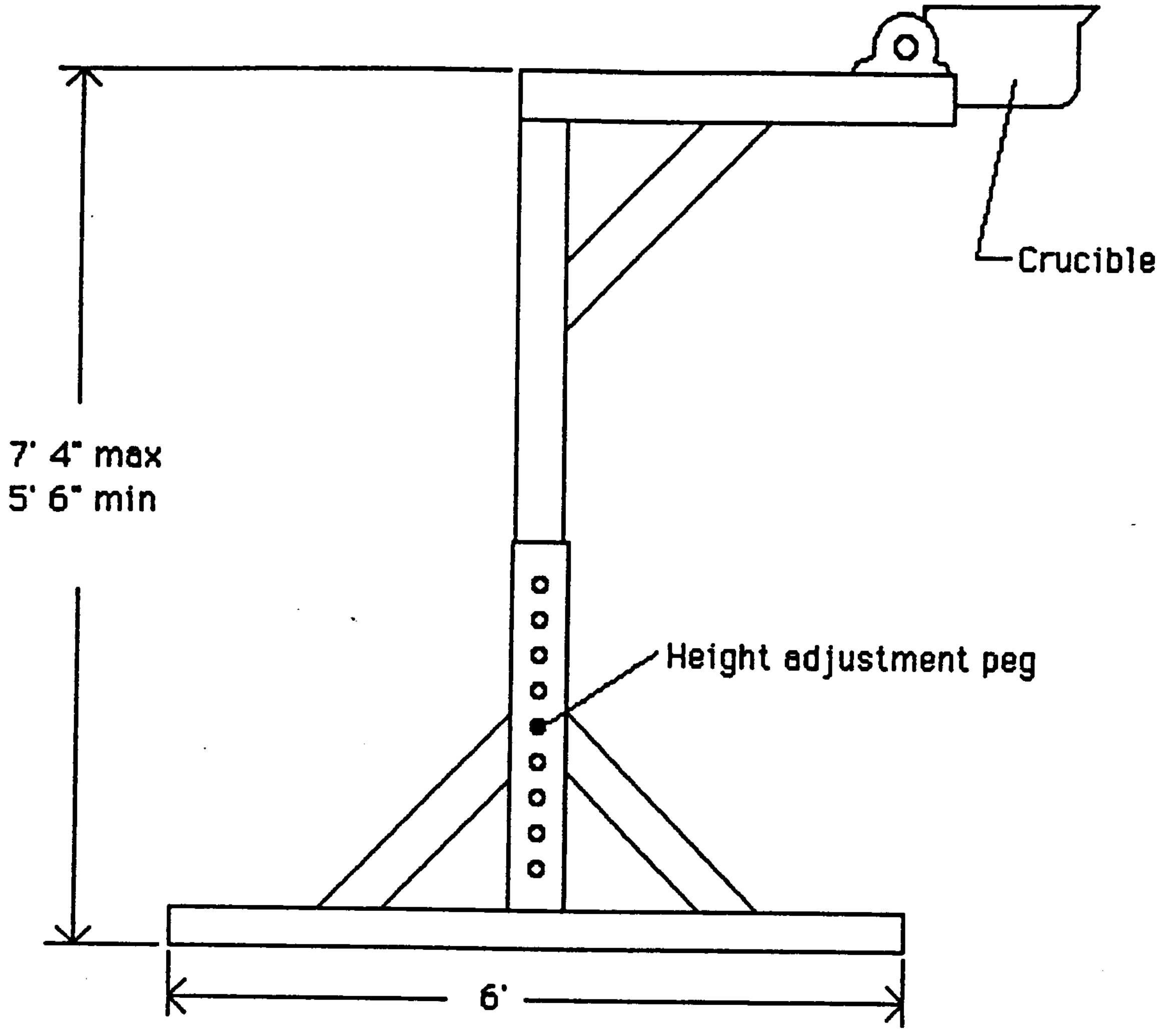

Figure 5. Crucible stand shown with small bucket crucible

The bottom pour crucible was a 17 gallon drum with a hand operated gate valve on the bottom. It was used with the large LSBO mold. (LSBO stands for Large Structure Business Operations, a division of Precision Castparts Corp.) Different pour rates could be obtained by opening the gate valve to a specific place. For a pour volume of

6.7 gallons, the approximate pour times were 10 seconds (slow), 6 seconds (medium) and 1.4 seconds (fast).

The small mold consisted of a tundish, 1.5" diameter downsprue, a 1.5" diameter runner, the inclusion trapping device, a 1.125" diameter gate, and the part mold. These were all mounted on a 29" X 18" piece of 0.5" clear plexiglass which was attached to the mold stand. The setup was positioned so the tundish was underneath the tilting crucible. See figure 6. The part mold used was the one used in earlier studies for flow evaluations.

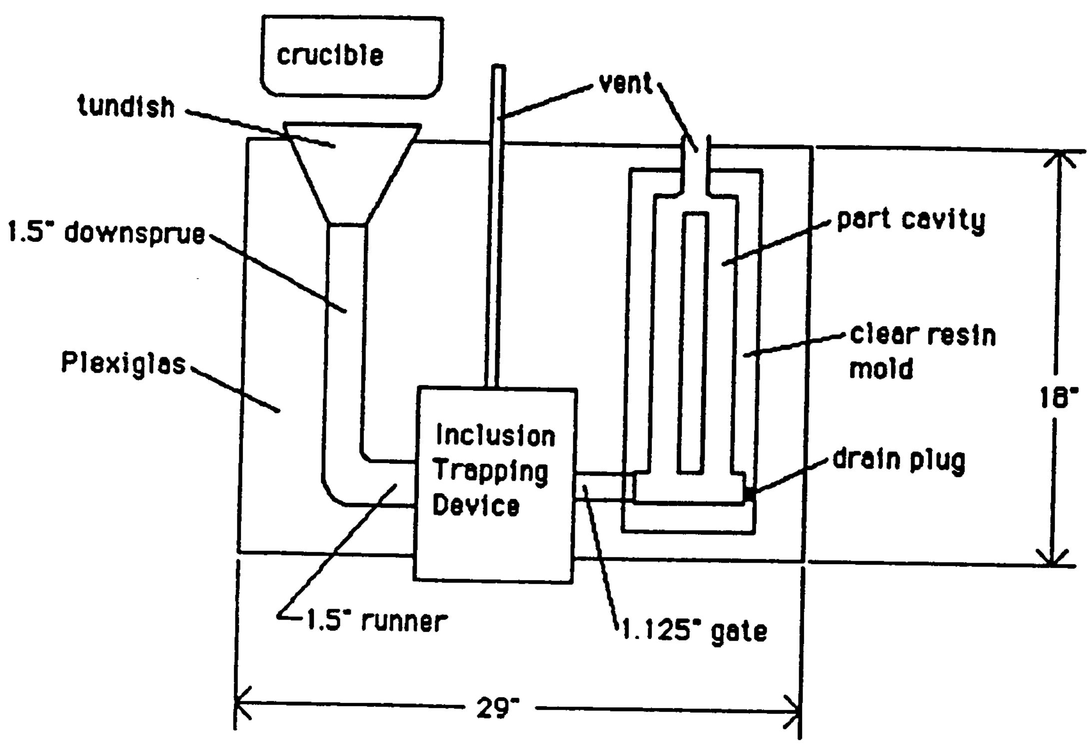

Figure 6. Small mold setup

A large mold was used to check the scaleability of the results. It consisted of a 3.5" downsprue, an 8" swirl chamber, four 2.5" outlet gates and four thin, square molds (approximately 12" X 10" X 5/8"). See figure 7. There was no tundish as the downsprue was connected directly with the bottom of the crucible.

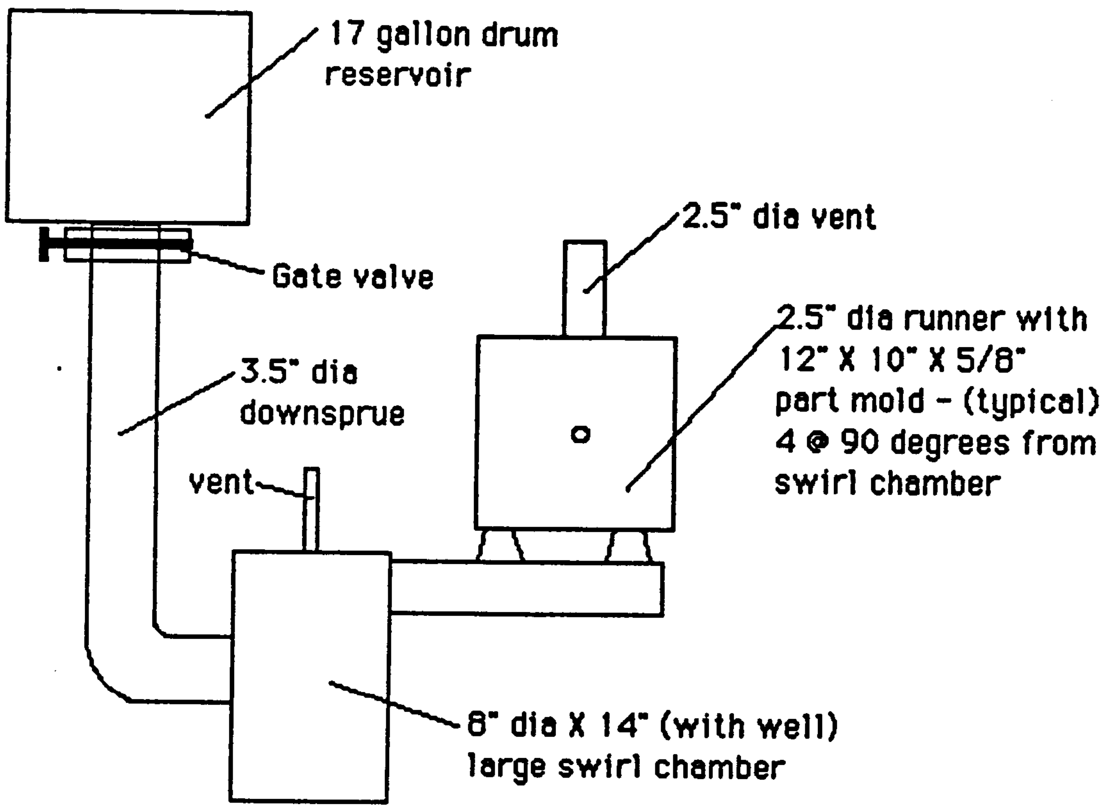

Figure 7. Large mold setup

A Panasonic AG-170 VHS videocamera was used to record the fills. The shutter speed was set to 1/500 which is faster than normal. This lead to darker pictures, requiring additional background lighting. However, the faster shutter speed gave clearer pictures when viewed on slow play or pause. A shroud made of plastic sheeting with a plexiglass viewport was built to cover the camera during experiments. This was to protect the camera from unplanned water splashing. A Sony trinitron monitor and Panasonic AG-2510 VCR were also used to analyze the fills and make backup tapes. The monitor was used to better focus the video camera, the screen giving a better picture than the camera's small internal viewing screen.

PROCEDURE

The procedure for modeling the inclusion traps is summarized below.

- Initial setup of the mold; tundish, downsprue, runner(s), inclusion trap and part mold(s). The crucible was filled with the proper amount of water.
- Each run was identified with a number. Before the pour, the camera was turned on.
- The crucible was either poured or gate valve opened at the desired pour rate.

- Inclusions were introduced to the fluid. The method depended on the particular setup and at what time the inclusions should be introduced.
- The fill was timed.
- The camera was turned off.
- A count of the inclusions at each critical location was made.

The efficiency of the inclusion trap was based on the number of inclusions that got through the trap and the number of inclusions captured by the trap. Any inclusions that didn't make it to the trap (remained in tundish, downsprue or runner) were not used in efficiency calculation.

There was no formal flow evaluation (for smoothness of mold filling) of each run as was done in previous work. The goal of this study was to find an inclusion trap that worked the best. Afterwards, if the flow in the runners or part mold was poor, it could be improved by using runner chokes or other techniques. This was the purpose of earlier work done at OSU. Another reason for not analyzing each flow was the sheer volume of them. Giving a numerical flow evaluation number to each pour was a long, tedious and somewhat arbitrary task. The number of inclusion runs was around 2500. This high number is due to two things. First, the nearly infinite number of possible inclusion trapping geometries. Second, it was found early on that one run was not enough to adequately find the efficiency of the trap. Usually, five identical runs were made with every setup to give a better statistical average.

All flows are on video tape. They can be viewed by contacting the Department of Mechanical Engineering at Oregon State University.

III. WORK DONE

The work done can be roughly summarized below.

- Various configurations of the cylindrical separation chambers (which used buoyancy) were tested on the small mold.
- The 4", 3.5", 3" & 2.5" dia. swirl chambers were tested on the small mold with various configurations.
- Two cone shaped swirl chambers were tested on the small mold.
- Miscellaneous traps were tried on the small mold.
- An 8" dia. swirl chamber was tested on the large mold. This was to verify the small swirl chamber results and see effects of more runners and larger volumes.

BUOYANCY CHAMBER

Our studies began by investigating chambers which used buoyancy to trap inclusions. This chamber was a cylinder (3.5" I.D. X 3.75" long max) positioned horizontally with inlet and outlet passages on each end. Fluid would fill the chamber completely, then any light inclusions would float to the top and heavy inclusions would sink to the bottom.

Clean fluid would be taken off in the middle as shown on figure 8.

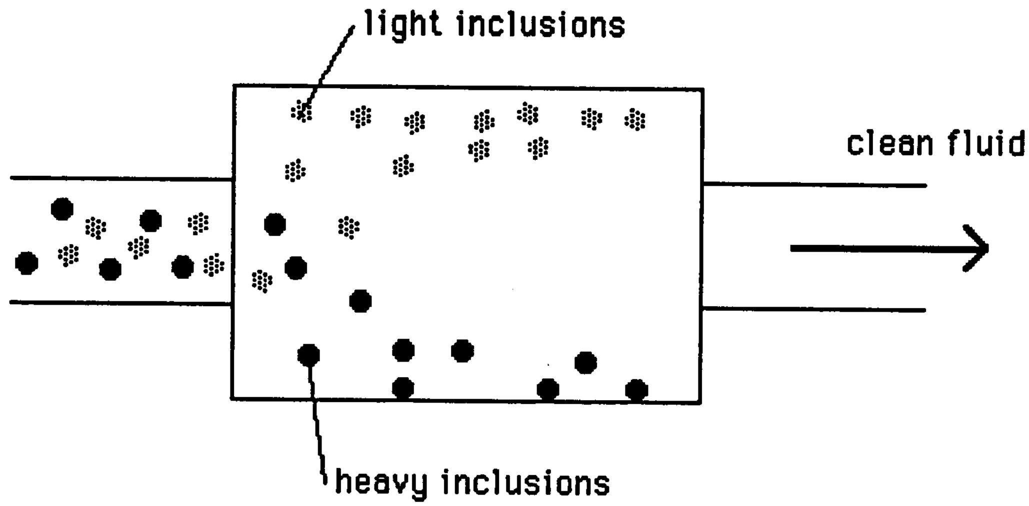

Figure 8. Mechanism to separate inclusions using buoyancy

The cylinder was adjustable as shown in figure 9. The endcaps were movable, so the effective length of the cylinder could be varied as well as the inlet's and outlet's relative position to each other. Various shaped chokes (figure 10) could be located at the inlet and/or exit. Internal baffles of various shapes could also be placed inside.

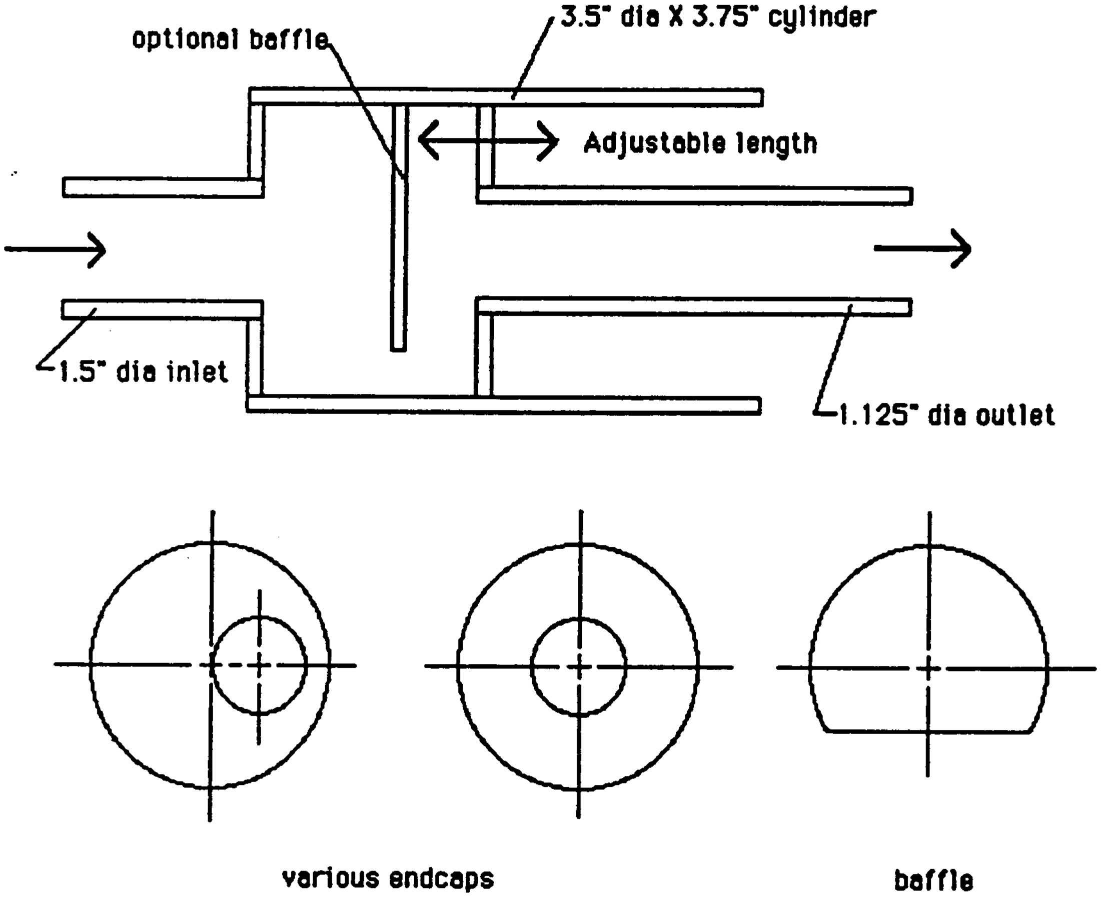

Figure 9. Buoyancy cylinder

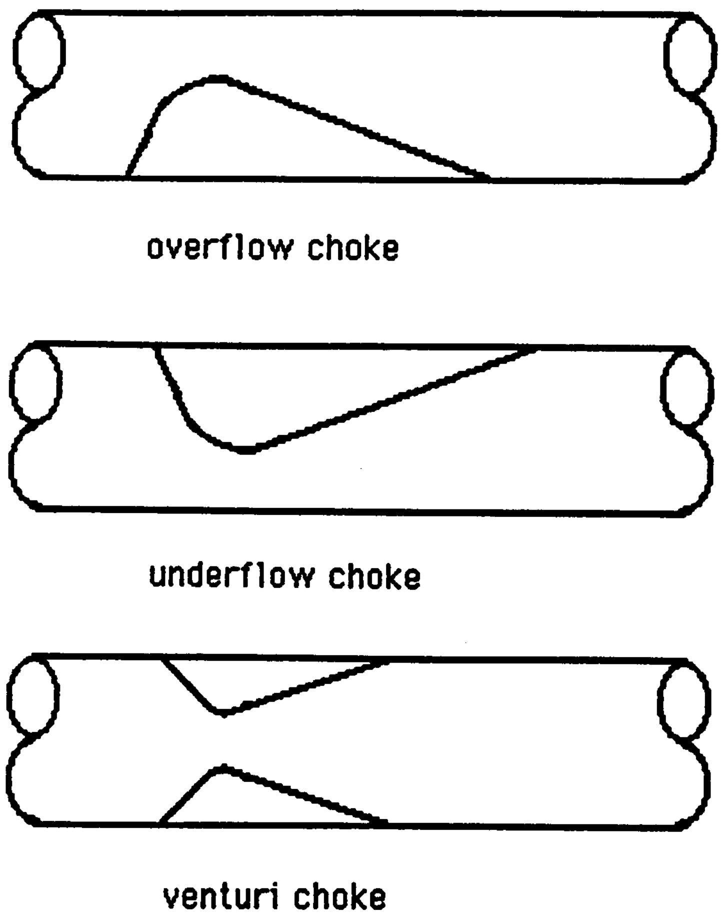

Figure 10. Various shaped chokes

Tests using the cylinders were done on the small mold. Usually, the small 3mm wood beads were used, but some tests used the larger wood beads for camera visibility. Tests using heavy inclusions were also done.

The inclusions were introduced at various places and times during the pour.

Middle (M): inclusions were put in by hand at the top of the tundish when approximately half of the fluid was out of the crucible.

Beginning (B): inclusions were put in by hand at the top of the tundish when the fluid just started to leave the tundish.

Pre-Pour (PP): inclusions were placed at the bottom of the downsprue at the elbow before the fluid was poured.

SMALL SWIRL CHAMBER

During this experiment, four small swirl chambers were made with inside diameters of 2.5", 3", 3.5" and 4". These had inside heights of 3.5". The cylinders were made from sections and held together with clear tape so they were adjustable. The inlet passage could be above or below the exit.

The exit passage could leave tangentially "with" the inlet fluid or "against" it (which we called anti-tangential). As shown in figure 11, wells, extensions and caps could easily be attached. Chokes could be placed at the inlet and/or exit.

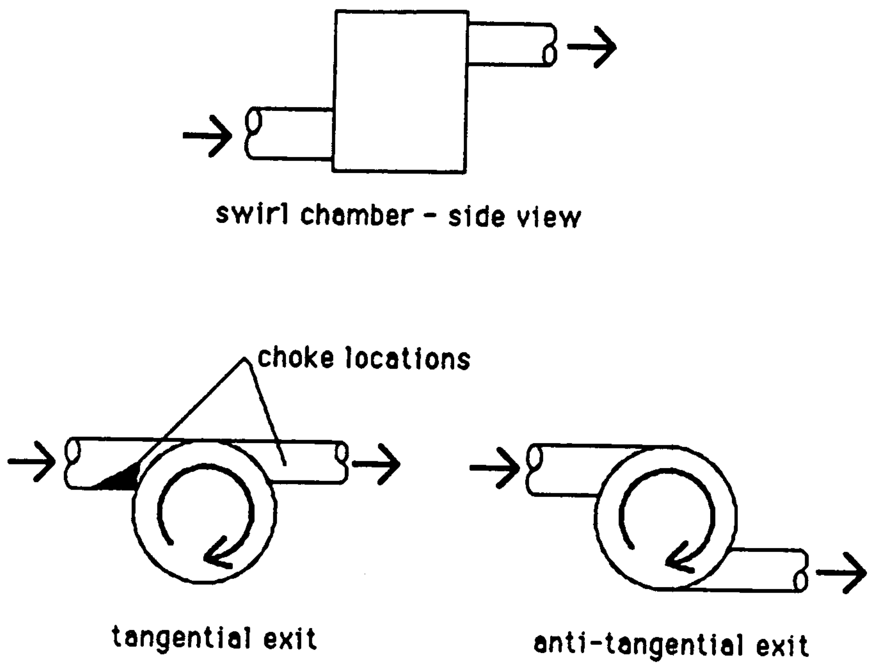

Figure 11. Small swirl chamber

The small swirl chambers were tested on the small mold, in the same way that the buoyant traps were done. The tests were nearly exclusively done with light inclusions, since the swirl chamber was specifically designed for them. Some testing was done with heavy inclusions for completeness. Nearly all inclusion introduction was pre-pour since that appeared to be the worst case and the best test of separators.

CONICAL SWIRL CHAMBERS

Two cone shaped swirl chambers were cast from plastic resin. These are shown in figure 12. The inlets and outlets were the same size as used on the small swirl chambers (1.5" and 1.125" respectively). Cone 1 had two tangential exits, one of which was plugged with clay during testing. Cone 2 had a radial exit.

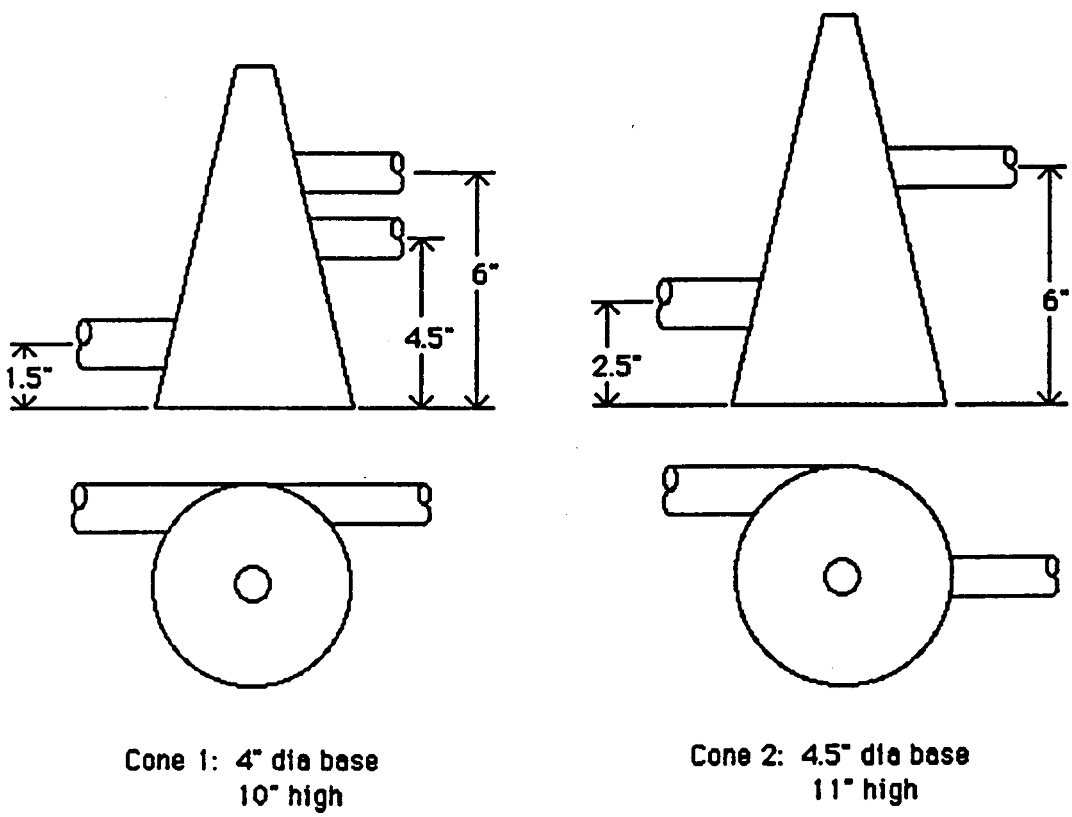

Figure 12. Conical swirl chambers

LARGE SWIRL CHAMBER

The later part of the work was on a large, 8" dia swirl chamber (see figure 7). The large swirl chamber was built to see if the results and trends of the smaller ones were consistent. One main difference in the large swirl chamber was the use of four outlets going to four part cavities, instead of just one. In a meeting with PCC in October of 1991, they expressed interest in a large swirl chamber that could feed parts radially. PCC already makes large circular parts such as turbines and nozzles. The downsprue is in the middle of the part, and runners feed off radially. They wanted something that could also be stuck in the middle of the part with a minimum amount of modification to their existing wax patterns.

The part cavities attached to this swirl chamber are the ones used previously to model a mold for PCC's LSBO.

Inclusions were introduced in two ways for the large swirl chamber. Usually, the light beads were put in a "basket" with the bottom made from window screen. This was then flipped over and placed at the bottom of the drum above the gate valve. For late inclusions, a small hole was drilled in the downsprue just above the elbow. A piece of tubing was connected to the hole and a large syringe. The inclusions were then injected into the flow.

IV. RESULTS

The raw data for all runs are given in the appendix. Only summaries of the results for each configuration are presented here.

BUOYANCY CHAMBER

The tests using the cylindrical buoyancy chambers (figure 9) were the first runs made. The first step was to find a trap that worked well enough to be a starting point. This accounted for the large number of various configurations and few number of runs made at each pour rate. If a setup looked promising, work continued, but if it didn't, the idea was dropped. Testing was not continued to see "how bad" something was. For this reason, it is nearly impossible to show specifically how different variables affected performance. However, generalizations can be made.

Having the inlet and exit passages on the same axis or using a top inlet, bottom exit gave poor performance for light inclusions. The flow did not slow down enough in the chamber to allow the inclusions time to separate. Efficiencies rarely got above 50% (see runs 635-670). These types of traps would probably work better in sand casting where the pour rates are much slower.

The time and location that the inclusions are introduced into the flow had a large effect on the efficiency of the inclusion trap. The pre-pour introduction gave the worst performance and resulted in all inclusions getting into the mold when no trapping devices were used. This is shown in runs 769-795 in the appendix. As a result, it was decided to use this method for the majority of the tests. It was felt that if a device will separate the inclusions with this type of introduction, it would do better with other later types of introduction. It was also more consistent since it did not rely on a person's timing.

The chamber did show some promise when the inlet and outlet passage were moved to opposite sides of the cylinder as shown in figure 13. Offsetting the inlet and outlet to each side of the chamber slowed the fluid down and removed a fair amount of inclusions.

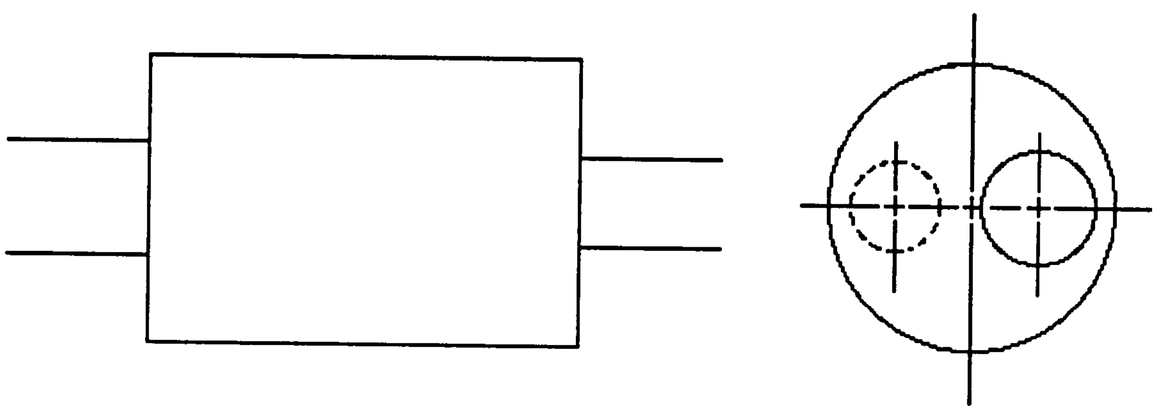

Figure 13. Buoyancy chamber with offset inlet and exit

A datum to judge performance was made (runs 821-825) using a 3.75" long buoyancy chamber with an offset inlet and exit. Other setups were tested against this. For each case, five runs were made, and both heavy (1.2 sg, 3mm acetate balls) and light (0.5 sg, 3mm wooden cubic beads) inclusions were used.

Inclusion introduction was pre-pour (pp), meaning they were placed at the elbow at the bottom of the downsprue. Table I shows the separation efficiency (number of beads caught in separator divided by the number of beads caught plus the number that got through) for different pour rates and for both heavy and light inclusions. It can be seen that light inclusions were not as affected by pour rates as heavy ones. This was not the case for all devices (see swirl chambers).

Table I. Effect of pour rate on heavy and light inclusion separation efficiency for a 3.5" dia. X 3.75" horizontal cylinder using buoyancy for separation. (runs 806-830)

	slow	med	fast
light inclusions	51	54	44
heavy inclusions	98	68	56

The cylinder length had a considerable effect on both heavy and light inclusions. This is obviously due to the fact that a longer cylinder gives more time for inclusions to be separated. Table II shows the performance of the 3.5" diameter cylindrical buoyancy chamber for various lengths.

Table II. Effect of cylinder length on heavy and light inclusion separation efficiency for a 3.5" dia. horizontal cylinder using buoyancy for separation. All pours medium speed. (runs 821-825, 836-840, 846-850)

	light	heavy
3.75" long	54	68
2.5" long	37	52
1.5" long	6	10

Putting an overflow choke on the exit of the cylinder increased the efficiency for both heavy and light inclusions. This is shown in table III. Again, this slows flow and gives inclusions longer to separate.

Table III. Effect of overflow outlet choke on heavy and light inclusion separation efficiency for a 3.5" dia. X 3.75" horizontal cylinder using buoyancy for separation. All pours medium speed. (runs 821-825, 831-835)

	light	heavy
no choke	54	68
overflow outlet choke	72	88

It was noticed that inclusions that got through the chamber lingered and swirled before going on to the mold. This led us to try a two chamber design that was made by placing a baffle in the original chamber. This is shown on figure 14.

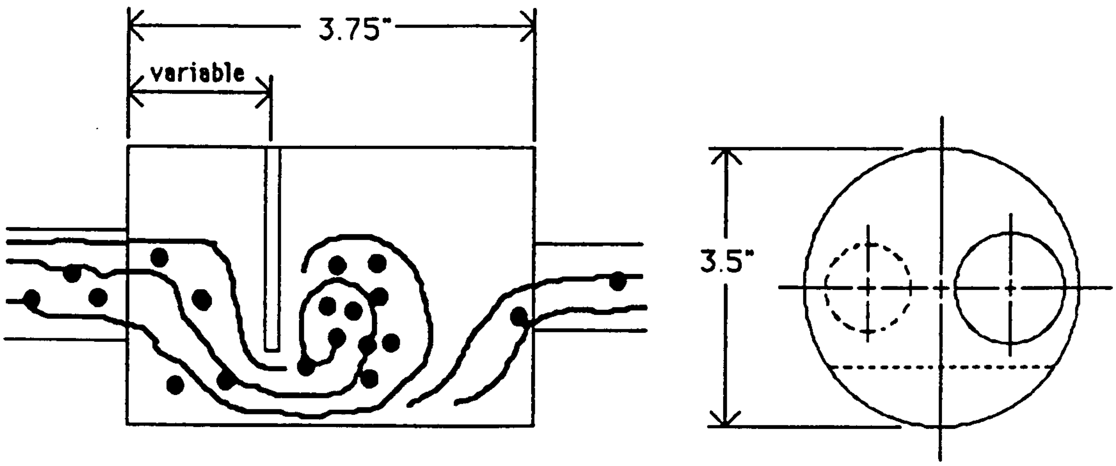

Figure 14. Buoyancy cylinder with baffle

Various locations of the baffle were tried. The design worked well with the inlet passage on top, the exit passage to one side, and the baffle one inch from the front with the opening down. The flow was dampened in the first chamber, then formed a swirl in the second chamber that would catch inclusions. The design didn't work well for faster pours and heavy inclusions, but did improve efficiency for light inclusions at slow pours. Table IV shows the efficiency of the cylinder with a baffle located one inch from the inlet compared to the cylinder without a baffle.

Table IV. Effect of internal baffle on heavy and light inclusion separation efficiency for a 3.5" dia. X 3.75" horizontal cylinder using buoyancy for separation. All pours medium speed. (runs 806-830, 851-865)

	slow	med	fast
light	51	54	44
heavy	98	68	56
with baffle, light	70	38	14
with baffle, heavy	48	35	24

SMALL SWIRL CHAMBERS

Several arrangements of inlets and outlets were tried with the small swirl chamber. In all cases, having the exit passage above the inlet passage worked best. This seems wrong since the beads are lighter than the surrounding water and would tend to float. In reality the swirl was observed to form before the fluid level reached the outlet. For cases with the inlet above the outlet, the fluid fell and splashed as shown on figure 15. This turbulence kept the inclusions mixed and the swirl took longer to develop, allowing early inclusions to get through.

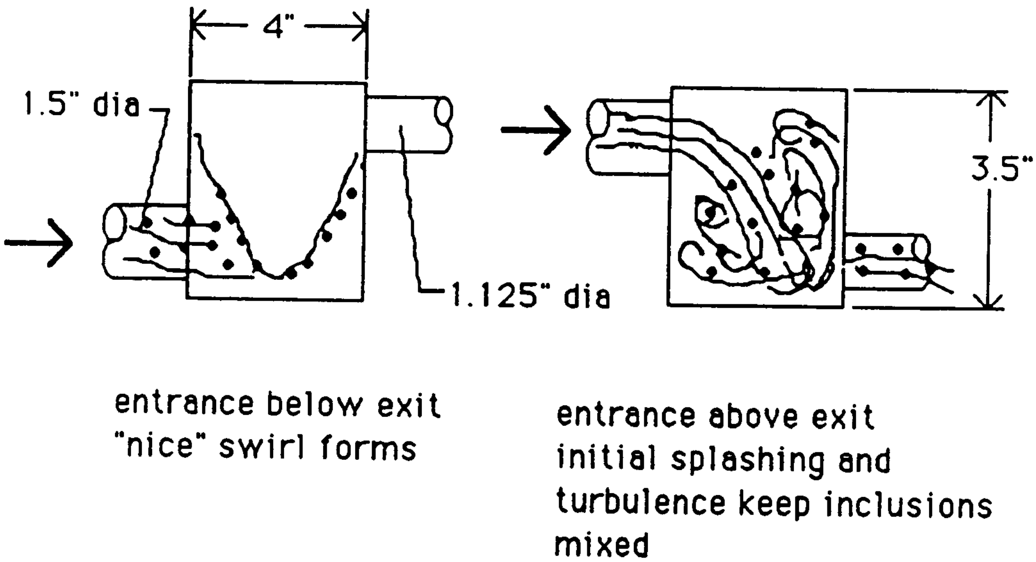

Figure 15. Inlet vs. outlet location on swirl chamber

The major sets of tests were

- plain swirl chambers
- swirl chambers with 2" wells
- swirl chambers with 2" extensions
- swirl chambers with 2" caps
- swirl chambers with inlet chokes
- swirl chambers with exit chokes
- swirl chambers with plugged vent holes
- optimum combinations

Each configuration was tried with enough runs (usually five) to get a confident estimate of efficiency. All runs were made with the inlet below the exit as described above. For obviously poor setups, less runs were made. The raw data for all runs are in the appendix and a summary of the results is given table V. Some of the data have been plotted in figures 17-28.

Table V. Summary of Results for Small Swirl Chambers

Description	Dia.	Efficiency			Fill time		
		S	M	F	S	M	F
plain swirl chamber	2.5	10	3	3	3.47	1.44	0.87
	3.0	39	14	7	4.05	1.90	1.14
	3.5	83	47	34	3.96	1.90	1.14
	4.0	84	64	53	3.83	1.55	1.25
swirl chamber with 2" well	2.5	63	54	59	3.76	1.85	1.10
	3.0	98	86	85	3.90	2.82	1.16
	3.5	93	85	81	4.38	2.07	1.53
	4.0	94	81	77	4.69	2.03	1.64
swirl chamber with 2" extension	2.5	10	13	21	4.06	1.87	1.19
	3.0	33	42	39	3.83	2.29	1.38
	3.5	79	83	72	4.15	2.14	1.21
	4.0	93	94	83	4.62	1.95	1.51
swirl chamber with 2" cap	2.5	53	21	28	3.97	2.16	1.17
	3.0	65	39	29	4.18	1.68	1.00
	3.5	89	69	45	3.68	1.42	1.03
	4.0	92	63	52	4.15	1.52	1.02
plain swirl chamber with outlet venturi choke	2.5	16	27	18	3.93	3.16	1.92
	3.0	56	30	22	4.02	2.61	1.59
	3.5	86	67	46	4.28	2.83	1.82
	4.0	89	92	86	4.10	2.76	2.05
plain swirl chamber with plugged vent hole	2.5	30	15	10	3.89	2.34	1.29
	3.0	30	25	20	4.14	2.94	1.84
	3.5	75	75	20	3.96	2.90	1.58
	4.0	81	77	83	3.96	2.93	1.90

Table V continued. Summary of Results for Small Swirl Chambers

Description	Dia.	Efficiency S	Efficiency M	Efficiency F	Fill time S	Fill time M	Fill time F
plain chamber with 50% choke inlet	2.5	87	53	39	3.87	2.71	2.23
	3.0	96	60	40	4.09	2.80	1.75
	3.5	92	75	79	3.94	3.48	2.67
	4.0	95	76	57	4.80	3.31	2.65
plain chamber with 75% choke inlet	2.5	98	53	24	4.45	3.25	2.63
	3.0	100	80	37	4.69	3.21	2.48
	3.5	94	84	65	5.01	3.92	3.51
	4.0	100	97	62	4.94	4.13	3.15
swirl chamber with 50% inlet choke and 2" well	2.5	99	90	75	4.06	2.65	1.37
	3.0	96	95	80	4.45	2.06	1.48
	3.5	99	91	89	4.60	2.29	1.66
	4.0	96	90	89	4.74	2.52	2.10
swirl chamber with 75% inlet choke and 2" well	2.5	100	97	88	4.67	3.61	3.32
	3.0	98	99	68	4.84	3.17	2.69
	3.5	97	87	78	5.10	3.98	2.84
	4.0	100	100	95	5.77	4.63	3.34
2" well, 50% inlet choke, overflow exit choke	2.5	94	96	83	4.45	3.2	3.26
	3.0	100	100	90	4.66	2.59	1.82
	3.5	97	95	90	4.58	2.67	1.95
	4.0	99	94	98	5.02	2.59	2.14

Table V continued. Summary of Results for Small Swirl Chambers

Description	Dia.	Efficiency			Fill time		
		S	M	F	S	M	F
75% inlet choke and venturi outlet choke	2.5	95	46	37	4.37	3.35	2.61
2" well, 50% inlet choke vertical position	3.5	99	91	89	4.60	2.29	1.66
2" well, 50% inlet choke tilted 45 degrees	3.5	98	82	80	4.53	2.05	1.66
2" well, 50% inlet choke horizontal position	3.5	88	66	73	4.08	2.02	1.73
All setups shown were run with the inlet passage below the exit passage and with both inlet and exit stream flowing in the same angular direction. Both the overflow exit choke and the venturi exit choke had a flow area of 0.22 in^2, a reduction in area of 88%. Inlet tube = 1.5" I.D. Exit tube = 1.125" I.D.							

Plain, wells, caps and extensions

Increasing the time for the swirl to develop was done by either adding a well, cap or extension as shown in figure 16.

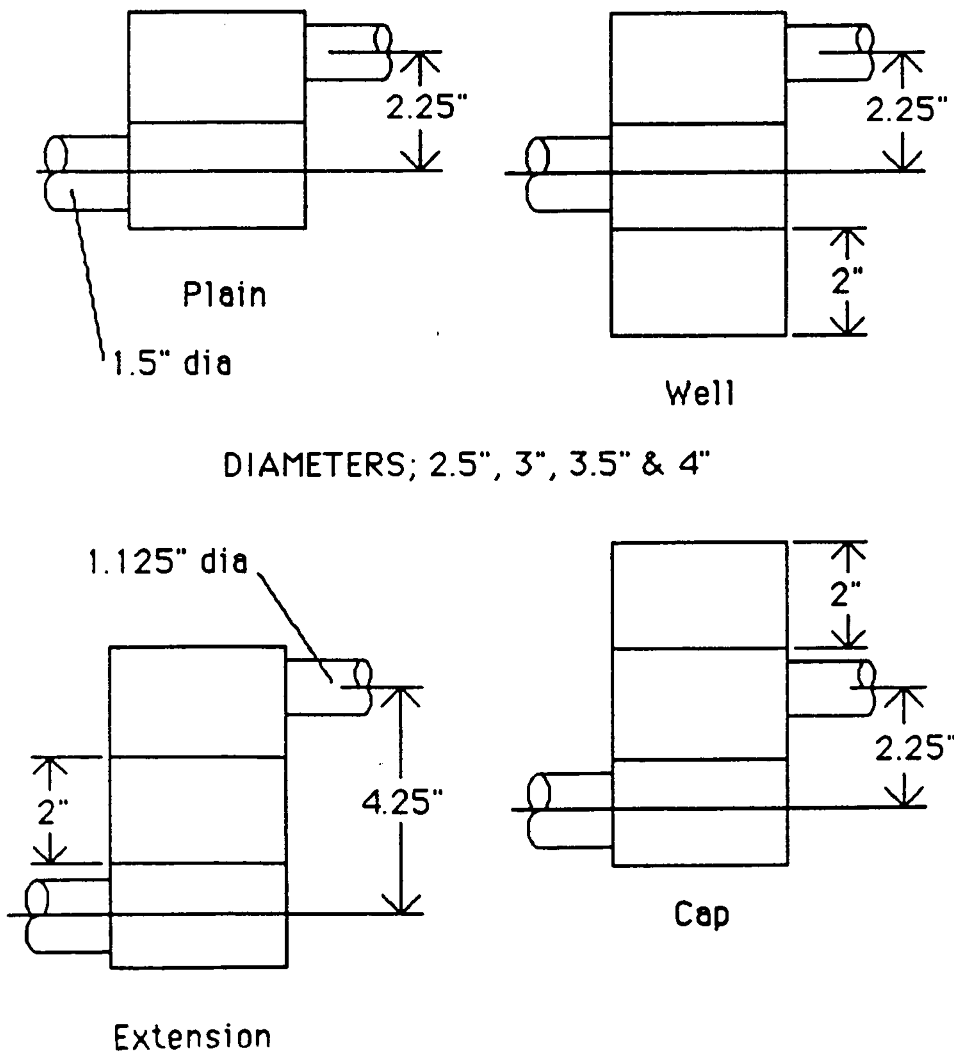

Figure 16. Small swirl chambers; plain, well, extension and cap

For all pour rates, the well performed better than the cap and the cap performed better than a plain swirl chamber. The effect of an extension seems to vary with pour rate. At slow pours (figure 17), the extension was equivalent to a plain chamber. This was because the plain chamber had adequate time for the swirl to form before the fluid left. As the pour rates increased (figure 18 & 19), the effectiveness of the extension over the plain chamber increased due to the swirl being able to develop better.

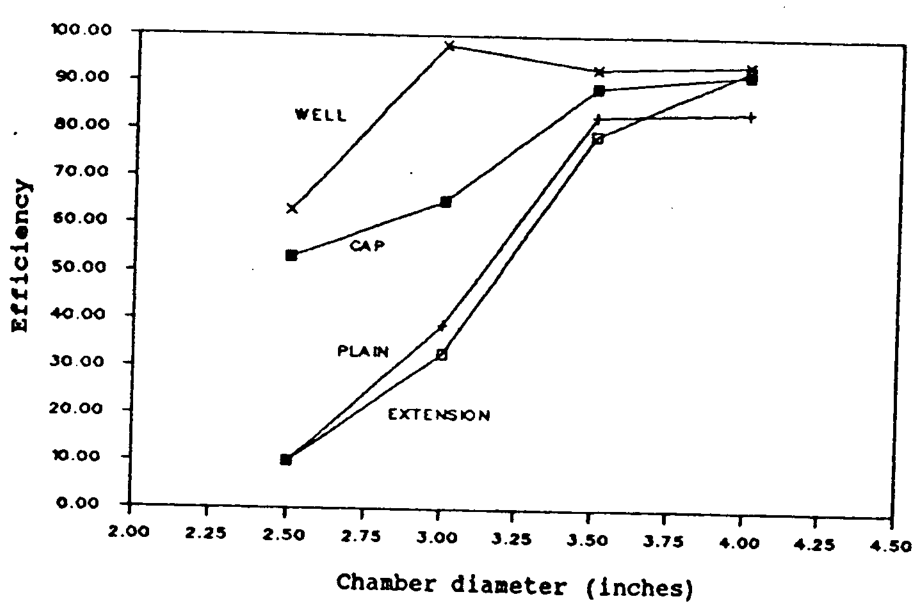

Figure 17. Small swirl chamber efficiency for slow pour

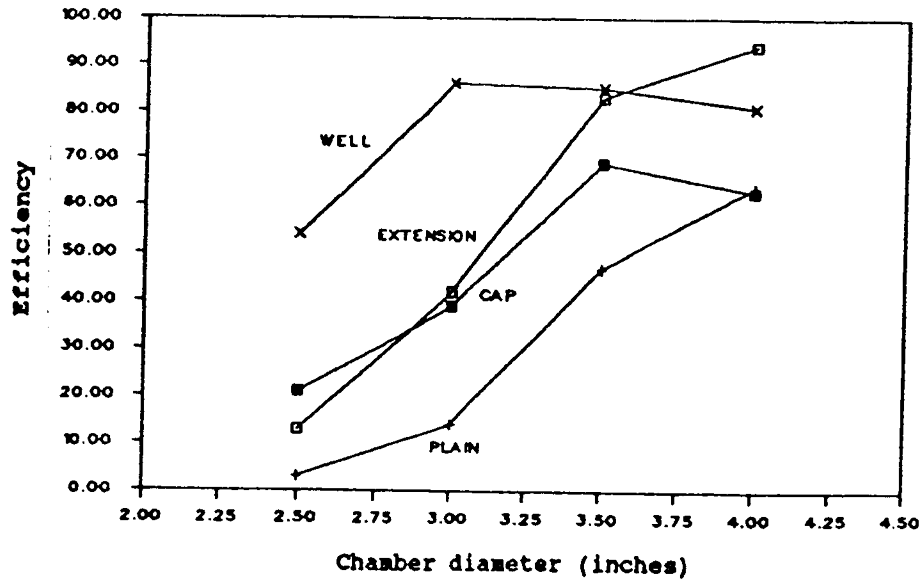

Figure 18. Small swirl chamber efficiency for medium pour

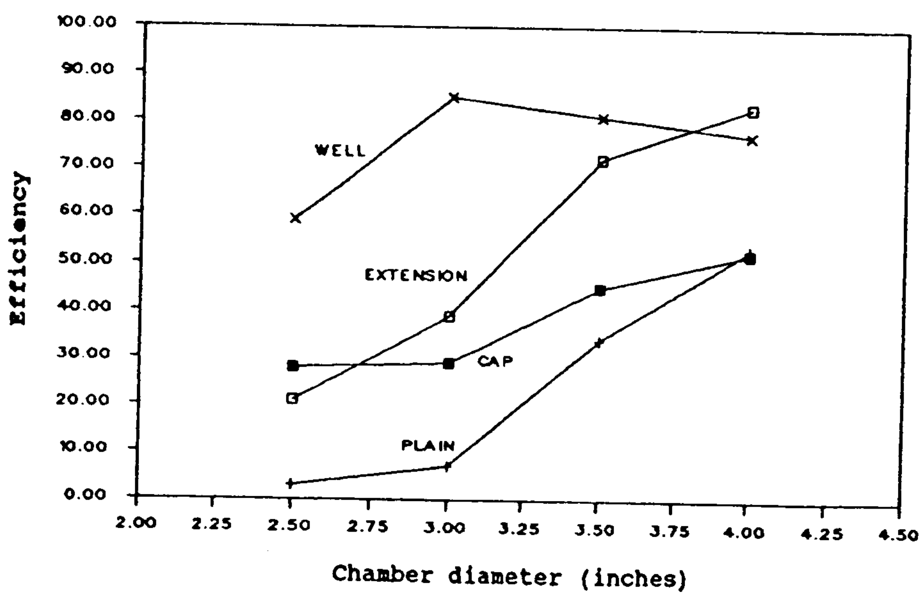

Figure 19. Small swirl chamber efficiency for fast pour

The inlet area on some runs of the plain swirl chambers was choked 50% and 75% of full open as shown in figure 11. The efficiencies of a plain swirl chamber with no inlet choke, 50% inlet choke and 75% inlet choke for various diameters are shown on figures 20-22 for slow, medium and fast pours, respectively. The corresponding fill times are shown on figures 23-25 for slow, medium and fast pours, respectively.

The chokes slow the incoming fluid down and make the chamber diameter bigger compared to the inlet stream. Both the 50% IC (inlet choke) and 75% IC gave definite efficiency increases over the unchoked chamber. While the 50% IC improvement was usually not as great as the 75% IC, its corresponding decrease in fill time made it more desirable.

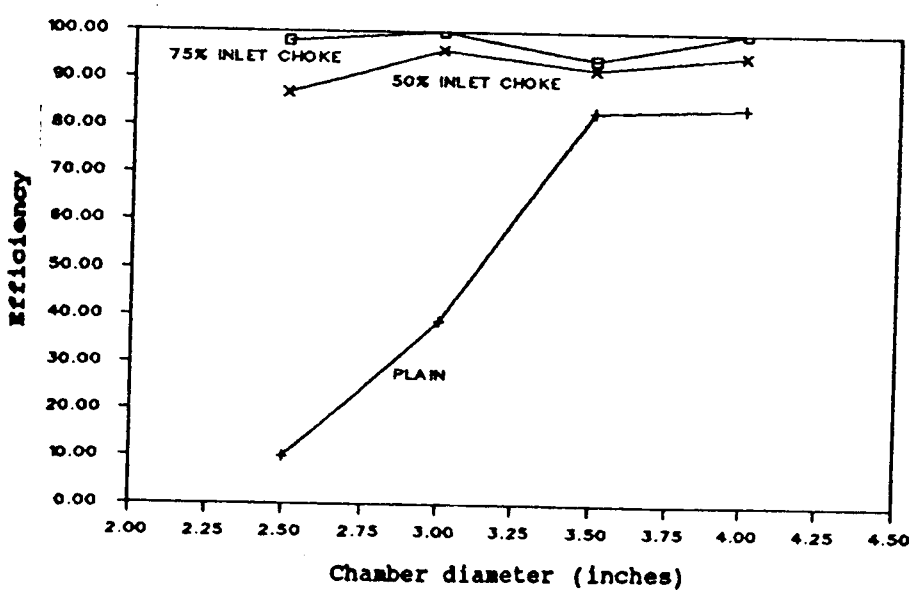

Figure 20. Efficiency of plain swirl chamber with inlet choke. Slow pour

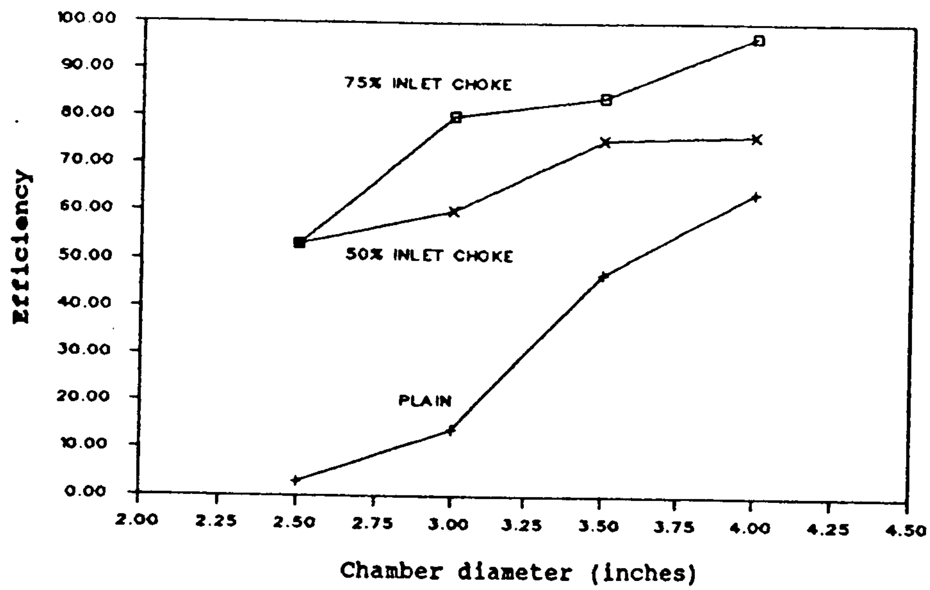

Figure 21. Efficiency of plain swirl chamber with inlet choke. Medium pour

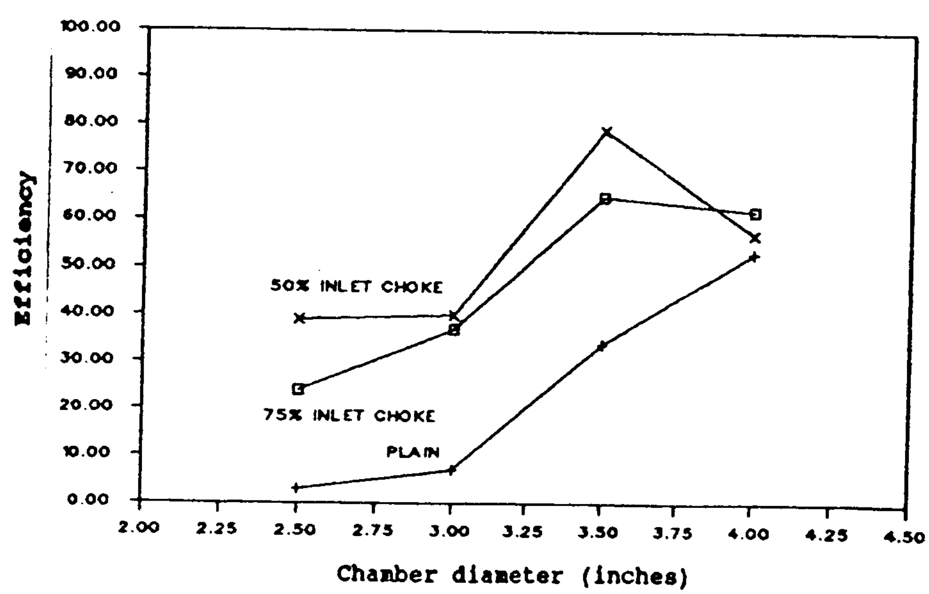

Figure 22. Efficiency of plain swirl chamber with inlet choke. Fast pour

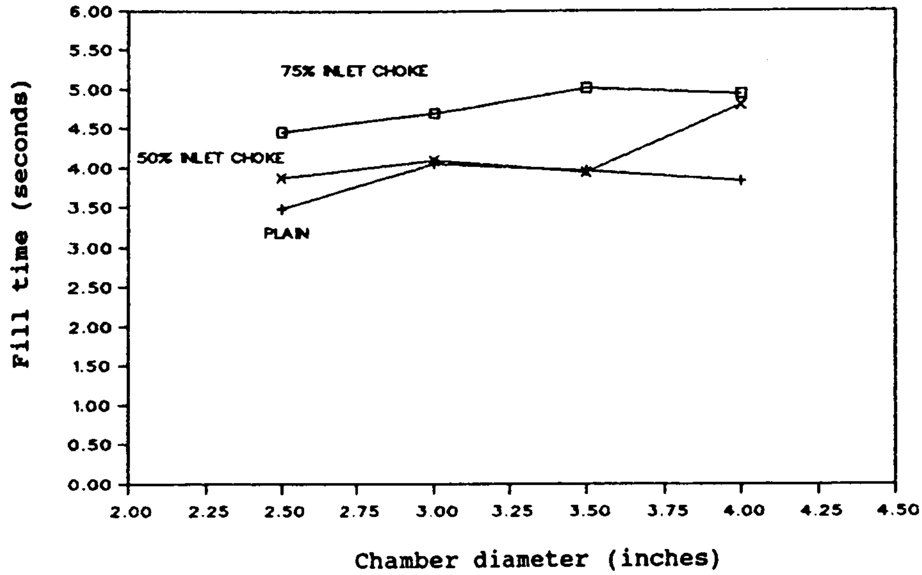

Figure 23. Fill time of plain swirl chamber with inlet choke. Slow pour

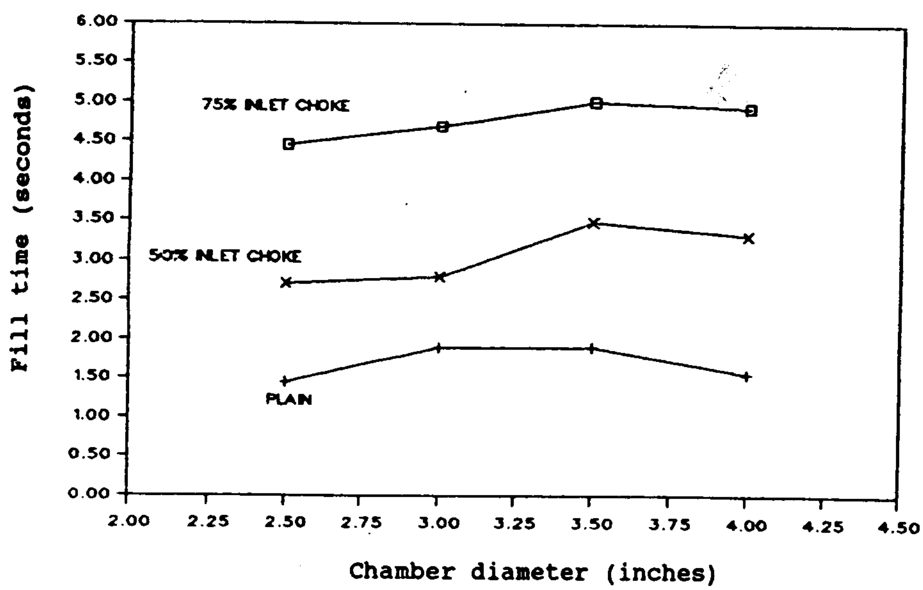

Figure 24. Fill time of plain swirl chamber with inlet choke. Medium pour

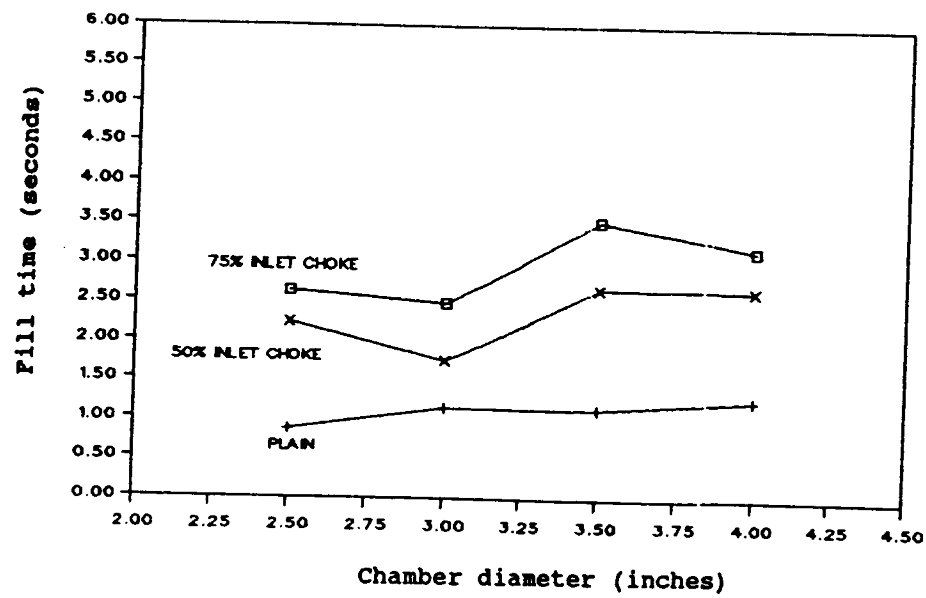

Figure 25. Fill time of plain swirl chamber with inlet choke. Fast pour

Table VI shows the effect of a venturi outlet choke. The use of an outlet choke on the plain swirl chambers gave highly improved efficiency, especially for fast pours. However, when used with the best setup (a 3.5" swirl chamber with a 2" well and 50% inlet choke) the improvement in efficiency was small.

Table VI. Effect of venturi outlet choke on separation efficiency for small swirl chambers

Swirl chamber configuration	Dia.	Without outlet choke	With outlet choke
plain	2.5"	10,3,3	16,27,18
plain	3.0"	39,14,7	56,30,22
plain	3.5"	83,47,34	86,67,46
plain	4.0"	84,64,53	89,92,86
2" well, 50% IC	3.5"	99,91,89	97,95,90

One concern that PCC had was the long, narrow vent tube required to ventilate the swirl chamber. Because it was so narrow, it could be susceptible to breakage. They were interested in the performance of the swirl chamber when a vent was not used.

When run without a vent hole, the plain swirl chambers actually seemed to give slightly better separation efficiency. However, the filling of the mold was unacceptable because the large pocket of air that would normally be vented ended up in the part cavity.

Optimization

Based on the above conclusions, the small swirl chambers were run with combinations of 2" wells, inlet chokes & exit chokes. The results for a swirl chamber with a 2" well and no outlet choke are shown in figures 26-28 for slow, medium and fast pours, respectively. Each figure gives the results for no inlet choke, a 50% inlet choke and a 75% inlet choke for various diameters.

It can be seen from these figures that a 3.5" to 4.0" swirl chamber with a 2" well and 50% inlet choke gives very good separation, equaling one with a 75% inlet choke but with a faster fill time.

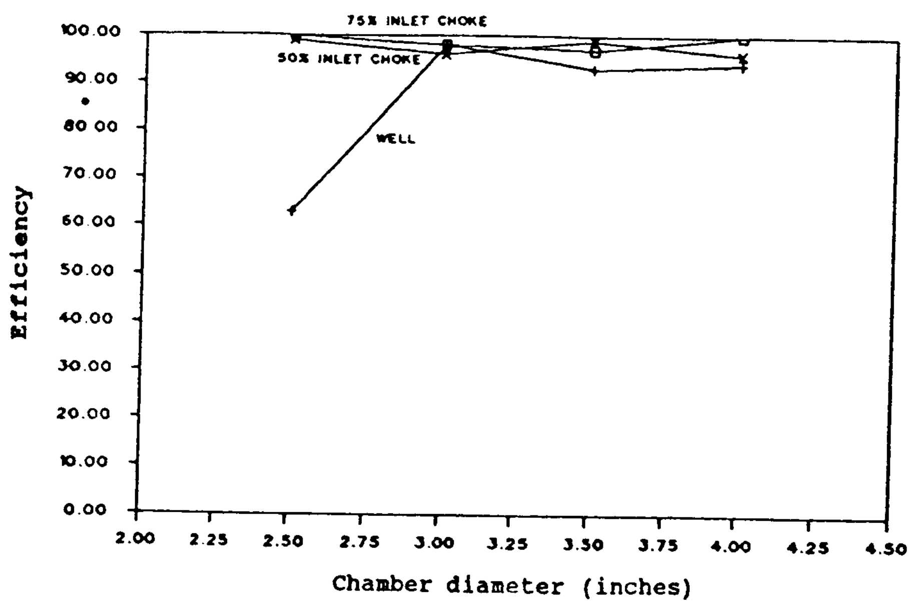

Figure 26. Efficiency of swirl chamber with inlet choke and 2" well. Slow pour

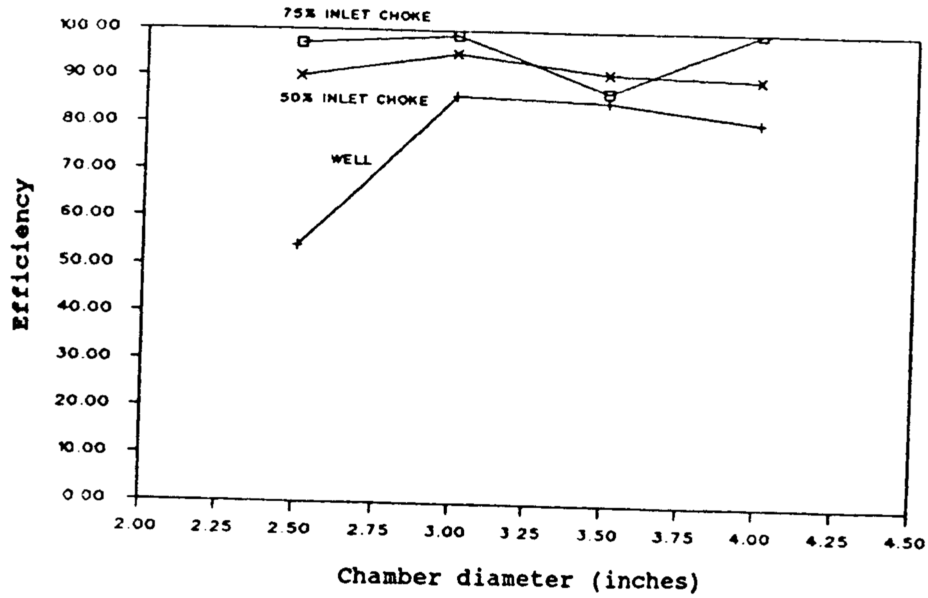

Figure 27. Efficiency of swirl chamber with inlet choke and 2" well. Medium pour

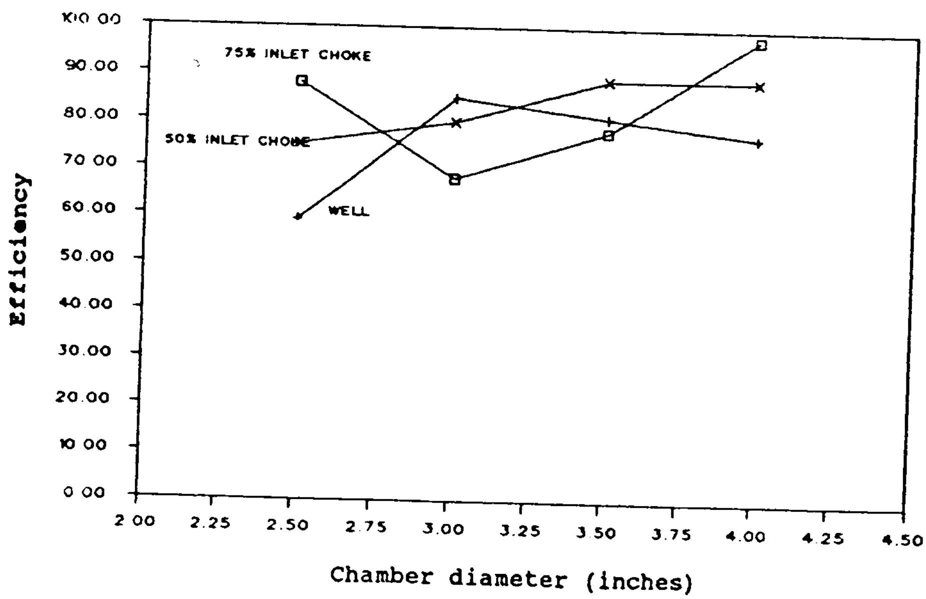

Figure 28. Efficiency of swirl chamber with inlet choke and 2" well. Fast pour

Other inclusion tests

A quantity of bubble alumina in three sizes was supplied by P.C.C. Each size consisted of both light (the alumina bubbles floated) and heavy (broken or deformed bubbles). The light bubble alumina was of the most interest, since it had a specific density around 0.85 which is heavier than the wood beads usually used (s.g. 0.5-0.6). Theoretically, they should be harder to separate, since their density is closer to the carrying medium. They are also much closer to the size that P.C.C. wanted studied (0.8 mm - 1.8 mm, vs smallest beads 3 mm). P.C.C also supplied sandblasting medium and silicon carbide particles which could be used to model heavy inclusions.

In order to study these inclusions, a small gate valve that would not interfere with flow was placed between the chamber and part mold. A given quantity of bubble alumina was placed at the bottom of the downsprue and the run was made. Immediately afterwards, the valve was shut and the alumina was removed from the two parts of the mold with a filter and allowed to dry. A digital scale was used to measure the amounts of alumina.

The video setup used to record the fills using beads was used for the alumina at first. However, due to the small size of the alumina and it's white color, a new method was tried. This consisted of enclosing the mold, stand and crucible stand in black plastic and using blacklight (ultra-violet light). Some alumina was painted with fluorescent paint.

When the run was viewed with the naked eye, the effect was quite impressive as the alumina bubbles glowed. Trying to capture this effect on video was less successful. The alumina wasn't nearly as bright, especially when the shutter speed was increased to reduce blur. An ultra-violet filter on the video camera lens gave the picture a much better overall quality, but seemed to decrease the brightness of the alumina. The tundish and part mold are slightly fluorescent themselves and the clear plastic being used filters some of the UV light leading to a lower quality picture. However, this method was definitely better than that previously used for tracking the smaller inclusions.

Comparing each case with its corresponding results done with wooden beads showed that bubble alumina runs had lower efficiencies. For example a 3.5" swirl chamber with 2" well and 50% inlet choke had efficiencies of 99%, 91% & 89% (slow, medium & fast pours) with the wooden bead inclusion models. The same setup using light bubble alumina inclusion models gave efficiencies of 96%, 90% & 78%. The decrease in efficiency, especially for fast pours, is probably due to the heavier inclusions. However, the performance was still quite good.

Fluid velocity

One concern expressed about the swirl chamber is that the fluid velocity at the wall may be too high and could erode the walls, contributing to more inclusions in the mold. A study was made to get an estimate to the fluid velocities in the downsprue and swirl chamber and how these compare.

This was done by putting inclusions into the flow and assuming that they are moving at approximately the same speed as the fluid. The video equipment used takes one frame every 1/60 sec. By advancing the tape frame by frame and getting the displacements of the beads, an estimate of the fluid velocity was made.

The swirl chamber tested was the 3" diameter with a 2" well. Both unchoked and 75% inlet choked were tried.

Numerical results are shown in table VII. It should be remembered that these are very rough estimates and some simplifying assumptions were made (inclusions are moving as fast as the fluid, the swirl has a constant angular velocity everywhere). It can be seen that maximum velocities are approximately 10% - 20% higher in the swirl chamber than in the downsprue.

Table VII. Fluid velocities in the 3" dia. swirl chamber with 2" well

max velocity at bottom of downsprue		
	unchoked	75% inlet choke
slow pour	5 (fps)	5
medium pour	8	8
fast pour	10	10
max velocity at swirl wall		
	unchoked	75% choke inlet
slow pour	6 (fps)	9
medium pour	9	11
fast pour	11	12

CONICAL SWIRL CHAMBERS

The results of the conical swirl chambers are shown in table VIII. Cone 1 (see figure 12) worked quite well with a 50% inlet choke and even better with an exit choke. This indicates that conical swirl chambers can work at least as well as the cylindrical shaped ones. One problem with studying the cones was their difficulty in casting. This made investigating many different cone geometries unfeasible.

Table VIII. Summary of Results for Conical Swirl Chambers

Description	Efficiency			Fill time		
cone #1, upper inlet	75	80	77	4.16	1.92	1.54
cone #1, lower inlet	82	86	75	3.56	1.62	1.20
cone #1, lower inlet, 50% inlet choke	100	92	84	5.00	2.26	1.80
cone #1, lower inlet, 50% inlet choke, overflow outlet choke	100	97	97	5.19	2.68	2.12
cone #1, lower inlet, 50% inlet choke, sideflow outlet choke	100	99	96	4.95	2.70	2.17
cone #2, radial outlet	88	87	85	3.75	1.66	1.44

LARGE SWIRL CHAMBER

A summary of the results for the large swirl chamber is given in table IX. During work with the small swirl chambers, it was found that a 3.5" swirl chamber with a 50% inlet choke and a well gave very good results, 99% (slow), 91% (medium) and 89% (fast). A larger 8" dia chamber with a 50% IC and well gave similar good results, 90%, 88% & 88%.

Table IX. Summary of Results for Large Swirl Chamber

RTA	PWCE	IC	OC	CN	Description	S	M	F
R	P					79	28	33
R	P	X				83	53	43
R	W					62	55	59
R	W	X				90	88	88
R	W	X		C1		81	93	77
R	W			C1		45	46	51
R	W	X	X			93	96	63
R	W	X	X	C1		91	89	77
R	P	X	X	C1		73	53	40
R	P	X		C1		58	57	38
R	C	X		C2		56	49	41
R	W	X		C2		83	91	73
T	W	X				89	90	58
T	W	X		C2		60	63	56
T	W	X	X	C2		69	72	64
T	W	X	X			94	94	71
T	P	X	X			43	15	11
T	P	X	X	C1		66	24	8
T	P	X				38	23	10
A	P	X				70	64	44
A	W	X				94	99	94
A	W	X		C2		79	88	79
A	W	X	X	C1		92	91	84
A	W	X	X			99	99	86
A	W	X	X	C2		96	95	88
A	P	X	X			81	76	50
A	P	X	X	C1		90	69	51

Table IX continued. Summary of Results for Large Swirl Chamber

RTA	PWCE	IC	OC	CN	Description	S	M	F
R	W	X			top outer cone (4 lbs clay)	98	96	100
R	W	X		C2	top outer cone (4 lbs clay)	53	52	61
R	P	X			top outer cone (4 lbs clay)	24	28	48
R	W	X			full outer cone (8 lbs clay)	33	62	56
R	W	X	X		full outer cone (8 lbs clay)	72	76	59
R	E	X			full outer cone (12 lbs clay)	92	86	67
R	E	X	X		full outer cone (12 lbs clay)	83	80	64
R	E	X				99	94	63
R	E	X	X			100	100	58
R	E	X	X		top outer cone (4 lbs clay)	82	81	73
R	E	X			top outer cone (4 lbs clay)	82	94	77
R	E	X		C2		100	91	51
R	E	X	X	C2		99	99	59
R	W	X			top outer cone (4 lbs clay)-late inc	61	74	61
R	W	X			late inclusions	96	93	95
A	W	X			top outer cone (4 lbs clay)	64	91	89
T	W	X			top outer cone (4 lbs clay)	87	94	81

Table IX continued. Summary of Results for Large Swirl Chamber

RTA	PWCE	IC	OC	CN	Description	S	M	F
R	W	X		C2*	ice cream cone	93	88	76
R	W	X		C2*	ice cream cone-late inclusions	91	89	94
R	W	X		C2*	ice cream cone-heavy inclusions	100	98	92

RTA; radial, tangential or anti-tangential outlet
PWCE; plain, well, cap or extension
IC; 50% inlet choke
OC; overflow outlet choke
IN; insert used. C1 = "stubby" cone, C2 = "pointy" cone, C2* = inverted poiny cone

Table X compares the results for different configurations of radial, tangential and anti-tangential outlets (see figure 29). In general, the trend seems to be anti-tangential and radial outlets are about equal and better than tangential outlets. This doesn't seem intuitive since tangential outlets will lead to a stronger swirl. But they let the fluid out quicker, giving the earlier inclusions less time to be separated.

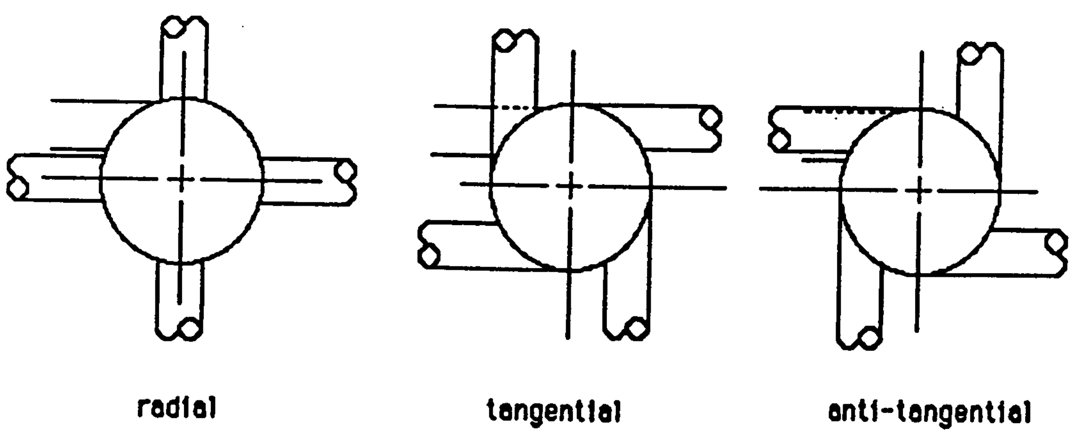

Figure 29. Radial, tangential and anti-tangential outlets

Table X. Effect of outlet configuration on large swirl chamber separation efficiency

	outlet		
configuration	rad	tan	anti-tan
well, IC	90,88,88	89,90,58	94,99,94
well, IC, OC	93,96,63	94,94,71	99,99,86
well, IC, insert 2	83,91,73	60,63,56	79,88,79
plain, IC	83,53,43	38,23,10	70,64,44
well, IC, *	98,96,100	87,94,81	64,91,89

IC=50% inlet choke, OC=overflow outlet choke, insert 2 is a 'pointy' cone placed inside the chamber. * = clay was placed at the top of the chamber to make a cone shaped top. The three numbers are efficiencies for slow, medium and fast pours.

Outlet chokes

The use of overflow outlet chokes rarely had a significant effect on efficiency. This trend conflicts with the small swirl chamber results that showed an outlet choke could give significant improvement. They do improve fill quality, however.

Conical swirl chambers and inserts

In order to decrease the chamber volume, clay was placed inside the chamber to make a cone shape as shown in figure 30. Various shaped insets were attached to the bottom of the chamber to take up even more space (see figure 18). Insert 2 was actually just one of the conical swirl chambers with the inlet and exit removed and plugged. A summary of the results with the clay are given in table XI.

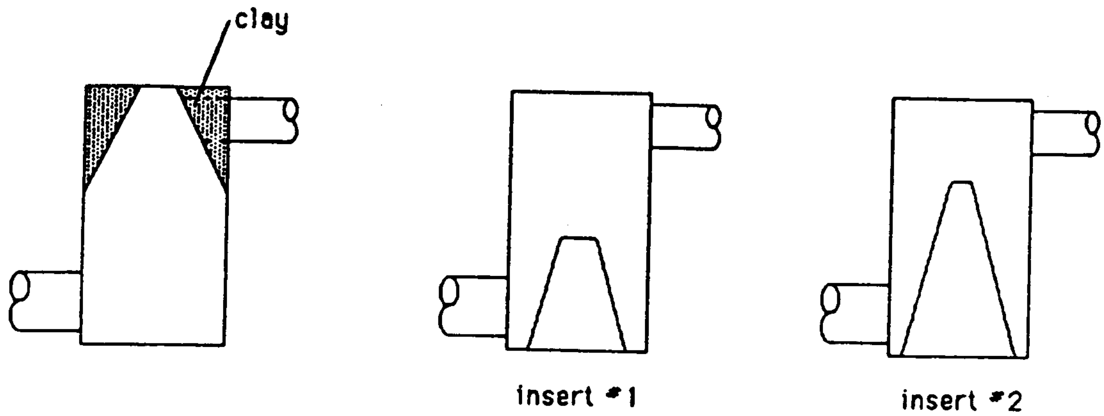

Table XI. Effect of clay filler on separation efficiency for large swirl chamber with well and 50% inlet choke

	no clay	clay cone
radial	90,88,88	98,96,100
tangential	89,90,58	87,94,81
anti-tangential	94,99,94	64,91,89

It can be seen that the cone shape made by the clay doesn't hurt and in fact helps considerably in some instances. However, viewing the video of the fills shows that the swirl is strong at the beginning near the bottom of the chamber, but is 'destroyed' when the fluid enters the conical portion. Most earlier injected inclusions (which are what we generally test) were already captured before the vortex dissipated. When the same test were run for later inclusion injection, the efficiency dropped.

Table XII gives the results from using insert 2 (see figure 30) in the chamber. They show the insert has a small negative effect on efficiency. However, insert #2 decreases the chamber volume by a third.

Table XII. Effect of insert 2 on separation efficiency for large swirl chamber with well and 50% inlet choke

	no cone	insert 2
radial	90,88,88	83,91,73
tangential	89,90,58	60,63,56
anti-tangential	94,99,94	79,88,79

Knowing that conical inserts could be placed in the chamber without decreasing the efficiency greatly, it was thought that these could be used in combination with the clay to form a cone-in-a-cone. However, no really promising combinations were found.

Using inserts by themselves seems to be the most promising way of decreasing chamber volume while keeping acceptable efficiencies.

An upside down cone insert was also tried. When viewing a fill of a chamber, the forming vortex looks like a "V" (figure 15). It was thought an insert could be made to match this so that the flow would be disrupted as little as possible. This lead to the upside down cone or "ice-cream cone" as shown in figure 19. The tests showed that this insert worked very well, matching the performance of any other insert. It also worked well for heavy and late inclusions. This is probably the best type of insert for decreasing chamber volume. The efficiency for this setup was 93% slow, 88% med & 76% fast.

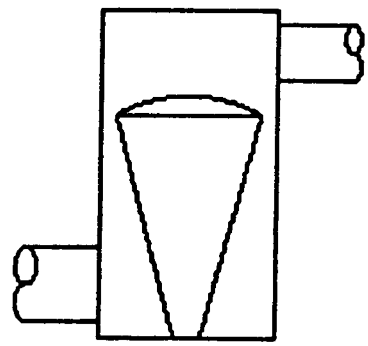

Figure 31. Ice-cream cone shaped insert

MISCELLANEOUS SEPARATORS

Many other ideas (some quite entertaining and imaginative!) were also investigated during this experiment. The are all listed in the raw data in the appendix. They were not discussed because of their poor performance and lack of promise. Some examples of these are trapezoidal shaped buoyancy chambers, the whirlgate described earlier, a "rifled" swirl chamber (much like the whirlgate, but using clay for the helix), swirl chambers with different diameter upper and lower halves, and baffles in the swirl chambers.

V. CONCLUSION

The use of an inclusion trap which uses buoyancy for separation probably will not work well with investment casting because of the fast pour rates. The inclusions do not have enough time to either float to the top or sink to the bottom of a chamber before they exit. These types of traps will work better at slower pour rates in applications such as sand casting.

A trap that uses centrifugal force (a swirl chamber) to separate inclusions can be very effective but needs to be set up properly. This type of separator is meant to be used with light inclusions which are forced towards the center of the cylinder. However, it was found that these traps (especially with a well) could catch nearly %100 of heavy inclusions, even for fast pours.

Some general guidelines for making the most effective swirl chambers are as follows.

The inlet runner should be below the exit runner(s). This seems wrong since bouyant forces will tend to push the lighter inclusions towards the top where the exit passages are located. However, putting the inlet above the exit results in the incoming stream having to fall and crash at the bottom of the cylinder. This leads to turbulence (which keeps the inclusions mixed) and slow swirl development.

An inlet choke should be used to force the incoming tangential stream more towards the walls of the chamber. It was found that a 50% inlet choke (which reduced the cross sectional area of the inlet passage by 50%) gave a good combination of increased separation efficiency and fast fill times.

A well at the bottom of the swirl chamber, below the inlet, improves separation efficiency. This is the best place to put additional chamber volume, and works better than a cap (on top of the swirl chamber) or an extension (a section between the inlet and exit).

The swirl chambers give better separation efficiency with slower pour rates (30 in^3/sec for the small mold, 150 in^3/sec for the large mold) than with fast pour rates (80 in^3/sec and 1100 in^3/sec for small and large molds, respectively). Although the centrifugal force acting on the inclusions will be larger for a faster angular velocity, slower pours give nicer, well formed swirls and less turbulence.

The configuration of the exit passages does affect separation efficiency. The best outlets are either radial or anti-tangential spokes (where the exiting stream travels in an angular direction opposite to the inlet). Tangential outlet passages (where the inlet and exit stream travel in the same angular direction) gave lower efficiencies. Adding an overflow choke to the exit passages does not usually improve separation efficiency, but will improve the filling of the part cavity.

The actual dimensions of the swirl chamber will obviously depend on the mold that it is being used on. Unfortuneately, the work did not produce any formulas or correlations in which on could input mold charactoristics (pour volume, diameter or area of inlet and exits, number of exit passages, pour rate, crucible head, etc.) and get the dimensions and specifications for the optimum swirl chamber.

The study showed that the larger the swirl chamber, the better it traps inclusions. However, an optimum chamber must combine separation with fast fill times, good filling charactoristics and the least amount of volume (wasted or scrap material).

The optimum swirl chamber found from the small mold was 3.5" in diameter, 5.5" high (which includes the 2" well), and had a 1.5" diameter inlet with a 50% inlet choke. The outlet was a single 1.125" diameter passage. The pour volume was around 2 liters (0.5 gallons). Separation efficiencies for light inclusions were 99%, 91% and 89% for slow, medium and fast pours, respectively. This swirl chamber was then scaled up by 2.25 to give the 8" diameter swirl chamber. This chamber did have more exit area (four 2.5" diameter passages) than the small swirl chamber. Pour volume was about 25 liters (6.7 gallons). This larger chamber gave similar high separation efficiencies of 90%, 88% and 88% for slow, medium and fast pours, respectively.

These findings show that the optimum small swirl chamber is a good starting point, and dimensions can be scaled to the size needed.

A small amount of work was done to see the effects of an extremely large pour volume in comparison to the swirl chamber volume. It showed that as a large pressure head builds up in the part cavity, the swirl which initially formed begins to be dampened, losing its effectiveness. This allows late inclusions to get through. Therefore, for much larger pour volumes, it is recommended that additional pouring head or faster pour rates be used.

The volume of the chamber in comparision to the pour volume may be objectionable in some cases. However, properly shaped inserts can be placed inside the chamber to reduce fill volume while still giving good efficiency and fills. The best shape found resembles an ice-cream cone; an inverted cone with a rounded top. The volume of the insert was one third the volume of the chamber.

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APPENDICES

Appendix A: Raw data for all runs

Raw data for all runs are given in the order shown.

INCLUSION CONTROL RUNS
THESE WERE RUN WITH NO INCLUSION TRAPPING DEVICE TO SEE WHERE THE
INCLUSIONS WERE MOST LIKELY TO END UP.
THE INCLUSIONS USED WERE 3mm & 6mm WOOD BEADS

								LOCATION OF INCLUSIONS		
RUN #	DATE	POUR RATE	INCLUSION INTRO.	INCLUSION SIZE	S.G.	# INCs	FILL TIME	TUNDISH	HORIZ. RUNNER	VERT. RUNNER, PART MOLD
769	6/21	S	B	3mm	0.5-0.6	10	2.21	1	0	9
770	6/21	M	B	3mm	0.5-0.6	10	0.85	1	0	9
771	6/21	F	B	3mm	0.5-0.6	10	0.58	7	0	3
772	6/21	S	M	3mm	0.5-0.6	10	2.28	1	0	9
773	6/21	M	M	3mm	0.5-0.6	10	0.79	5	0	5
774	6/21	F	M	3mm	0.5-0.6	10	0.47	7	0	3
775	6/21	S	B	6mm	0.6-0.7	10	2.08	2	0	8
776	6/21	M	B	6mm	0.6-0.7	10	0.71	2	0	8
777	6/21	F	B	6mm	0.6-0.7	10	0.48	6	0	4
778	6/21	S	M	6mm	0.6-0.7	10	1.97	10	0	0
779	6/21	M	M	6mm	0.6-0.7	10	0.77	4	1	5
780	6/21	F	M	6mm	0.6-0.7	10	0.62	7	0	3
781	6/21	S	B	3mm	0.5-0.6	10	2.85	0	0	10
782	6/21	M	B	3mm	0.5-0.6	10	2.28	2	0	8
783	6/21	F	B	3mm	0.5-0.6	10	1.31	4	0	6
784	6/21	S	M	3mm	0.5-0.6	10	2.95	9	1	0
785	6/21	M	M	3mm	0.5-0.6	10	2.4	5	0	5
786	6/21	F	M	3mm	0.5-0.6	10	1	8	0	2
787	6/21	S	B	6mm	0.6-0.7	10	2.94	1	0	9
788	6/21	M	B	6mm	0.6-0.7	10	2.06	2	0	8
789	6/21	F	B	6mm	0.6-0.7	10	1.1	5	1	3
790	6/21	S	M	6mm	0.6-0.7	10	3.04	9	1	0
791	6/21	M	M	6mm	0.6-0.7	10	1.42	4	1	5
792	6/21	F	M	6mm	0.6-0.7	10	1.08	3	1	6
793	6/21	S	PP	3mm	0.5-0.6	10	2.42	0	0	10
794	6/21	M	PP	3mm	0.5-0.6	10	1.89	0	0	10
795	6/21	F	PP	3mm	0.5-0.6	10	0.89	0	0	10

INCLUSION RUNS WITH 3.5" DIA CYLINDRICAL BUOYANCY CHAMBER

CHOKE TYPE

0.375" ID IS A VENTURI CHOKE WITH 0.375 IN^2 FLOW AREA

OVFL IS AN OVERFLOW CHOKE WITH THE INDICATED FLOW AREA IN IN^2

BAFFLE: THE BAFFLE WAS A 3.5" DIA CIRCLE WITH 0.5" REMOVED

INCLUSIONS: THE TYPES OF INCLUSIONS USED HERE ARE

6mm, 2.2 S.G. GLASS BALLS

6mm, 0.6 S.G. WOOD BEADS (ROUND)

3mm, 0.5 S.G. WOOD BEADS (SQUARE)

3mm, 2.0 S.G. TEFLON BALLS

3mm, 1.2 S.G. ACETATE BALLS

LOCATION OF INCLUSIONS

A. TUNDISH, DOWNSPRUE, 1ST HORIZONTAL RUNNER

B. CHAMBER, INCLUSION TRAPPING DEVICE

C. 2ND HORIZONTAL RUNNER

D. VERTICAL RUNNER, PART MOLD

E. WELL OR RUNNER EXTENSION, UF USED

IS THE NUMBER OF INCLUSIONS THAT WERE INTRODUCED

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	LOCATION OF INCLUSION AFTER THE POUR #	REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
590	4-16-91	S	B	3.75	CENTER/CENTER	4.5			2.35	6	2.2	10	0	9	0	0	1	100%		
591	4-16	F	M	3.75	CENTER/CENTER	4.5			1.35	6	2.2	10	0	9	0	0	1	100%		
592	4-16	M	B	3.75	CENTER/CENTER	4.5			1.48	6	2.2	10	0	7	0	0	3	100%		
593	4-16	S	B	3.5	CENTER/CENTER	4.5			2.91	6	2.2	10	0	10	0	0	0	100%		
594	4-16	M	B	3.5	CENTER/CENTER	4.5			1.21	6	2.2	10	0	7	0	0	3	100%		
595	4-16	F	B	3.5	CENTER/CENTER	4.5			1.09	6	2.2	10	1	8	0	0	1	100%		
596	4-16	S	B	2.25	CENTER/CENTER	4.5			3.44	6	2.2	10	0	8	0	0	2	100%		
626	4-16	M	B	2.25	CENTER/CENTER	4.5				6	2.2	10	0	7	0	0	3	100%		
627	4-16	F	B	2.25	CENTER/CENTER	4.5				6	2.2	10	0	5	0	0	4	100%		
628	4-18	S	B	0					1.49	6	2.2	10	6	0	4	0		0%		
629	4-18	M	B	0					2.21	6	2.2	10	1	0	3	6		0%		
630	4-18	S	B	0					3.59	6	2.2	10	0	0	3	7		0%		
631	4-18	F	B	0					1.55	6	2.2	10	2	0	0	7		0%		
632	4-18	F	B	3.75	BOTTOM/BOTTOM				1.31	6	2.2	10	0	9	0	1		90%		
635	6-6	S	B	3.75	BOTTOM/BOTTOM		.375" ID		3.29	6	0.6	10	2	5	0	3		63%		
636	6-6	M	B/M	3.75	BOTTOM/BOTTOM		.375" ID		2.29	6	0.6	10	3	4	0	3		57%		
637	6-6	F	M/E	3.75	BOTTOM/BOTTOM		.375" ID		2.09	6	0.6	10	7	2	0	1		67%		
638	6-6	S	B	3.75	BOTTOM/BOTTOM		.375" ID		2.18	3	0.5	10	1	6	0	3		67%		
639	6-6	M	M	3.75	BOTTOM/BOTTOM		.375" ID		1.63	3	0.5	10	4	4	0	2		67%		
640	6-6	F	B	3.75	BOTTOM/BOTTOM		.375" ID		1.49	3	0.5	10	5	2	0	2		50%		
641	6-6	F	B	3.75	BOTTOM/BOTTOM		.375" ID			3	0.5	10	0	5	0	5		50%		
642	6-6	F	B	3.75	BOTTOM/BOTTOM		.25" OVFL			3	0.5	9	0	5	0	4		56%		
643	6-6	S	B	2	BOTTOM/BOTTOM					3	0.5	10	9	1	0	0		100%		
644	6-7	S	B	2.5	BOTTOM/BOTTOM		.25" OVFL		3.66	3	0.5	10	2	5	0	3		63%		
645	6-7	M	B	2.5	BOTTOM/BOTTOM		.25" OVFL		3.45	3	0.5	10	6	2	0	2		50%		
646	6-7	M	B	2.5	BOTTOM/BOTTOM		.25" OVFL		2.35	3	0.5	10	2	2	0	0		100%		
647	6-7	M	B	2.5	BOTTOM/BOTTOM		.25" OVFL		3.45	3	0.5	10	1	9	0	0		100%		
648	6-7	F	B	2.5	BOTTOM/BOTTOM		.25" OVFL		2.67	3	0.5	10	5	4	0	1		80%		
649	6-7	S	B	3.75	TOP/BOTTOM				3.31	3	0.5	10	0	5	0	5		50%		
650	6-7	M	B	3.75	TOP/BOTTOM				2.73	3	0.5	10	0	3	0	7		30%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	#	LOCATION OF INCLUSION AFTER THE POUR REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
651	6-7	F	B	3.75	TOP/BOTTOM				2.4	3	0.5	10	7	1	0	2		33%		
652	6-7	S	B	2.5	TOP/BOTTOM				2.56	3	0.5	10	0	4	1	5		40%		
653	6-7	M	B	2.5	TOP/BOTTOM				2.05	3	0.5	10	2	2	0	6		25%		
653X	6-10	M	B	2.5	TOP/BOTTOM				1.95	3	0.5	10	3	1	0	6		14%		
654	6-10	F	B	2.5	TOP/BOTTOM				1.11	3	0.5	10	7	0	0	3		0%		
655	6-10	F	B	2.5	TOP/BOTTOM				1.18	3	0.5	10	4	1	0	5		17%		
656	6-10	S	B	1.5	TOP/BOTTOM				3.07	3	0.5	10	3	0	0	7		0%		
657	6-10	M	B	1.5	TOP/BOTTOM				1.51	3	0.5	10	6	1	0	3		25%		
658	6-10	F	B	1.5	TOP/BOTTOM				1.1	3	0.5	10	4	0	0	6		0%		
659	6-10	S	B	3.75	TOP/BOTTOM		0.22" OVFL		3.37	3	0.5	10	0	5	0	5		50%		
660	6-10	M	B	3.75	TOP/BOTTOM		0.22" OVFL		2.67	3	0.5	10	1	2	0	7		22%		
661	6-10	F	B	3.75	TOP/BOTTOM		0.22" OVFL		2.28	3	0.5	10	6	3	0	1		75%		
662	6-10	S	B	2.5	TOP/BOTTOM		0.22" OVFL		3.51	3	0.5	10	0	2	0	8		20%		
663	6-10	M	B	2.5	TOP/BOTTOM		0.22" OVFL		2.46	3	0.5	10	1	2	0	7		22%		
664	6-10	F	B	2.5	TOP/BOTTOM		0.22" OVFL		1.6	3	0.5	10	5	2	0	3		40%		
665	6-10	S	B	2.5	TOP/BOTTOM		0.115" OVFL		4.52	3	0.5	10	0	4	0	6		40%		
666	6-10	M	B	2.5	TOP/BOTTOM		0.115" OVFL		3.5	3	0.5	10	2	3	0	5		38%		
667	6-10	F	B	2.5	TOP/BOTTOM		0.115" OVFL		2.8	3	0.5	10	6	1	0	3		25%		
668	6-10	S	B/M	3.75	TOP/BOTTOM		0.115" OVFL		4.98	3	0.5	10	0	5	0	5		50%		
669	6-10	M	B	3.75	TOP/BOTTOM		0.115" OVFL		3.61	3	0.5	10	3	3	0	4		43%		
670	6-10	F	B	3.75	TOP/BOTTOM		0.115" OVFL		2.99	3	0.5	10	5	3	0	2		60%		
671	6-11	S	B	3.75	SIDE/SIDE				2.26	3	0.5	10	0	7	0	3		70%		
672	6-11	S	B	3.75	SIDE/SIDE				2.42	3	0.5	10	0	7	0	3		70%		
673	6-11	M	B	3.75	SIDE/SIDE				1.92	3	0.5	10	1	4	1	4		44%		
674	6-11	F	B	3.75	SIDE/SIDE				0.4	3	0.5	10	2	4	0	4		50%		
675	6-11	S	B	3.75	SIDE/SIDE				2.53	3	0.5	10	0	6	0	4		60%		
										3	2	10	0	10	0	0		100%		
676	6-11	S	B	2.5	SIDE/SIDE				2.19	3	0.5	10	1	1	0	8		11%		
677	6-11	M	B	2.5	SIDE/SIDE				0.9	3	0.5	10	0	2	0	8		20%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	#	LOCATION OF INCLUSION AFTER THE POUR REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
678	6-11	S	B	2.5	SIDE/SIDE		0.115" OVFL		2.71	3	0.5	10	0	8	0	2		80%		
679	6-11	M	B	2.5	SIDE/SIDE		0.115" OVFL		2.36	3	0.5	10	2	5	0	3		63%		
680	6-11	F	B	2.5	SIDE/SIDE		0.115" OVFL		2.19	3	0.5	10	6	3	0	1		75%		
681	6-11	S	B	3.75	SIDE/SIDE		0.115" OVFL		3.01	3	0.5	10	0	9	0	1		90%		
682	6-11	M	B	3.75	SIDE/SIDE		0.115" OVFL		2.76	3	0.5	10	3	4	0	3		57%		
										3	2	10	0	10	0	0		100%		
683	6-11	F	B	3.75	SIDE/SIDE		0.115" OVFL		2.35	3	0.5	10	3	6	0	1		86%		
684	6-11	S	B	1.5	SIDE/SIDE		0.115" OVFL		2.75	3	0.5	10	0	3	0	6		33%		
										3	2	10	0	10	0	0		100%		
685	6-11	S	B	3.75	SIDE/SIDE		0.115" OVFL		2.97	3	0.5	10	0	4	0	6		40%		
686	6-12	S	B	3.75	TOP/BOTTOM				2.15	3	0.5	10	0	4	1	5		40%		
687	6-12	S	B	3.75	TOP/BOTTOM			CENTER	3.31	3	0.5	10	2	4	1	3		50%		
688	6-13	S	B	3.75	TOP/BOTTOM			CENTER	3.17	3	0.5	10	1	6	0	3		67%		
689	6-13	M	B	3.75	TOP/BOTTOM			CENTER	2.07	3	0.5	10	0	5	0	5		50%		
690	6-13	F	B	3.75	TOP/BOTTOM			CENTER	1.02	3	0.5	10	4	2	0	4		33%		
691	6-13	S	B	3.75	SIDE/SIDE			CENTER	2.29	3	0.5	10	0	0	0	10		0%		
692	6-13	M	B	3.75	SIDE/SIDE			CENTER	1.82	3	0.5	10	0	2	0	8		20%		
693	6-13	F	B	3.75	SIDE/SIDE			CENTER	0.92	3	0.5	10	5	1	0	4		20%		
694	6-13	S	B	3.75	SIDE/SIDE			CENTER	2.34	3	0.5	10	0	7	0	3		70%		
695	6-13	M	B	3.75	SIDE/SIDE			CENTER	1.23	3	0.5	10	2	2	1	5		25%		
696	6-13	F	B	3.75	SIDE/SIDE			CENTER	0.91	3	0.5	10	4	3	0	2		60%		
697	6-13	F	B	3.75	SIDE/SIDE			CENTER	1.01	3	0.5	10	4	2	0	3		40%		
698	6-13	S	B	3.75	SIDE/SIDE			INLET+1"	2.14	3	0.5	10	0	9	0	1		90%		
699	6-13	M	B	3.75	SIDE/SIDE			INLET+1"	1.83	3	0.5	10	2	1	0	7		13%		
700	6-13	F	B	3.75	SIDE/SIDE			INLET+1"	1.07	3	0.5	10	4	1	0	5		17%		
										3	2	10	0	7	0	3		70%		
701	6-13	S	B	3.75	TOP/SIDE			INLET+1"	2.43	3	0.5	10	0	9	1	0		90%		
702	6-13	M	B	3.75	TOP/SIDE			INLET+1"	1.17	3	0.5	10	2	7	0	1		88%		
703	6-13	F	B	3.75	TOP/SIDE			INLET+1"	0.97	3	0.5	10	2	2	0	6		25%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	LOCATION OF INCLUSION AFTER THE POUR #	REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
803	6-24	S	PP	2.5	SIDE/SIDE		0.115" OVFL		2.13	3	0.5	10	0	3	0	7		30%		
804	6-24	M	PP	2.5	SIDE/SIDE		0.115" OVFL		1.18	3	0.5	10	0	1	0	9		10%		
805	6-24	F	PP	2.5	SIDE/SIDE		0.115" OVFL		0.98	3	0.5	10	0	3	0	7		30%		
806	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	6	0	4		60%		
807	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	0	5		50%		
808	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	0	5		50%		
809	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	4	1	5		40%		
810	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	6	0	4		60%	51%	7.4%
811	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	0	5		50%		
812	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	1	4		50%		
813	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	4	1	5		40%		
814	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	6	0	4		60%		
815	6-24	S	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	0	5		50%		
816	6-24	S	PP	3.75	SIDE/SIDE					3	1.2	10	0	10	0	0		100%		
817	6-24	S	PP	3.75	SIDE/SIDE					3	1.2	10	0	10	0	0		100%		
818	6-24	S	PP	3.75	SIDE/SIDE					3	1.2	10	0	10	0	0		100%	98%	4.5%
819	6-24	S	PP	3.75	SIDE/SIDE					3	1.2	10	0	10	0	0		100%		
820	6-24	S	PP	3.75	SIDE/SIDE					3	1.2	10	0	9	0	1		90%		
821	6-24	M	PP	3.75	SIDE/SIDE					3	0.5	10	0	2	1	7		20%		
										3	1.2	10	0	7	1	2		70%		
822	6-24	M	PP	3.75	SIDE/SIDE					3	0.5	10	0	6	0	4		60%		
										3	1.2	10	0	7	1	2		70%		
823	6-24	M	PP	3.75	SIDE/SIDE					3	0.5	10	0	7	0	3		70%	54%	20.7%
										3	1.2	10	0	6	0	4		60%	68%	8.4%
824	6-24	M	PP	3.75	SIDE/SIDE					3	0.5	10	0	7	0	3		70%		
										3	1.2	10	0	8	0	2		80%		
825	6-24	M	PP	3.75	SIDE/SIDE					3	0.5	10	0	5	1	4		50%		
										3	1.2	10	0	6	1	3		60%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	#	LOCATION OF INCLUSION AFTER THE POUR REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
826	6-25	F	PP	3.75	SIDE/SIDE					3	0.5	10	0	3	0	7		30%		
										3	1.2	10	0	6	0	4		60%		
827	6-25	F	PP	3.75	SIDE/SIDE					3	0.5	10	0	7	1	2		70%		
										3	1.2	10	0	3	1	6		30%		
828	6-25	F	PP	3.75	SIDE/SIDE					3	0.5	10	0	4	0	6		40%	44%	15.2%
										3	1.2	10	0	8	0	2		80%	56%	18.2%
829	6-25	F	PP	3.75	SIDE/SIDE					3	0.5	10	0	4	2	4		40%		
										3	1.2	10	0	5	1	4		50%		
830	6-25	F	PP	3.75	SIDE/SIDE					3	0.5	10	0	4	2	4		40%		
										3	1.2	10	0	6	0	4		60%		
831	6-25	M	PP	3.75	SIDE/SIDE		0.115" OVFL			3	0.5	10	0	7	0	3		70%		
										3	1.2	10	0	9	0	1		90%		
832	6-25	M	PP	3.75	SIDE/SIDE		0.115" OVFL			3	0.5	10	0	7	0	3		70%		
										3	1.2	10	0	9	0	1		90%		
833	6-25	M	PP	3.75	SIDE/SIDE		0.115" OVFL			3	0.5	10	0	9	0	1		90%	72%	11.0%
										3	1.2	10	0	8	0	2		80%	88%	8.4%
834	6-25	M	PP	3.75	SIDE/SIDE		0.115" OVFL			3	0.5	10	0	6	0	4		60%		
										3	1.2	10	0	10	0	0		100%		
835	6-25	M	PP	3.75	SIDE/SIDE		0.115" OVFL			3	0.5	10	0	7	0	3		70%		
										3	1.2	10	0	8	0	2		80%		
836	6-25	M	PP	1.5	SIDE/SIDE					3	0.5	10	0	0	0	10		0%		
										3	1.2	10	0	1	0	9		10%		
837	6-25	M	PP	1.5	SIDE/SIDE					3	0.5	10	0	1	0	9		10%		
										3	1.2	10	0	3	0	7		30%		
838	6-25	M	PP	1.5	SIDE/SIDE					3	0.5	10	0	0	0	10		0%	6%	8.9%
										3	1.2	10	0	0	2	8		0%	10%	12.2%
839	6-25	M	PP	1.5	SIDE/SIDE					3	0.5	10	0	0	1	9		0%		
										3	1.2	10	0	0	0	10		0%		
840	6-25	M	PP	1.5	SIDE/SIDE					3	0.5	10	0	2	0	8		20%		
										3	1.2	10	0	1	0	9		10%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	#	LOCATION OF INCLUSION AFTER THE POUR REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
841	6-25	S	PP	3.75	SIDE/SIDE			INLET+1"		3	0.5	10	0	5	0	5		50%		
										3	1.2	10	0	3	0	7		30%		
842	6-25	S	PP	3.75	SIDE/SIDE			INLET+1"		3	0.5	10	0	2	0	8		20%		
										3	1.2	10	0	1	0	9		10%		
843	6-25	S	PP	3.75	SIDE/SIDE			INLET+1"		3	0.5	10	0	4	0	6		40%	48%	21.7%
										3	1.2	10	0	2	0	8		20%	26%	15.2%
844	6-25	S	PP	3.75	SIDE/SIDE			INLET+1"		3	0.5	10	0	5	0	5		50%		
										3	1.2	10	0	5	0	5		50%		
845	6-25	S	PP	3.75	SIDE/SIDE			INLET+1"		3	0.5	10	0	8	0	2		80%		
										3	1.2	10	0	2	0	8		20%		
846	6-25	M	PP	2.5	SIDE/SIDE					3	0.5	10	0	4	2	4		40%		
										3	1.2	10	0	8	1	1		80%		
847	6-25	M	PP	2.5	SIDE/SIDE					3	0.5	10	0	3	0	7		30%		
										3	1.2	10	0	4	0	6		40%		
848	6-25	M	PP	2.5	SIDE/SIDE					3	0.5	10	0	4	0	6		40%	38%	5.8%
										3	1.2	10	0	4	0	6		40%	52%	16.4%
849	6-25	M	PP	2.5	SIDE/SIDE					3	0.5	9	0	4	3	2		44%		
										3	1.2	10	0	5	1	4		50%		
850	6-25	M	PP	2.5	SIDE/SIDE					3	0.5	9	0	3	1	5		33%		
										3	1.2	10	0	5	1	4		50%		
851	6-25	S	PP	3.75	TOP/SIDE			INLET+1"		3	0.5	10	0	5	0	5		50%		
										3	1.2	10	0	3	0	7		30%		
852	6-25	S	PP	3.75	TOP/SIDE			INLET+1"		3	0.5	10	0	7	0	3		70%		
										3	1.2	10	0	6	0	4		60%		
853	6-25	S	PP	3.75	TOP/SIDE			INLET+1"		3	0.5	10	0	7	0	3		70%	70%	18.7%
										3	1.2	10	0	7	0	3		70%	48%	16.4%
854	6-25	S	PP	3.75	TOP/SIDE			INLET+1"		3	0.5	10	0	10	0	0		100%		
										3	1.2	10	0	4	0	6		40%		
855	6-25	S	PP	3.75	TOP/SIDE			INLET+1"		3	0.5	10	0	6	0	4		60%		
										3	1.2	10	0	4	2	4		40%		

INCLUSION RUNS WITH 3.5" DIAMETER CYLINDRICAL BUOYANCY CHAMBER

RUN #	DATE	POUR RATE S,M,F	INCL. INTRO	CYL LENGTH	CHAMBER SET-UP ENTRY/EXIT	RUNNER EXTEN	CHOKE TYPE	BAFFLE LOCATION	(SEC) FILL TIME	(mm) INCLUSION SIZE	S.G	#	LOCATION OF INCLUSION AFTER THE POUR REGION A	B	C	D	E	CHAM EFF	AVE EFF	STND DEV
856	6-25	M	PP	3.75	TOP/SIDE					3	0.5	10	0	5	0	5		50%		
										3	1.2	10	0	4	0	5		44%		
857	6-25	M	PP	3.75	TOP/SIDE					3	0.5	10	0	4	0	6		40%		
										3	1.2	10	0	5	0	5		50%		
858	6-25	M	PP	3.75	TOP/SIDE					3	0.5	10	0	2	0	8		20%	38%	13.0%
										3	1.2	10	0	1	0	9		10%	35%	15.7%
859	6-25	M	PP	3.75	TOP/SIDE					3	0.5	10	0	5	0	5		50%		
										3	1.2	10	0	4	0	6		40%		
860	6-25	M	PP	3.75	TOP/SIDE					3	0.5	10	0	3	1	6		30%		
										3	1.2	10	0	3	1	6		30%		
861	6-25	F	PP	3.75	TOP/SIDE					3	0.5	10	0	2	0	8		20%		
										3	1.2	10	0	2	0	8		20%		
862	6-25	F	PP	3.75	TOP/SIDE					3	0.5	10	0	1	1	8		10%		
										3	1.2	10	0	3	0	7		30%		
863	6-25	F	PP	3.75	TOP/SIDE					3	0.5	10	0	1	0	9		10%	14%	5.5%
										3	1.2	10	0	2	0	8		20%	24%	5.5%
864	6-25	F	PP	3.75	TOP/SIDE					3	0.5	10	0	2	1	7		20%		
										3	1.2	10	0	2	0	8		20%		
865	6-25	F	PP	3.75	TOP/SIDE					3	0.5	10	0	1	2	7		10%		
										3	0.5	10	0	3	0	7		30%		

INCLUSION RUNS WITH SMALL SWIRL CHAMBER

SWIRL CHAMBER NOTES

PR RT: Pour rate, slow, medium or fast

INC INT: Inclusion introduction; beginning, middle or pre-pour

SETUP: All setups are bottom inlet, top exit unless otherwise stated

FILL: Fill time is from bottom of vertical runner to the top

INCLUSION DATA: Gives size, reference number (see inclusion summary) & specific gravity

DROP: Number of inclusions introduced into pour

A: Inclusions in the tundish, downspruce or first horizontal runner

B: Inclusions that were trapped in the chamber

C: Inclusions in the second horizontal runner

D: Inclusions in the vertical runner and potentially part mold

EFF: Efficiency of the chamber, based on how many the chamber caught and how many got through the chamber (does not use section A)

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
726	6-19-91	S	B	4.0	TANGENTIAL, TOP IN	3.09	3mm/#6/0.5-0.6	10	0	3	0	7	30%		
727	6-19-91	M	B	4.0	TANGENTIAL, TOP IN	1.37	3mm/#6/0.5-0.6	10	0	3	0	7	30%		
728	6-19-91	F	B	4.0	TANGENTIAL, TOP IN	0.52	3mm/#6/0.5-0.6	11	5	3	0	3	50%		
729	6-19-91	S	M	4.0	TANGENTIAL, TOP IN	3.81	3mm/#6/0.5-0.6	10	2	8	0	0	100%		
730	6-19-91	M	M	4.0	TANGENTIAL, TOP IN		3mm/#6/0.5-0.6	10	2	5	1	2	63%		
731	6-19-91	F	M	4.0	TANGENTIAL, TOP IN		3mm/#6/0.5-0.6	10	1	6	0	3	67%		
732	6-19-91	S	B	4.0	TANGENTIAL, TOP IN	3.2	6mm/#7/0.6-0.7	10	0	5	0	5	50%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
733	6-19-91	M	B	4.0	TANGENTIAL, TOP IN	1.17	6mm/#7/0.6-0.7	10	0	3	0	7	30%		
734	6-19-91	F	B	4.0	TANGENTIAL, TOP IN	0.57	6mm/#7/0.6-0.7	10	2	4	0	4	50%		
735	6-19-91	S	M	4.0	TANGENTIAL, TOP IN	3.38	6mm/#7/0.6-0.7	9	0	9	0	0	100%		
736	6-19-91	M	M?	4.0	TANGENTIAL, TOP IN	1.1	6mm/#7/0.6-0.7	10	0	2	0	8	20%		
737	6-19-91	M	M	4.0	TANGENTIAL, TOP IN	0.97	6mm/#7/0.6-0.7	10	1	5	0	4	56%		
738	6-19-91	F	M	4.0	TANGENTIAL, TOP IN	0.61	6mm/#7/0.6-0.7	10	4	5	0	1	83%		
739	6-19-91	S	B	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	10	0	10	0	0	100%		
740	6-19-91	M	B	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	10	0	1	0	9	10%		
741	6-19-91	F	B	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	10	2	4	0	4	50%		
742	6-19-91	S	M	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	10	0	9	0	1	90%		
743	6-19-91	M	M	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	9	0	9	0	0	100%		
744	6-19-91	F	M	4.0	TANGENTIAL, TOP IN, 2" WELL		6mm/#7/0.6-0.7	10	0	9	0	1	90%		
745	6-20-91	S	B	4.0	TANGENTIAL, TOP IN, 2" WELL	3.95	3mm/#6/0.5-0.6	10	0	9	0	1	90%		
746	6-20-91	M	B	4.0	TANGENTIAL, TOP IN, 2" WELL	1.29	3mm/#6/0.5-0.6	10	2	7	0	1	88%		
747	6-20-91	F	B	4.0	TANGENTIAL, TOP IN, 2" WELL	0.78	3mm/#6/0.5-0.6	10	0	6	0	4	60%		
748	6-20-91	S	M	4.0	TANGENTIAL, TOP IN, 2" WELL	3.72	3mm/#6/0.5-0.6	10	1	7	0	2	78%		
749	6-20-91	M	M	4.0	TANGENTIAL, TOP IN, 2" WELL	1.26	3mm/#6/0.5-0.6	10	0	7	0	3	70%		
750	6-20-91	F	M	4.0	TANGENTIAL, TOP IN, 2" WELL	0.81	3mm/#6/0.5-0.6	10	5	5	0	0	100%		
751	6-20-91	S	B	4.0	TANGENTIAL	2.93	3mm/#6/0.5-0.6	9	0	8	0	1	89%		
752	6-20-91	M	B	4.0	TANGENTIAL	0.7	3mm/#6/0.5-0.6	10	3	5	0	2	71%		
753	6-20-91	F	B	4.0	TANGENTIAL	0.55	3mm/#6/0.5-0.6	10	3	6	0	1	86%		
754	6-20-91	S	M	4.0	TANGENTIAL	1.96	3mm/#6/0.5-0.6	10	0	8	0	2	80%		
755	6-20-91	M	M	4.0	TANGENTIAL	0.92	3mm/#6/0.5-0.6	10	0	9	0	1	90%		
756	6-20-91	F	M	4.0	TANGENTIAL	0.78	3mm/#6/0.5-0.6	10	1	8	0	1	89%		
757	6-20-91	S	B	4.0	ANTI-TANGENTIAL, TOP IN	2.45	3mm/#6/0.5-0.6	10	0	6	0	4	60%		
758	6-20-91	M	B	4.0	ANTI-TANGENTIAL, TOP IN	0.88	3mm/#6/0.5-0.6	10	3	3	0	4	43%		
759	6-20-91	F	B	4.0	ANTI-TANGENTIAL, TOP IN	0.74	3mm/#6/0.5-0.6	10	0	5	0	5	50%		
760	6-20-91	S	M	4.0	ANTI-TANGENTIAL, TOP IN	2.05	3mm/#6/0.5-0.6	10	2	6	1	1	75%		
761	6-20-91	M	M	4.0	ANTI-TANGENTIAL, TOP IN	1.06	3mm/#6/0.5-0.6	9	3	4	0	2	67%		
762	6-20-91	F	M	4.0	ANTI-TANGENTIAL, TOP IN	0.54	3mm/#6/0.5-0.6	10	5	5	0	0	100%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
763	6-20-91	S	B	4.0	ANTI-TANGENTIAL	2.31	3mm/#6/0.5-0.6	10	0	7	0	3	70%		
764	6-20-91	M	B	4.0	ANTI-TANGENTIAL	1.15	3mm/#6/0.5-0.6	10	4	4	0	2	67%		
765	6-20-91	F	B	4.0	ANTI-TANGENTIAL	0.72	3mm/#6/0.5-0.6	10	2	4	0	4	50%		
766	6-20-91	S	M	4.0	ANTI-TANGENTIAL	1.85	3mm/#6/0.5-0.6	10	3	5	0	2	71%		
767	6-20-91	M	M	4.0	ANTI-TANGENTIAL	1.29	3mm/#6/0.5-0.6	10	2	7	0	1	88%		
768	6-20-91	F	M	4.0	ANTI-TANGENTIAL	0.76	3mm/#6/0.5-0.6	10	2	6	0	2	75%		
799	6-21-91	S	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	10	0	10	0	0	100%		
800	6-21-91	M	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	10	0	10	0	0	100%		
801	6-21-91	F	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	10	0	7	0	3	70%		
866	6-27-91	S	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	30	0	30	0	0	100%		
867	6-27-91	M	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	20	0	19	0	1	95%		
868	6-27-91	F	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	20	0	14	0	6	70%		
869	6-27-91	S	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	20	0	20	0	0	100%		
870	6-27-91	M	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	20	0	19	0	1	95%		
871	6-27-91	F	PP	4.0	TANGENTIAL, 2" WELL		3mm/#6/0.5-0.6	20	0	15	1	4	75%		
872	6-27-91	S	PP	4.0	TANGENTIAL, 2" WELL		3mm/#14/1.2	10	0	10	0	0	100%		
							6mm/#21/2.2	10	0	10	0	0	100%		
873	6-27-91	M	PP	4.0	TANGENTIAL, 2" WELL		3mm/#14/1.2	10	0	10	0	0	100%		
							6mm/#21/2.2	10	0	10	0	0	100%		
874	6-27-91	F	PP	4.0	TANGENTIAL, 2" WELL		3mm/#14/1.2	10	0	9	1	0	90%		
							6mm/#21/2.2	10	0	10	0	0	100%		
875	6-27-91	S	PP	4.0	TANGENTIAL, EXTENSION		3mm/#6/0.5-0.6	20	0	20	0	0	100%		
876	6-27-91	M	PP	4.0	TANGENTIAL, EXTENSION		3mm/#6/0.5-0.6	20	0	18	0	2	90%		
877	6-27-91	F	PP	4.0	TANGENTIAL, EXTENSION		3mm/#6/0.5-0.6	20	0	17	0	3	85%		
878	6-27-91	F	PP	4.0	TANGENTIAL, EXTENSION		3mm/#6/0.5-0.6	20	0	17	0	3	85%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
967	7-17-91	S	PP	4.0	TANGENTIAL	3.95	3mm/#6/0.5-0.6	15	0	11	0	4	73%		
968	7-17-91	S	PP	4.0	TANGENTIAL	4.39	3mm/#6/0.5-0.6	15	0	15	0	0	100%		
969	7-17-91	S	PP	4.0	TANGENTIAL	4.15	3mm/#6/0.5-0.6	15	0	14	1	0	93%	84%	11.8%
970	7-17-91	S	PP	4.0	TANGENTIAL	4.37	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
971	7-17-91	S	PP	4.0	TANGENTIAL	4.21	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
972	7-17-91	M	PP	4.0	TANGENTIAL	1.74	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
973	7-17-91	M	PP	4.0	TANGENTIAL	2.13	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
974	7-17-91	M	PP	4.0	TANGENTIAL	2.23	3mm/#6/0.5-0.6	20	0	11	0	9	55%	64%	8.2%
975	7-17-91	M	PP	4.0	TANGENTIAL	2.24	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
976	7-17-91	M	PP	4.0	TANGENTIAL	2.17	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
977	7-17-91	F	PP	4.0	TANGENTIAL	2.7	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
978	7-17-91	F	PP	4.0	TANGENTIAL	2.68	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
979	7-17-91	F	PP	4.0	TANGENTIAL	3	3mm/#6/0.5-0.6	20	0	8	0	12	40%	52%	11.0%
980	7-17-91	F	PP	4.0	TANGENTIAL	2.45	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
981	7-17-91	F	PP	4.0	TANGENTIAL	2.81	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
982	7-17-91	S	PP	3.5	TANGENTIAL	4.57	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
983	7-17-91	S	PP	3.5	TANGENTIAL	4.33	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
984	7-17-91	S	PP	3.5	TANGENTIAL	4.3	3mm/#6/0.5-0.6	20	0	17	0	3	85%	83%	9.1%
985	7-17-91	S	PP	3.5	TANGENTIAL	4.39	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
986	7-17-91	S	PP	3.5	TANGENTIAL	4.02	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
987	7-17-91	M	PP	3.5	TANGENTIAL	3.78	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
988	7-17-91	M	PP	3.5	TANGENTIAL	3.38	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
989	7-17-91	M	PP	3.5	TANGENTIAL	3.17	3mm/#6/0.5-0.6	20	0	13	0	7	65%	47%	16.8%
990	7-17-91	M	PP	3.5	TANGENTIAL	3.67	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
991	7-17-91	M	PP	3.5	TANGENTIAL	3.78	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
992	7-18-91	F	PP	3.5	TANGENTIAL	2.57	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
993	7-18-91	F	PP	3.5	TANGENTIAL	2.87	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
994	7-18-91	F	PP	3.5	TANGENTIAL	2.7	3mm/#6/0.5-0.6	20	0	4	0	16	20%	34%	19.8%
995	7-18-91	F	PP	3.5	TANGENTIAL	2.91	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
996	7-18-91	F	PP	3.5	TANGENTIAL	2.74	3mm/#6/0.5-0.6	20	0	5	0	15	25%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
997	7-18-91	S	PP	3.0	TANGENTIAL	4.83	3mm/#6/0.5-0.6	20	0	7	1	12	35%		
998	7-18-91	S	PP	3.0	TANGENTIAL	4.58	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
999	7-18-91	S	PP	3.0	TANGENTIAL	5.04	3mm/#6/0.5-0.6	20	0	12	3	5	60%	39%	17.1%
1000	7-18-91	S	PP	3.0	TANGENTIAL	4.74	3mm/#6/0.5-0.6	20	0	7	2	11	35%		
1001	7-18-91	S	PP	3.0	TANGENTIAL	4.96	3mm/#6/0.5-0.6	20	0	3	11	6	15%		
1002	7-18-91	M	PP	3.0	TANGENTIAL	3.37	3mm/#6/0.5-0.6	20	0	0	0	20	0%		
1003	7-18-91	M	PP	3.0	TANGENTIAL	3.41	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1004	7-18-91	M	PP	3.0	TANGENTIAL	3.49	3mm/#6/0.5-0.6	20	0	8	0	12	40%	14%	18.0%
1005	7-18-91	M	PP	3.0	TANGENTIAL	3.21	3mm/#6/0.5-0.6	20	0	2	1	17	10%		
1006	7-18-91	F	PP	3.0	TANGENTIAL	3.11	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1007	7-18-91	F	PP	3.0	TANGENTIAL	3.07	3mm/#6/0.5-0.6	20	0	1	0	19	5%	7%	2.9%
1008	7-18-91	F	PP	3.0	TANGENTIAL	2.67	3mm/#6/0.5-0.6	20	0	2	1	17	10%		
1009	7-18-91	S	PP	2.5	TANGENTIAL	5.13	3mm/#6/0.5-0.6	20	0	1	1	18	5%		
1010	7-18-91	S	PP	2.5	TANGENTIAL	5.01	3mm/#6/0.5-0.6	20	0	4	0	16	20%	10%	8.7%
1011	7-18-91	S	PP	2.5	TANGENTIAL	4.87	3mm/#6/0.5-0.6	20	0	1	1	18	5%		
1012	7-18-91	M	PP	2.5	TANGENTIAL	3.02	3mm/#6/0.5-0.6	20	0	0	0	20	0%		
1013	7-18-91	M	PP	2.5	TANGENTIAL	3.31	3mm/#6/0.5-0.6	20	0	1	0	19	5%	3%	2.9%
1014	7-18-91	M	PP	2.5	TANGENTIAL	3.37	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1015	7-18-91	F	PP	2.5	TANGENTIAL	2.26	3mm/#6/0.5-0.6	20	0	0	0	20	0%		
1016	7-18-91	F	PP	2.5	TANGENTIAL	1.59	3mm/#6/0.5-0.6	20	0	2	0	18	10%	3%	5.8%
1017	7-18-91	F	PP	2.5	TANGENTIAL	1.2	3mm/#6/0.5-0.6	20	0	0	0	20	0%		
1051	7-22-91	S	PP	4.0	TANGENTIAL, 2" WELL	4.7	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1052	7-22-91	S	PP	4.0	TANGENTIAL, 2" WELL	4.81	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1053	7-22-91	S	PP	4.0	TANGENTIAL, 2" WELL	4.75	3mm/#6/0.5-0.6	20	0	17	0	3	85%	94%	6.5%
1054	7-22-91	S	PP	4.0	TANGENTIAL, 2" WELL	4.47	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1055	7-22-91	S	PP	4.0	TANGENTIAL, 2" WELL	4.71	3mm/#6/0.5-0.6	20	0	20	0	0	100%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1056	7-22-91	M	PP	4.0	TANGENTIAL, 2" WELL	1.96	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1057	7-22-91	M	PP	4.0	TANGENTIAL, 2" WELL	2.16	3mm/#6/0.5-0.6	20	1	15	4	0	79%		
1058	7-22-91	M	PP	4.0	TANGENTIAL, 2" WELL	2.22	3mm/#6/0.5-0.6	20	0	18	0	2	90%	81%	10.3%
1059	7-22-91	M	PP	4.0	TANGENTIAL, 2" WELL	2.01	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1060	7-22-91	M	PP	4.0	TANGENTIAL, 2" WELL	1.81	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1061	7-22-91	F	PP	4.0	TANGENTIAL, 2" WELL	1.43	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1062	7-22-91	F	PP	4.0	TANGENTIAL, 2" WELL	1.69	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1063	7-22-91	F	PP	4.0	TANGENTIAL, 2" WELL	1.71	3mm/#6/0.5-0.6	20	0	12	0	8	60%	77%	10.4%
1064	7-22-91	F	PP	4.0	TANGENTIAL, 2" WELL	1.89	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1065	7-22-91	F	PP	4.0	TANGENTIAL, 2" WELL	1.49	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1066	7-22-91	S	PP	3.5	TANGENTIAL, 2" WELL	4.47	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1067	7-22-91	S	PP	3.5	TANGENTIAL, 2" WELL	4.31	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1068	7-22-91	S	PP	3.5	TANGENTIAL, 2" WELL	4.19	3mm/#6/0.5-0.6	20	0	20	0	0	100%	93%	8.4%
1069	7-22-91	S	PP	3.5	TANGENTIAL, 2" WELL	4.41	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1070	7-22-91	S	PP	3.5	TANGENTIAL, 2" WELL	4.52	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1071	7-22-91	M	PP	3.5	TANGENTIAL, 2" WELL	2.36	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1072	7-22-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.98	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1073	7-22-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.86	3mm/#6/0.5-0.6	20	0	16	0	4	80%	85%	12.7%
1074	7-23-91	M	PP	3.5	TANGENTIAL, 2" WELL	2.01	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1075	7-23-91	M	PP	3.5	TANGENTIAL, 2" WELL	2.14	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1076	7-23-91	F	PP	3.5	TANGENTIAL, 2" WELL	1.87	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1077	7-23-91	F	PP	3.5	TANGENTIAL, 2" WELL	1.61	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1078	7-23-91	F	PP	3.5	TANGENTIAL, 2" WELL	1.5	3mm/#6/0.5-0.6	20	0	16	0	4	80%	81%	8.9%
1079	7-23-91	F	PP	3.5	TANGENTIAL, 2" WELL	1.43	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1080	7-23-91	F	PP	3.5	TANGENTIAL, 2" WELL	1.26	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1081	7-23-91	S	PP	3.0	TANGENTIAL, 2" WELL	3.76	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1082	7-23-91	S	PP	3.0	TANGENTIAL, 2" WELL	3.7	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1083	7-23-91	S	PP	3.0	TANGENTIAL, 2" WELL	3.93	3mm/#6/0.5-0.6	20	0	18	0	2	90%	98%	4.5%
1084	7-23-91	S	PP	3.0	TANGENTIAL, 2" WELL	3.81	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1085	7-23-91	S	PP	3.0	TANGENTIAL, 2" WELL	4.3	3mm/#6/0.5-0.6	20	0	20	0	0	100%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1086	7-23-91	M	PP	3.0	TANGENTIAL, 2" WELL	2.69	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1087	7-23-91	M	PP	3.0	TANGENTIAL, 2" WELL	3.08	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1088	7-23-91	M	PP	3.0	TANGENTIAL, 2" WELL	2.72	3mm/#6/0.5-0.6	20	0	17	0	3	85%	86%	10.2%
1089	7-23-91	M	PP	3.0	TANGENTIAL, 2" WELL	2.47	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1090	7-23-91	M	PP	3.0	TANGENTIAL, 2" WELL	3.14	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1091	7-23-91	F	PP	3.0	TANGENTIAL, 2" WELL	1.16	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1092	7-23-91	F	PP	3.0	TANGENTIAL, 2" WELL	1.14	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1093	7-23-91	F	PP	3.0	TANGENTIAL, 2" WELL	1.2	3mm/#6/0.5-0.6	20	0	16	0	4	80%	85%	3.4%
1094	7-23-91	F	PP	3.0	TANGENTIAL, 2" WELL	1.2	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1095	7-23-91	F	PP	3.0	TANGENTIAL, 2" WELL	1.1	3mm/#6/0.5-0.6	20	1	17	0	2	89%		
1096	7-23-91	S	PP	2.5	TANGENTIAL, 2" WELL	3.63	3mm/#6/0.5-0.6	20	0	14	1	5	70%		
1097	7-23-91	S	PP	2.5	TANGENTIAL, 2" WELL	3.86	3mm/#6/0.5-0.6	20	0	12	1	7	60%		
1098	7-23-91	S	PP	2.5	TANGENTIAL, 2" WELL	3.66	3mm/#6/0.5-0.6	20	0	15	2	3	75%	63%	16.8%
1099	7-23-91	S	PP	2.5	TANGENTIAL, 2" WELL	3.75	3mm/#6/0.5-0.6	20	0	15	2	3	75%		
1100	7-23-91	S	PP	2.5	TANGENTIAL, 2" WELL	3.89	3mm/#6/0.5-0.6	20	0	7	2	11	35%		
1101	7-23-91	M	PP	2.5	TANGENTIAL, 2" WELL	1.93	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1102	7-23-91	M	PP	2.5	TANGENTIAL, 2" WELL	1.76	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1103	7-23-91	M	PP	2.5	TANGENTIAL, 2" WELL	1.84	3mm/#6/0.5-0.6	20	0	15	0	5	75%	54%	22.2%
1104	7-23-91	M	PP	2.5	TANGENTIAL, 2" WELL	2.01	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1105	7-23-91	M	PP	2.5	TANGENTIAL, 2" WELL	1.7	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1106	7-23-91	F	PP	2.5	TANGENTIAL, 2" WELL	1.09	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1107	7-23-91	F	PP	2.5	TANGENTIAL, 2" WELL	1.12	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1108	7-23-91	F	PP	2.5	TANGENTIAL, 2" WELL	1.09	3mm/#6/0.5-0.6	20	0	13	0	7	65%	59%	12.9%
1109	7-23-91	F	PP	2.5	TANGENTIAL, 2" WELL	1.17	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1110	7-23-91	F	PP	2.5	TANGENTIAL, 2" WELL	1.03	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1111	7-23-91	S	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.35	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1112	7-23-91	S	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.37	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1113	7-23-91	S	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.01	3mm/#6/0.5-0.6	20	0	19	0	1	95%	89%	8.9%
1114	7-23-91	S	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.8	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1115	7-23-91	S	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.95	3mm/#6/0.5-0.6	20	0	16	0	4	80%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1116	7-24-91	M	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.47	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1117	7-24-91	M	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.13	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1118	7-24-91	M	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.66	3mm/#6/0.5-0.6	20	0	19	0	1	95%	92%	4.5%
1119	7-24-91	M	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.32	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1120	7-24-91	M	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.2	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1121	7-24-91	F	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.78	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1122	7-24-91	F	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.11	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1123	7-24-91	F	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.7	3mm/#6/0.5-0.6	20	0	20	0	0	100%	86%	8.2%
1124	7-24-91	F	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.36	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1125	7-24-91	F	PP	4.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.3	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1126	7-24-91	S	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.3	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1127	7-24-91	S	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.19	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1128	7-24-91	S	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.36	3mm/#6/0.5-0.6	20	0	17	0	3	85%	86%	4.2%
1129	7-24-91	S	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.23	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1130	7-24-91	S	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.31	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1131	7-24-91	M	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.97	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1132	7-24-91	M	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.7	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1133	7-24-91	M	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.88	3mm/#6/0.5-0.6	20	0	12	0	8	60%	67%	13.5%
1134	7-24-91	M	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.09	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1135	7-24-91	M	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.51	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1136	7-24-91	F	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.93	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1137	7-24-91	F	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.72	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1138	7-24-91	F	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.65	3mm/#6/0.5-0.6	20	0	12	0	8	60%	46%	13.4%
1139	7-24-91	F	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.73	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1140	7-24-91	F	PP	3.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.07	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1141	7-24-91	S	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.81	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1142	7-24-91	S	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.01	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1143	7-24-91	S	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.8	3mm/#6/0.5-0.6	20	0	7	0	13	35%	56%	20.7%
1144	7-24-91	S	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.27	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1145	7-24-91	S	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	4.2	3mm/#6/0.5-0.6	20	0	9	0	11	45%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1146	7-24-91	M	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.63	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1147	7-24-91	M	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.24	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1148	7-24-91	M	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.96	3mm/#6/0.5-0.6	20	0	8	0	12	40%	30%	10.6%
1149	7-24-91	M	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	2.22	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1150	7-24-91	M	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	3.01	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1151	7-24-91	F	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.27	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1152	7-24-91	F	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.59	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1153	7-24-91	F	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.71	3mm/#6/0.5-0.6	20	0	5	0	15	25%	22%	9.1%
1154	7-24-91	F	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.82	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1155	7-24-91	F	PP	3.0	TANGENTIAL, OUTLET VENTURI CHOKE	1.54	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1156	7-24-91	S	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.91	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1157	7-24-91	S	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	4.37	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1158	7-24-91	S	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	4	3mm/#6/0.5-0.6	20	0	4	0	16	20%	16%	9.6%
1159	7-24-91	S	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.87	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1160	7-24-91	S	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.85	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1161	7-24-91	M	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.44	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1162	7-24-91	M	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.52	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1163	7-24-91	M	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	3.2	3mm/#6/0.5-0.6	20	0	6	0	14	30%	27%	9.7%
1164	7-24-91	M	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.88	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1165	7-24-91	M	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.76	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1166	7-24-91	F	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.74	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1167	7-24-91	F	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.84	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1168	7-24-91	F	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	1.55	3mm/#6/0.5-0.6	20	0	5	0	15	25%	18%	4.5%
1169	7-24-91	F	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.19	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1170	7-24-91	F	PP	2.5	TANGENTIAL, OUTLET VENTURI CHOKE	2.3	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1186	7-25-91	S	PP	4.0	TANGENTIAL, 2" EXTENSION	4.38	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1187	7-25-91	S	PP	4.0	TANGENTIAL, 2" EXTENSION	4.55	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1188	7-25-91	S	PP	4.0	TANGENTIAL, 2" EXTENSION	4.64	3mm/#6/0.5-0.6	20	0	17	0	3	85%	93%	5.7%
1189	7-25-91	S	PP	4.0	TANGENTIAL, 2" EXTENSION	4.46	3mm/#6/0.5-0.6	20	0	19	1	0	95%		
1190	7-25-91	S	PP	4.0	TANGENTIAL, 2" EXTENSION	5.08	3mm/#6/0.5-0.6	20	0	19	1	0	95%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	INCLUSION DATA FILL	SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1191	7-25-91	M	PP	4.0	TANGENTIAL, 2" EXTENSION	2.22	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1192	7-25-91	M	PP	4.0	TANGENTIAL, 2" EXTENSION	1.7	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1193	7-25-91	M	PP	4.0	TANGENTIAL, 2" EXTENSION	2.1	3mm/#6/0.5-0.6	20	0	18	0	2	90%	94%	4.2%
1194	7-25-91	M	PP	4.0	TANGENTIAL, 2" EXTENSION	1.9	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1195	7-25-91	M	PP	4.0	TANGENTIAL, 2" EXTENSION	1.85	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1196	7-25-91	F	PP	4.0	TANGENTIAL, 2" EXTENSION	1.49	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1197	7-25-91	F	PP	4.0	TANGENTIAL, 2" EXTENSION	1.39	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1198	7-25-91	F	PP	4.0	TANGENTIAL, 2" EXTENSION	1.43	3mm/#6/0.5-0.6	20	0	16	0	4	80%	83%	2.7%
1199	7-25-91	F	PP	4.0	TANGENTIAL, 2" EXTENSION	1.79	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1200	7-25-91	F	PP	4.0	TANGENTIAL, 2" EXTENSION	1.46	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1201	7-25-91	S	PP	3.5	TANGENTIAL, 2" EXTENSION	4.17	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1202	7-25-91	S	PP	3.5	TANGENTIAL, 2" EXTENSION	1.19	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1203	7-25-91	S	PP	3.5	TANGENTIAL, 2" EXTENSION	4.17	3mm/#6/0.5-0.6	20	0	19	0	1	95%	79%	17.1%
1204	7-25-91	S	PP	3.5	TANGENTIAL, 2" EXTENSION	4.1	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1205	7-25-91	S	PP	3.5	TANGENTIAL, 2" EXTENSION	4.11	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1206	7-25-91	M	PP	3.5	TANGENTIAL, 2" EXTENSION	2.77	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1207	7-25-91	M	PP	3.5	TANGENTIAL, 2" EXTENSION	2.17	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1208	7-25-91	M	PP	3.5	TANGENTIAL, 2" EXTENSION	2.06	3mm/#6/0.5-0.6	20	0	18	0	2	90%	83%	11.5%
1209	7-25-91	M	PP	3.5	TANGENTIAL, 2" EXTENSION	1.96	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1210	7-25-91	M	PP	3.5	TANGENTIAL, 2" EXTENSION	1.75	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1211	7-25-91	F	PP	3.5	TANGENTIAL, 2" EXTENSION	1.21	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1212	7-25-91	F	PP	3.5	TANGENTIAL, 2" EXTENSION	1.05	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1213	7-25-91	F	PP	3.5	TANGENTIAL, 2" EXTENSION	1.27	3mm/#6/0.5-0.6	20	0	17	0	3	85%	72%	13.5%
1214	7-25-91	F	PP	3.5	TANGENTIAL, 2" EXTENSION	1.31	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1215	7-25-91	F	PP	3.5	TANGENTIAL, 2" EXTENSION	1.23	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1216	7-25-91	S	PP	3.0	TANGENTIAL, 2" EXTENSION	3.63	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1217	7-25-91	S	PP	3.0	TANGENTIAL, 2" EXTENSION	4.01	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1218	7-25-91	S	PP	3.0	TANGENTIAL, 2" EXTENSION	3.61	3mm/#6/0.5-0.6	20	0	8	0	12	40%	33%	11.0%
1219	7-25-91	S	PP	3.0	TANGENTIAL, 2" EXTENSION	3.96	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1220	7-25-91	S	PP	3.0	TANGENTIAL, 2" EXTENSION	3.93	3mm/#6/0.5-0.6	20	0	3	0	17	15%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1221	7-25-91	M	PP	3.0	TANGENTIAL, 2" EXTENSION	2.43	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1222	7-25-91	M	PP	3.0	TANGENTIAL, 2" EXTENSION	1.96	3mm/#6/0.5-0.6	20	0	6	1	13	30%		
1223	7-25-91	M	PP	3.0	TANGENTIAL, 2" EXTENSION	2.82	3mm/#6/0.5-0.6	20	0	10	3	7	50%	37%	13.0%
1224	7-25-91	M	PP	3.0	TANGENTIAL, 2" EXTENSION	1.99	3mm/#6/0.5-0.6	20	0	4	1	15	20%		
1225	7-25-91	M	PP	3.0	TANGENTIAL, 2" EXTENSION	2.27	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1226	7-25-91	F	PP	3.0	TANGENTIAL, 2" EXTENSION	1.31	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1227	7-26-91	F	PP	3.0	TANGENTIAL, 2" EXTENSION	1.45	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1228	7-26-91	F	PP	3.0	TANGENTIAL, 2" EXTENSION	1.32	3mm/#6/0.5-0.6	20	0	12	0	8	60%	39%	17.8%
1229	7-26-91	F	PP	3.0	TANGENTIAL, 2" EXTENSION	1.31	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1230	7-26-91	F	PP	3.0	TANGENTIAL, 2" EXTENSION	1.51	3mm/#6/0.5-0.6	20	0	5	1	14	25%		
1231	7-26-91	S	PP	2.5	TANGENTIAL, 2" EXTENSION	4.02	3mm/#6/0.5-0.6	20	0	0	0	20	0%		
1232	7-26-91	S	PP	2.5	TANGENTIAL, 2" EXTENSION	4.14	3mm/#6/0.5-0.6	20	0	3	1	16	15%		
1233	7-26-91	S	PP	2.5	TANGENTIAL, 2" EXTENSION	4.13	3mm/#6/0.5-0.6	20	0	3	0	17	15%	10%	7.1%
1234	7-26-91	S	PP	2.5	TANGENTIAL, 2" EXTENSION	3.95	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1235	7-26-91	S	PP	2.5	TANGENTIAL, 2" EXTENSION	4.05	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1236	7-26-91	M	PP	2.5	TANGENTIAL, 2" EXTENSION	1.77	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1237	7-26-91	M	PP	2.5	TANGENTIAL, 2" EXTENSION	1.93	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1238	7-26-91	M	PP	2.5	TANGENTIAL, 2" EXTENSION	1.99	3mm/#6/0.5-0.6	20	0	3	0	17	15%	13%	5.7%
1239	7-26-91	M	PP	2.5	TANGENTIAL, 2" EXTENSION	1.75	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1240	7-26-91	M	PP	2.5	TANGENTIAL, 2" EXTENSION	1.9	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1241	7-26-91	F	PP	2.5	TANGENTIAL, 2" EXTENSION	1.13	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1242	7-26-91	F	PP	2.5	TANGENTIAL, 2" EXTENSION	1.19	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1243	7-26-91	F	PP	2.5	TANGENTIAL, 2" EXTENSION	1.14	3mm/#6/0.5-0.6	20	0	5	0	15	25%	21%	20.4%
1244	7-26-91	F	PP	2.5	TANGENTIAL, 2" EXTENSION	1.23	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1245	7-26-91	F	PP	2.5	TANGENTIAL, 2" EXTENSION	1.16	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1269	7-30-91	S	PP	3.5	TANGENTIAL, RIFLED	3.97	3mm/#6/0.5-0.6	20	0	3	1	16	15%		
1270	7-30-91	S	PP	3.5	TANGENTIAL, RIFLED	3.79	3mm/#6/0.5-0.6	19	0	3	4	12	16%		
1271	7-30-91	M	PP	3.5	TANGENTIAL, RIFLED	1.69	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1272	7-30-91	F	PP	3.5	TANGENTIAL, RIFLED	1.13	3mm/#6/0.5-0.6	20	0	2	0	18	10%		

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RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1302	8-1-91	S	PP	4.0	TANGENTIAL, PLUGGED VENT	3.96	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1303	8-1-91	S	PP	4.0	TANGENTIAL, PLUGGED VENT	3.98	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1304	8-1-91	S	PP	4.0	TANGENTIAL, PLUGGED VENT	3.87	3mm/#6/0.5-0.6	20	0	12	0	8	60%	81%	15.2%
1305	8-1-91	S	PP	4.0	TANGENTIAL, PLUGGED VENT	3.89	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1306	8-1-91	S	PP	4.0	TANGENTIAL, PLUGGED VENT	4.12	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1307	8-2-91	M	PP	4.0	TANGENTIAL, PLUGGED VENT	2.89	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1308	8-2-91	M	PP	4.0	TANGENTIAL, PLUGGED VENT	3.2	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1309	8-2-91	M	PP	4.0	TANGENTIAL, PLUGGED VENT	2.78	3mm/#6/0.5-0.6	20	0	13	0	7	65%	77%	11.5%
1310	8-2-91	M	PP	4.0	TANGENTIAL, PLUGGED VENT	2.77	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1311	8-2-91	M	PP	4.0	TANGENTIAL, PLUGGED VENT	3.02	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1312	8-2-91	F	PP	4.0	TANGENTIAL, PLUGGED VENT	2.28	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1313	8-2-91	F	PP	4.0	TANGENTIAL, PLUGGED VENT	2.07	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1314	8-2-91	F	PP	4.0	TANGENTIAL, PLUGGED VENT	1.54	3mm/#6/0.5-0.6	20	0	18	0	2	90%	83%	5.7%
1315	8-2-91	F	PP	4.0	TANGENTIAL, PLUGGED VENT	1.55	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1316	8-2-91	F	PP	4.0	TANGENTIAL, PLUGGED VENT	2.07	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1317	8-2-91	S	PP	3.5	TANGENTIAL, PLUGGED VENT	3.99	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1318	8-2-91	S	PP	3.5	TANGENTIAL, PLUGGED VENT	3.93	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1319	8-2-91	M	PP	3.5	TANGENTIAL, PLUGGED VENT	2.9	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1320	8-2-91	F	PP	3.5	TANGENTIAL, PLUGGED VENT	1.58	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1321	8-2-91	S	PP	3.0	TANGENTIAL, PLUGGED VENT	4.14	3mm/#6/0.5-0.6	20	0	6	5	9	30%		
1322	8-2-91	M	PP	3.0	TANGENTIAL, PLUGGED VENT	2.94	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1323	8-2-91	F	PP	3.0	TANGENTIAL, PLUGGED VENT	1.84	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1324	8-2-91	S	PP	2.5	TANGENTIAL, PLUGGED VENT	3.89	3mm/#6/0.5-0.6	20	0	6	4	10	30%		
1325	8-2-91	M	PP	2.5	TANGENTIAL, PLUGGED VENT	2.34	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1326	8-2-91	F	PP	2.5	TANGENTIAL, PLUGGED VENT	1.29	3mm/#6/0.5-0.6	20	0	2	0	18	10%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1327	8-2-91	S	PP	3.5	TANGENTIAL, 75% IC	5.33	3mm/#6/0.5-0.6	20	0	19	1	0	95%		
1328	8-2-91	S	PP	3.5	TANGENTIAL, 75% IC	5.07	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1329	8-2-91	S	PP	3.5	TANGENTIAL, 75% IC	4.97	3mm/#6/0.5-0.6	20	0	18	0	2	90%	94%	6.5%
1330	8-2-91	S	PP	3.5	TANGENTIAL, 75% IC	4.95	3mm/#6/0.5-0.6	20	0	17	1	2	85%		
1331	8-2-91	S	PP	3.5	TANGENTIAL, 75% IC	4.71	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1332	8-2-91	M	PP	3.5	TANGENTIAL, 75% IC	3.72	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1333	8-2-91	M	PP	3.5	TANGENTIAL, 75% IC	3.91	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1334	8-2-91	M	PP	3.5	TANGENTIAL, 75% IC	3.86	3mm/#6/0.5-0.6	20	0	17	0	3	85%	84%	11.4%
1335	8-2-91	M	PP	3.5	TANGENTIAL, 75% IC	4	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1336	8-2-91	M	PP	3.5	TANGENTIAL, 75% IC	4.11	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1337	8-2-91	F	PP	3.5	TANGENTIAL, 75% IC	3.36	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1338	8-2-91	F	PP	3.5	TANGENTIAL, 75% IC	4	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1339	8-2-91	F	PP	3.5	TANGENTIAL, 75% IC	3.63	3mm/#6/0.5-0.6	20	0	12	0	8	60%	65%	7.1%
1340	8-2-91	F	PP	3.5	TANGENTIAL, 75% IC	3.43	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1341	8-2-91	F	PP	3.5	TANGENTIAL, 75% IC	3.14	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1342	8-2-91	S	PP	3.5	TANGENTIAL, 50% IC	4.27	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1343	8-2-91	S	PP	3.5	TANGENTIAL, 50% IC	3.94	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1344	8-2-91	S	PP	3.5	TANGENTIAL, 50% IC	3.75	3mm/#6/0.5-0.6	20	0	18	0	2	90%	92%	4.5%
1345	8-2-91	S	PP	3.5	TANGENTIAL, 50% IC	3.53	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1346	8-2-91	S	PP	3.5	TANGENTIAL, 50% IC	4.19	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1347	8-2-91	M	PP	3.5	TANGENTIAL, 50% IC	3.46	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1348	8-2-91	M	PP	3.5	TANGENTIAL, 50% IC	3.5	3mm/#6/0.5-0.6	20	0	13	0	7	65%		
1349	8-2-91	M	PP	3.5	TANGENTIAL, 50% IC	3.15	3mm/#6/0.5-0.6	20	0	16	0	4	80%	75%	9.4%
1350	8-2-91	M	PP	3.5	TANGENTIAL, 50% IC	3.58	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1351	8-2-91	M	PP	3.5	TANGENTIAL, 50% IC	3.71	3mm/#6/0.5-0.6	20	0	13	0	7	65%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1352	8-2-91	F	PP	3.5	TANGENTIAL, 50% IC	2.9	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1353	8-2-91	F	PP	3.5	TANGENTIAL, 50% IC	2.54	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1354	8-2-91	F	PP	3.5	TANGENTIAL, 50% IC	2.55	3mm/#6/0.5-0.6	20	0	16	0	4	80%	79%	11.4%
1355	8-2-91	F	PP	3.5	TANGENTIAL, 50% IC	2.65	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1356	8-2-91	F	PP	3.5	TANGENTIAL, 50% IC	2.71	3mm/#6/0.5-0.6	20	0	12	1	7	60%		
1357	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC	4.79	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1358	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC	4.34	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1359	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC	4.43	3mm/#6/0.5-0.6	20	0	20	0	0	100%	98%	4.5%
1360	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC	4.33	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1361	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC	4.34	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1362	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC	3.29	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1363	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC	3.08	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1364	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC	3.15	3mm/#6/0.5-0.6	20	0	11	0	9	55%	53%	8.4%
1365	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC	3.17	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1366	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC	3.55	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1367	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC	2.74	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1368	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC	2.65	3mm/#6/0.5-0.6	20	0	2	0	18	10%		
1369	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC	2.46	3mm/#6/0.5-0.6	20	0	5	0	15	25%	24%	16.7%
1370	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC	2.6	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1371	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC	2.7	3mm/#6/0.5-0.6	20	0	1	0	19	5%		
1372	8-5-91	S	PP	2.5	TANGENTIAL, 50% IC	4.08	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1373	8-5-91	S	PP	2.5	TANGENTIAL, 50% IC	3.83	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1374	8-5-91	S	PP	2.5	TANGENTIAL, 50% IC	4.03	3mm/#6/0.5-0.6	20	0	16	0	4	80%	87%	5.7%
1375	8-5-91	S	PP	2.5	TANGENTIAL, 50% IC	3.45	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1376	8-5-91	S	PP	2.5	TANGENTIAL, 50% IC	3.98	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1377	8-5-91	M	PP	2.5	TANGENTIAL, 50% IC	2.59	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1378	8-5-91	M	PP	2.5	TANGENTIAL, 50% IC	2.73	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1379	8-5-91	M	PP	2.5	TANGENTIAL, 50% IC	2.69	3mm/#6/0.5-0.6	20	0	12	0	8	60%	53%	6.7%
1380	8-5-91	M	PP	2.5	TANGENTIAL, 50% IC	2.79	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1381	8-5-91	M	PP	2.5	TANGENTIAL, 50% IC	2.77	3mm/#6/0.5-0.6	20	0	10	0	10	50%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1382	8-5-91	F	PP	2.5	TANGENTIAL, 50% IC	2.17	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1383	8-5-91	F	PP	2.5	TANGENTIAL, 50% IC	2.19	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1384	8-5-91	F	PP	2.5	TANGENTIAL, 50% IC	2.24	3mm/#6/0.5-0.6	20	0	9	0	11	45%	39%	10.8%
1385	8-5-91	F	PP	2.5	TANGENTIAL, 50% IC	2.26	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1386	8-5-91	F	PP	2.5	TANGENTIAL, 50% IC	2.27	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1387	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	4.88	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1388	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	4.37	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1389	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	4.15	3mm/#6/0.5-0.6	20	0	19	0	1	95%	95%	6.1%
1390	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	4.34	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1391	8-5-91	S	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	4.11	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1392	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	3.27	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1393	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	3.35	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1394	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	3.38	3mm/#6/0.5-0.6	20	0	6	0	14	30%	46%	13.9%
1395	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	3.36	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1396	8-5-91	M	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	3.4	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1397	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	2.49	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1398	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	2.59	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1399	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	2.64	3mm/#6/0.5-0.6	20	0	11	0	9	55%	37%	13.0%
1400	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	2.64	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1401	8-5-91	F	PP	2.5	TANGENTIAL, 75% IC, VENTURI OC	2.7	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1425	8-6-91	S	PP	4.0	TANGENTIAL, 50% IC	4.92	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1426	8-6-91	S	PP	4.0	TANGENTIAL, 50% IC	5.06	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1427	8-6-91	S	PP	4.0	TANGENTIAL, 50% IC	5.01	3mm/#6/0.5-0.6	20	0	20	0	0	100%	95%	5.0%
1428	8-6-91	S	PP	4.0	TANGENTIAL, 50% IC	4.82	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1429	8-6-91	S	PP	4.0	TANGENTIAL, 50% IC	4.17	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1430	8-6-91	M	PP	4.0	TANGENTIAL, 50% IC	3.51	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1431	8-6-91	M	PP	4.0	TANGENTIAL, 50% IC		3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1432	8-6-91	M	PP	4.0	TANGENTIAL, 50% IC	3.09	3mm/#6/0.5-0.6	20	0	16	0	4	80%	76%	7.4%
1433	8-6-91	M	PP	4.0	TANGENTIAL, 50% IC	3.35	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1434	8-6-91	M	PP	4.0	TANGENTIAL, 50% IC	3.29	3mm/#6/0.5-0.6	20	0	13	0	7	65%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1435	8-6-91	F	PP	4.0	TANGENTIAL, 50% IC	3.21	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1436	8-6-91	F	PP	4.0	TANGENTIAL, 50% IC	2.86	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1437	8-6-91	F	PP	4.0	TANGENTIAL, 50% IC	2.69	3mm/#6/0.5-0.6	20	0	11	0	9	55%	57%	17.5%
1438	8-6-91	F	PP	4.0	TANGENTIAL, 50% IC	1.71	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1439	8-6-91	F	PP	4.0	TANGENTIAL, 50% IC	2.8	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1461	8-8-91	S	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.51	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1462	8-8-91	S	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.68	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1463	8-8-91	S	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.5	3mm/#6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1464	8-8-91	S	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.95	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1465	8-8-91	S	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.71	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1466	8-8-91	M	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.29	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1467	8-8-91	M	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.56	3mm/#6/0.5-0.6	19	0	19	0	0	100%		
1468	8-8-91	M	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.31	3mm/#6/0.5-0.6	20	0	18	0	2	90%	97%	4.5%
1469	8-8-91	M	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	4.07	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1470	8-8-91	M	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.84	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1471	8-8-91	F	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	2.99	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1472	8-8-91	F	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.67	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1473	8-8-91	F	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.28	3mm/#6/0.5-0.6	20	0	17	0	3	85%	88%	9.1%
1474	8-8-91	F	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.46	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1475	8-8-91	F	PP	2.5	TANGENTIAL, 2" WELL, 75% IC	3.22	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1520	8-13-91	S	PP	2.5	TANGENTIAL, 2" CAP	3.49	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1523	8-13-91	S	PP	2.5	TANGENTIAL, 2" CAP	4.13	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1524	8-13-91	S	PP	2.5	TANGENTIAL, 2" CAP	4.03	3mm/#6/0.5-0.6	20	0	13	0	7	65%	53%	10.4%
1525	8-13-91	S	PP	2.5	TANGENTIAL, 2" CAP	4.22	3mm/#6/0.5-0.6	20	0	11	0	9	55%		
1526	8-13-91	S	PP	2.5	TANGENTIAL, 2" CAP	3.97	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1521	8-13-91	M	PP	2.5	TANGENTIAL, 2" CAP	1.56	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1527	8-13-91	M	PP	2.5	TANGENTIAL, 2" CAP	2.05	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1528	8-13-91	M	PP	2.5	TANGENTIAL, 2" CAP	2.2	3mm/#6/0.5-0.6	20	0	5	0	15	25%	21%	4.2%
1529	8-13-91	M	PP	2.5	TANGENTIAL, 2" CAP	2.87	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1530	8-13-91	M	PP	2.5	TANGENTIAL, 2" CAP	2.14	3mm/#6/0.5-0.6	20	0	3	0	17	15%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1522	8-13-91	F	PP	2.5	TANGENTIAL, 2" CAP	1.1	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1531	8-13-91	F	PP	2.5	TANGENTIAL, 2" CAP	1.14	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1532	8-13-91	F	PP	2.5	TANGENTIAL, 2" CAP	1.14	3mm/#6/0.5-0.6	20	0	9	0	11	45%	28%	13.5%
1533	8-13-91	F	PP	2.5	TANGENTIAL, 2" CAP	1.25	3mm/#6/0.5-0.6	20	0	4	0	16	20%		
1534	8-13-91	F	PP	2.5	TANGENTIAL, 2" CAP	1.2	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1544	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	4.7	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1545	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	4.63	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1546	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	4.54	3mm/#6/0.5-0.6	20	0	20	0	0	100%	99%	2.2%
1547	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	4.49	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1548	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	4.63	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1549	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.87	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1550	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	2.13	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1551	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	2.04	3mm/#6/0.5-0.6	20	0	19	0	1	95%	91%	4.2%
1552	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	2.26	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1553	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	3.17	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1554	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.72	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1555	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.58	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1556	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.59	3mm/#6/0.5-0.6	20	0	19	0	1	95%	89%	8.9%
1557	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.56	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1558	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	1.83	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1559	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	5.38	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1560	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	4.91	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1561	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	5.04	3mm/#6/0.5-0.6	20	0	19	0	1	95%	97%	2.7%
1562	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	5	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1563	8-15-91	S	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	5.19	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1564	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	4.26	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1565	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	3.76	3mm/#6/0.5-0.6	20	0	17	1	2	85%		
1566	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	4.13	3mm/#6/0.5-0.6	20	0	17	0	3	85%	87%	9.1%
1567	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	3.87	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1568	8-15-91	M	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	3.89	3mm/#6/0.5-0.6	20	0	15	2	3	75%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1569	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	2.77	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1570	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	2.75	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1571	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	2.95	3mm/#6/0.5-0.6	21	1	15	0	5	75%	78%	4.7%
1572	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	2.85	3mm/#6/0.5-0.6	20	1	14	0	5	74%		
1573	8-15-91	F	PP	3.5	TANGENTIAL, 2" WELL, 75% IC	2.88	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1604	8-19-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.68	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1605	8-19-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.76	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1606	8-19-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.75	3mm/#6/0.5-0.6	20	0	15	0	5	75%	75%	15.0%
1607	8-19-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.72	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1608	8-19-91	M	PP	3.5	TANGENTIAL, 2" WELL	1.66	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1609	8-19-91	M	PP	3.5	TANGENTIAL	1.44	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1610	8-19-91	M	PP	3.5	TANGENTIAL	1.47	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1611	8-19-91	M	PP	3.5	TANGENTIAL	1.52	3mm/#6/0.5-0.6	20	0	7	0	13	35%	34%	7.4%
1612	8-19-91	M	PP	3.5	TANGENTIAL	1.51	3mm/#6/0.5-0.6	20	0	9	0	11	45%		
1613	8-19-91	M	PP	3.5	TANGENTIAL	1.6	3mm/#6/0.5-0.6	20	0	6	0	14	30%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1659	8-20-91	S	PP	3.0	TANGENTIAL, 2" CAP	4.11	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1660	8-20-91	S	PP	3.0	TANGENTIAL, 2" CAP	4.37	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1661	8-20-91	S	PP	3.0	TANGENTIAL, 2" CAP	4.17	3mm/#6/0.5-0.6	20	0	13	0	7	65%	65%	16.6%
1662	8-20-91	S	PP	3.0	TANGENTIAL, 2" CAP	3.99	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1663	8-20-91	S	PP	3.0	TANGENTIAL, 2" CAP	4.28	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1664	8-20-91	M	PP	3.0	TANGENTIAL, 2" CAP	2.02	3mm/#6/0.5-0.6	20	0	5	0	15	25%		
1665	8-20-91	M	PP	3.0	TANGENTIAL, 2" CAP	1.56	3mm/#6/0.5-0.6	20	0	10	0	10	50%		
1666	8-20-91	M	PP	3.0	TANGENTIAL, 2" CAP	1.83	3mm/#6/0.5-0.6	20	0	9	0	11	45%	39%	9.6%
1667	8-20-91	M	PP	3.0	TANGENTIAL, 2" CAP	1.46	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1668	8-20-91	M	PP	3.0	TANGENTIAL, 2" CAP	1.54	3mm/#6/0.5-0.6	20	0	7	0	13	35%		
1669	8-20-91	F	PP	3.0	TANGENTIAL, 2" CAP	0.89	3mm/#6/0.5-0.6	20	0	3	0	17	15%		
1670	8-20-91	F	PP	3.0	TANGENTIAL, 2" CAP	1.12	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1671	8-20-91	F	PP	3.0	TANGENTIAL, 2" CAP	0.93	3mm/#6/0.5-0.6	20	0	6	0	14	30%	29%	8.9%
1672	8-20-91	F	PP	3.0	TANGENTIAL, 2" CAP	1.05	3mm/#6/0.5-0.6	20	0	6	0	14	30%		
1673	8-20-91	F	PP	3.0	TANGENTIAL, 2" CAP	1.01	3mm/#6/0.5-0.6	20	0	8	0	12	40%		
1730	8-28-91	S	PP	4.0	TANGENTIAL, 2" CAP	4.78	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1731	8-28-91	S	PP	4.0	TANGENTIAL, 2" CAP	4.66	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1732	8-29-91	S	PP	4.0	TANGENTIAL, 2" CAP	4.34	3 mm/6/0.5-0.6	20	0	16	0	4	80%	92%	7.6%
1733	8-29-91	S	PP	4.0	TANGENTIAL, 2" CAP	3.49	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1734	8-29-91	S	PP	4.0	TANGENTIAL, 2" CAP	3.50	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1735	8-29-91	M	PP	4.0	TANGENTIAL, 2" CAP	1.48	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1736	8-29-91	M	PP	4.0	TANGENTIAL, 2" CAP	1.54	3 mm/6/0.5-0.6	20	0	8	0	12	40%		
1737	8-29-91	M	PP	4.0	TANGENTIAL, 2" CAP	1.54	3 mm/6/0.5-0.6	20	0	15	0	5	75%	63%	13.5%
1738	8-29-91	M	PP	4.0	TANGENTIAL, 2" CAP	1.53	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1739	8-29-91	M	PP	4.0	TANGENTIAL, 2" CAP	1.50	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1740	8-29-91	F	PP	4.0	TANGENTIAL, 2" CAP	1.01	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1741	8-29-91	F	PP	4.0	TANGENTIAL, 2" CAP	1.02	3 mm/6/0.5-0.6	20	0	11	0	9	55%		
1742	8-29-91	F	PP	4.0	TANGENTIAL, 2" CAP	0.99	3 mm/6/0.5-0.6	20	0	10	0	10	50%	52%	14.4%
1743	8-29-91	F	PP	4.0	TANGENTIAL, 2" CAP	1.09	3 mm/6/0.5-0.6	20	0	11	0	9	55%		
1744	8-29-91	F	PP	4.0	TANGENTIAL, 2" CAP	0.97	3 mm/6/0.5-0.6	20	0	6	0	14	30%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1745	8-29-91	S	PP	3.5	TANGENTIAL, 2" CAP	4.10	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1746	8-29-91	S	PP	3.5	TANGENTIAL, 2" CAP		3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1747	8-29-91	S	PP	3.5	TANGENTIAL, 2" CAP	3.19	3 mm/6/0.5-0.6	20	0	16	0	4	80%	89%	8.9%
1748	8-29-91	S	PP	3.5	TANGENTIAL, 2" CAP	3.37	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1749	8-29-91	S	PP	3.5	TANGENTIAL, 2" CAP	4.07	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1750	8-29-91	M	PP	3.5	TANGENTIAL, 2" CAP	1.38	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1751	8-29-91	M	PP	3.5	TANGENTIAL, 2" CAP	1.31	3 mm/6/0.5-0.6	20	0	12	0	8	60%		
1752	8-29-91	M	PP	3.5	TANGENTIAL, 2" CAP	1.43	3 mm/6/0.5-0.6	20	0	14	0	6	70%	69%	13.4%
1753	8-29-91	M	PP	3.5	TANGENTIAL, 2" CAP	1.33	3 mm/6/0.5-0.6	20	0	11	0	9	55%		
1754	8-29-91	M	PP	3.5	TANGENTIAL, 2" CAP	1.43	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1755	8-29-91	F	PP	3.5	TANGENTIAL, 2" CAP	1.00	3 mm/6/0.5-0.6	20	0	10	0	10	50%		
1756	8-29-91	F	PP	3.5	TANGENTIAL, 2" CAP	0.97	3 mm/6/0.5-0.6	20	0	7	0	13	35%		
1757	8-29-91	F	PP	3.5	TANGENTIAL, 2" CAP	1.03	3 mm/6/0.5-0.6	20	0	7	0	13	35%	45%	10.6%
1758	8-29-91	F	PP	3.5	TANGENTIAL, 2" CAP	1.07	3 mm/6/0.5-0.6	20	0	9	0	11	45%		
1759	8-29-91	F	PP	3.5	TANGENTIAL, 2" CAP	1.08	3 mm/6/0.5-0.6	20	0	12	0	8	60%		
1760	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	4.21	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1761	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	4.47	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1762	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	4.63	3 mm/6/0.5-0.6	20	0	20	0	0	100%	96%	5.5%
1763	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	4.43	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1764	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	4.32	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1765	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.86	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1766	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.74	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1767	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.88	3 mm/6/0.5-0.6	20	0	19	0	1	95%	95%	5.0%
1768	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.92	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1769	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	2.89	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1770	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.41	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1771	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.38	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1772	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.90	3 mm/6/0.5-0.6	20	0	17	0	3	85%	80%	10.0%
1773	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.34	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1774	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	1.37	3 mm/6/0.5-0.6	20	0	15	0	5	75%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1775	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	4.79	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1776	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	4.93	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1777	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	4.99	3 mm/6/0.5-0.6	20	0	20	0	0	100%	98%	4.5%
1778	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	4.84	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1779	8-29-91	S	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	4.66	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1780	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	3.27	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1781	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	3.25	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1782	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	3.13	3 mm/6/0.5-0.6	20	0	20	0	0	100%	99%	2.2%
1783	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	3.13	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1784	8-29-91	M	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	3.07	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1785	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	2.43	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1786	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	2.73	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1787	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	2.82	3 mm/6/0.5-0.6	20	0	12	0	8	60%	66%	8.2%
1788	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	2.55	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1789	8-29-91	F	PP	3.0	TANGENTIAL, 2" WELL, 75% IC	2.92	3 mm/6/0.5-0.6	20	0	12	0	8	60%		
1805	9-3-91	S	PP	3.0	TANGENTIAL, 75% IC	4.73	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1806	9-3-91	S	PP	3.0	TANGENTIAL, 75% IC	4.69	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1807	9-3-91	S	PP	3.0	TANGENTIAL, 75% IC	4.52	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1808	9-3-91	S	PP	3.0	TANGENTIAL, 75% IC	4.97	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1809	9-3-91	S	PP	3.0	TANGENTIAL, 75% IC	4.53	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1810	9-3-91	M	PP	3.0	TANGENTIAL, 75% IC	3.25	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1811	9-3-91	M	PP	3.0	TANGENTIAL, 75% IC	3.19	3 mm/6/0.5-0.6	20	0	14	1	5	70%		
1812	9-3-91	M	PP	3.0	TANGENTIAL, 75% IC	3.20	3 mm/6/0.5-0.6	20	0	17	0	3	85%	80%	12.2%
1813	9-3-91	M	PP	3.0	TANGENTIAL, 75% IC	2.96	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1814	9-3-91	M	PP	3.0	TANGENTIAL, 75% IC	3.44	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1815	9-3-91	F	PP	3.0	TANGENTIAL, 75% IC	2.26	3 mm/6/0.5-0.6	20	0	7	0	13	35%		
1816	9-3-91	F	PP	3.0	TANGENTIAL, 75% IC	2.44	3 mm/6/0.5-0.6	20	0	6	0	14	30%		
1817	9-3-91	F	PP	3.0	TANGENTIAL, 75% IC	2.78	3 mm/6/0.5-0.6	20	0	15	0	5	75%	37%	23.6%
1818	9-3-91	F	PP	3.0	TANGENTIAL, 75% IC	2.65	3 mm/6/0.5-0.6	20	0	7	0	13	35%		
1819	9-3-91	F	PP	3.0	TANGENTIAL, 75% IC	2.28	3 mm/6/0.5-0.6	20	0	2	0	18	10%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1820	9-3-91	S	PP	3.0	TANGENTIAL, 50% IC	4.49	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1821	9-3-91	S	PP	3.0	TANGENTIAL, 50% IC	4.18	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1822	9-3-91	S	PP	3.0	TANGENTIAL, 50% IC	4.06	3 mm/6/0.5-0.6	20	0	20	0	0	100%	96%	4.2%
1823	9-3-91	S	PP	3.0	TANGENTIAL, 50% IC	4.13	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1824	9-3-91	S	PP	3.0	TANGENTIAL, 50% IC	2.59	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1825	9-3-91	M	PP	3.0	TANGENTIAL, 50% IC	2.77	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1826	9-3-91	M	PP	3.0	TANGENTIAL, 50% IC	2.79	3 mm/6/0.5-0.6	20	0	7	0	13	35%		
1827	9-3-91	M	PP	3.0	TANGENTIAL, 50% IC	2.85	3 mm/6/0.5-0.6	20	0	14	0	6	70%	60%	15.8%
1828	9-3-91	M	PP	3.0	TANGENTIAL, 50% IC	2.72	3 mm/6/0.5-0.6	20	0	15	0	5	75%		
1829	9-3-91	M	PP	3.0	TANGENTIAL, 50% IC	2.86	3 mm/6/0.5-0.6	20	0	11	0	9	55%		
1830	9-3-91	F	PP	3.0	TANGENTIAL, 50% IC	1.53	3 mm/6/0.5-0.6	20	0	5	0	15	25%		
1831	9-3-91	F	PP	3.0	TANGENTIAL, 50% IC	2.17	3 mm/6/0.5-0.6	20	0	9	0	11	45%		
1832	9-3-91	F	PP	3.0	TANGENTIAL, 50% IC	1.71	3 mm/6/0.5-0.6	20	0	11	0	9	55%	40%	16.6%
1833	9-3-91	F	PP	3.0	TANGENTIAL, 50% IC	1.67	3 mm/6/0.5-0.6	20	0	4	0	16	20%		
1834	9-3-91	F	PP	3.0	TANGENTIAL, 50% IC	1.67	3 mm/6/0.5-0.6	20	0	11	0	9	55%		
1835	9-3-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	4.37	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1836	9-3-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	3.78	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1837	9-3-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	4.02	3 mm/6/0.5-0.6	20	0	20	0	0	100%	99%	2.2%
1838	9-3-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	3.83	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1839	9-3-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	4.30	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1840	9-3-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	2.34	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1841	9-3-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	2.64	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1842	9-3-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	2.88	3 mm/6/0.5-0.6	20	0	19	0	1	95%	90%	7.9%
1843	9-3-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	2.41	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1844	9-3-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	2.98	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1845	9-3-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	1.56	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1846	9-3-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	1.36	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1847	9-3-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	1.36	3 mm/6/0.5-0.6	20	0	17	0	3	85%	75%	10.0%
1848	9-3-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	1.37	3 mm/6/0.5-0.6	20	0	15	0	5	75%		
1849	9-3-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC	1.20	3 mm/6/0.5-0.6	20	0	13	0	7	65%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1850	9-3-91	S	PP	4.0	TANGENTIAL, 75% IC	5.09	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1851	9-3-91	S	PP	4.0	TANGENTIAL, 75% IC	5.18	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1852	9-3-91	S	PP	4.0	TANGENTIAL, 75% IC	4.91	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1853	9-3-91	S	PP	4.0	TANGENTIAL, 75% IC	4.74	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1854	9-3-91	S	PP	4.0	TANGENTIAL, 75% IC	4.80	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1855	9-3-91	M	PP	4.0	TANGENTIAL, 75% IC	4.43	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1856	9-3-91	M	PP	4.0	TANGENTIAL, 75% IC	3.91	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1857	9-3-91	M	PP	4.0	TANGENTIAL, 75% IC	4.24	3 mm/6/0.5-0.6	20	0	20	0	0	100%	97%	4.5%
1858	9-3-91	M	PP	4.0	TANGENTIAL, 75% IC	4.23	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1859	9-3-91	M	PP	4.0	TANGENTIAL, 75% IC	3.83	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1860	9-3-91	F	PP	4.0	TANGENTIAL, 75% IC	3.52	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1861	9-3-91	F	PP	4.0	TANGENTIAL, 75% IC	2.93	3 mm/6/0.5-0.6	20	0	9	0	11	45%		
1862	9-3-91	F	PP	4.0	TANGENTIAL, 75% IC	2.86	3 mm/6/0.5-0.6	20	0	9	0	11	45%	62%	17.2%
1863	9-3-91	F	PP	4.0	TANGENTIAL, 75% IC	3.53	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1864	9-3-91	F	PP	4.0	TANGENTIAL, 75% IC	2.91	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1865	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	5.65	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1866	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	5.87	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1867	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	5.63	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1868	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	5.76	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1869	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	5.94	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1870	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	4.56	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1871	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	4.94	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1872	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	4.59	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1873	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	4.31	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1874	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	4.74	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1875	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	3.37	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1876	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	3.30	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1877	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	3.48	3 mm/6/0.5-0.6	20	0	20	0	0	100%	95%	3.5%
1878	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	3.27	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1879	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 75% IC	3.28	3 mm/6/0.5-0.6	20	0	19	0	1	95%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1880	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	4.49	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1881	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	4.92	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1882	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	4.79	3 mm/6/0.5-0.6	20	0	18	0	2	90%	96%	4.2%
1883	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	4.73	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1884	9-3-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	4.76	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1885	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.53	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1886	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.55	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1887	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.47	3 mm/6/0.5-0.6	20	0	18	0	2	90%	90%	7.9%
1888	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.48	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1889	9-3-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.60	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1890	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.14	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1891	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.04	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1892	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.13	3 mm/6/0.5-0.6	20	0	18	0	2	90%	89%	7.4%
1893	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.10	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1894	9-3-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC	2.07	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1931	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	4.04	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1932	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	4.03	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1933	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	3.99	3 mm/6/0.5-0.6	20	0	16	0	4	80%	88%	7.6%
1934	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	4.07	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1935	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	4.27	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1936	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.99	3 mm/6/0.5-0.6	20	0	12	0	8	60%		
1937	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	2.02	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1938	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	2.04	3 mm/6/0.5-0.6	20	0	12	0	8	60%	66%	6.5%
1939	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.99	3 mm/6/0.5-0.6	20	0	15	0	5	75%		
1940	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	2.05	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1941	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.67	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1942	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.74	3 mm/6/0.5-0.6	20	0	13	0	7	65%		
1943	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.70	3 mm/6/0.5-0.6	20	0	14	0	6	70%	73%	9.7%
1944	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.78	3 mm/6/0.5-0.6	20	0	14	0	6	70%		
1945	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 90 DEG	1.75	3 mm/6/0.5-0.6	20	0	18	0	2	90%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1946	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	4.50	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1947	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	4.74	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1948	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	4.54	3 mm/6/0.5-0.6	20	0	19	0	1	95%	98%	2.7%
1949	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	4.40	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1950	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	4.45	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1951	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	2.15	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1952	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	2.20	3 mm/6/0.5-0.6	20	0	15	0	5	75%		
1953	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.89	3 mm/6/0.5-0.6	20	0	16	0	4	80%	82%	8.4%
1954	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.89	3 mm/6/0.5-0.6	20	0	15	0	5	75%		
1955	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	2.10	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1956	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.65	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1957	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.72	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1958	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.58	3 mm/6/0.5-0.6	20	0	16	0	4	80%	80%	12.2%
1959	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.69	3 mm/6/0.5-0.6	20	0	16	0	4	80%		
1960	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC TILTED 45 DEG	1.64	3 mm/6/0.5-0.6	20	0	12	0	8	60%		
1961	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	4.50	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1962	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	4.87	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1963	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	4.52	3 mm/6/0.5-0.6	20	0	20	0	0	100%	97%	2.7%
1964	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	4.56	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1965	9-10-91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	4.44	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1966	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.50	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1967	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.44	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1968	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.36	3 mm/6/0.5-0.6	20	0	18	0	2	90%	95%	5.0%
1969	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.97	3 mm/6/0.5-0.6	20	0	18	0	2	90%		
1970	9-10-91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.87	3 mm/6/0.5-0.6	20	0	19	0	1	95%		
1971	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	1.98	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1972	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	1.89	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1973	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	1.94	3 mm/6/0.5-0.6	20	0	19	0	1	95%	90%	7.1%
1974	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	1.93	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1975	9-10-91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC, 0.22" OVFLW OC	2.02	3 mm/6/0.5-0.6	20	0	17	0	3	85%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1976	9-11-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	4.84	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1977	9-11-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	4.47	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1978	9-11-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	4.67	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1979	9-11-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	4.64	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1980	9-11-91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	4.69	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1981	9-11-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	2.48	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1982	9-11-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	2.61	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1983	9-11-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	2.69	3 mm/6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1984	9-11-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	2.75	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1985	9-11-91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	2.42	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1986	9-11-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	1.59	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1987	9-11-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	1.84	3 mm/6/0.5-0.6	20	0	17	0	3	85%		
1988	9-11-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	1.95	3 mm/6/0.5-0.6	20	0	18	0	2	90%	90%	6.1%
1989	9-11-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	1.95	3 mm/6/0.5-0.6	20	0	20	0	0	100%		
1990	9-11-91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC, 0.115" OVRFLW OC	1.79	3 mm/6/0.5-0.6	20	0	18	0	2	90%		

SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
2081	9-13-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.73	3/6/0.5-0.6	20	0	18	0	2	90%		
2082	9-13-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.58	3/6/0.5-0.6	20	0	19	0	1	95%		
2083	9-13-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.43	3/6/0.5-0.6	20	0	18	0	2	90%	94%	4.2%
2084	9-13-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.27	3/6/0.5-0.6	20	0	20	0	0	100%		
2085	9-13-91	S	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.23	3/6/0.5-0.6	20	0	19	0	1	95%		
2086	9-13-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.03	3/6/0.5-0.6	20	0	20	0	0	100%		
2087	9-13-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.21	3/6/0.5-0.6	20	0	19	0	1	95%		
2088	9-13-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.30	3/6/0.5-0.6	20	0	19	0	1	95%	96%	4.2%
2089	9-13-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.25	3/6/0.5-0.6	20	0	18	0	2	90%		
2090	9-13-91	M	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.19	3/6/0.5-0.6	20	0	20	0	0	100%		
2091	9-13-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.34	3/6/0.5-0.6	20	0	18	0	2	90%		
2092	9-13-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.28	3/6/0.5-0.6	20	0	15	0	5	75%		
2093	9-13-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.58	3/6/0.5-0.6	20	0	17	0	3	85%	83%	5.7%
2094	9-13-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	3.14	3/6/0.5-0.6	20	0	17	0	3	85%		
2095	9-13-91	F	PP	2.5	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.97	3/6/0.5-0.6	20	0	16	0	4	80%		
2096	9-13-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.95	3/6/0.5-0.6	20	0	20	0	0	100%		
2097	9-13-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	4.98	3/6/0.5-0.6	20	0	19	0	1	95%		
2098	9-13-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	5.02	3/6/0.5-0.6	20	0	20	0	0	100%	99%	2.2%
2099	9-13-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	5.13	3/6/0.5-0.6	20	0	20	0	0	100%		
2100	9-13-91	S	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	5.02	3/6/0.5-0.6	20	0	20	0	0	100%		
2101	9-13-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.59	3/6/0.5-0.6	20	0	19	0	1	95%		
2102	9-13-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.63	3/6/0.5-0.6	20	0	20	0	0	100%		
2103	9-13-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.67	3/6/0.5-0.6	20	0	19	0	1	95%	94%	4.2%
2104	9-13-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.39	3/6/0.5-0.6	20	0	18	0	2	90%		
2105	9-13-91	M	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.65	3/6/0.5-0.6	20	0	18	0	2	90%		
2106	9-13-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.13	3/6/0.5-0.6	20	0	20	0	0	100%		
2107	9-13-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	1.98	3/6/0.5-0.6	20	0	19	0	1	95%		
2108	9-13-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.19	3/6/0.5-0.6	20	0	20	0	0	100%	98%	2.7%
2109	9-13-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.16	3/6/0.5-0.6	20	0	20	0	0	100%		
2110	9-13-91	F	PP	4.0	TANGENTIAL, 2" WELL, 50% IC, 0.068" OVFLW OC	2.24	3/6/0.5-0.6	20	0	19	0	1	95%		

PARTICAL INCLUSIONS IN THE SWIRL CHAMBER

RUN #	DATE	PR RT	INC INT	DIA	SETUP	INCLUSION TYPE	FILL TIME	INCLUSIONS CHAMBER (grams)	PART MOLD (grams)	% EFF.
1895	9/4/91	S	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		3.8	0.2	95%
1896	9/4/91	M	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		3.5	0.5	88%
1897	9/4/91	F	PP	3.0	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		2.5	1.5	63%
1898	9/5/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		2.9	0.1	97%
1899	9/5/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		3.4	0.4	89%
1900	9/5/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT		3.1	0.9	78%
1901	9/5/91	S	PP	3.0	TANGENTIAL, 2" WELL	FINE BUBBLE ALUMINA-LIGHT		3.4	0.4	89%
1902	9/5/91	M	PP	3.0	TANGENTIAL, 2" WELL	FINE BUBBLE ALUMINA-LIGHT		3.9	0.4	91%
1903	9/5/91	F	PP	3.0	TANGENTIAL, 2" WELL	FINE BUBBLE ALUMINA-LIGHT		1.4	1.9	42%
1904	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT	4.52	4.4	0.1	98%
1905	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT	2.33	2.9	0.4	88%
1906	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-LIGHT	1.96	3.3	0.6	85%
1907	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-HEAVY	4.42	6.2	0.2	97%
1908	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-HEAVY	2.42	5.4	0.4	93%
1909	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	FINE BUBBLE ALUMINA-HEAVY	1.93	3.8	2.2	63%
1910	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	4.51	3	0.2	94%
1911	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	2.70	2.2	0.2	92%
1912	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	1.98	2	0.8	71%
1913	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	4.40	6.7	0.2	97%
1914	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	2.64	7.3	0.4	95%
1915	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	COARSE BUBBLE ALUMINA-LIGHT	1.90	3.8	2.1	64%
1916	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SANDBLASTING MEDIUM, MCA	4.59	18.8	0.1	99%
1917	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SANDBLASTING MEDIUM, MCA	2.44	25	0.4	98%
1918	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SANDBLASTING MEDIUM, MCA	1.93	14.8	5.8	72%
1919	9/9/91	S	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SILICON CARBIDE	4.69	13.2	0.1	99%
1920	9/9/91	M	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SILICON CARBIDE	2.55	14	0.2	99%
1921	9/9/91	F	PP	3.5	TANGENTIAL, 2" WELL, 50% IC	SILICON CARBIDE	2.70	12.1	2.4	83%

MISCELLANEOUS SMALL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	DIA	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF
1402	8-5-91	S	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	4.44	3mm/#6/0.5-0.6	20	0	2	1	17	10%
1403	8-5-91	S	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	4.51	3mm/#6/0.5-0.6	20	0	3	0	17	15%
1404	8-5-91	M	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	4.11	3mm/#6/0.5-0.6	20	0	1	0	19	5%
1405	8-5-91	M	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	3.92	3mm/#6/0.5-0.6	20	0	2	0	18	10%
1406	8-5-91	F	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	3.68	3mm/#6/0.5-0.6	20	0	5	0	15	25%
1407	8-5-91	F	PP	3.5	TANGENTIAL, 1" DIA BAFFLE	4.13	3mm/#6/0.5-0.6	20	0	3	2	15	15%
1408	8-5-91	S	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	3.88	3mm/#6/0.5-0.6	20	0	13	0	7	65%
1409	8-5-91	S	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	3.49	3mm/#6/0.5-0.6	20	0	15	0	5	75%
1410	8-5-91	S	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	3.65	3mm/#6/0.5-0.6	20	0	8	0	12	40%
1411	8-5-91	M	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	2.69	3mm/#6/0.5-0.6	20	0	4	3	13	20%
1412	8-5-91	M	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	2.42	3mm/#6/0.5-0.6	20	0	9	0	11	45%
1413	8-5-91	M	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	2.51	3mm/#6/0.5-0.6	20	0	6	0	14	30%
1414	8-5-91	F	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	1.1	3mm/#6/0.5-0.6	20	0	3	0	17	15%
1415	8-5-91	F	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	1.15	3mm/#6/0.5-0.6	20	0	6	0	14	30%
1416	8-5-91	F	PP		TANGENTIAL, 3.5" BOTT, 2.5" TOP	2.32	3mm/#6/0.5-0.6	20	0	6	1	13	30%
1417	8-6-91	S	PP	3.5	TANGENTIAL, 2.75" BAFFLE	5.08	3mm/#6/0.5-0.6	20	0	19	0	1	95%
1418	8-6-91	S	PP	3.5	TANGENTIAL, 2.75" BAFFLE	4.51	3mm/#6/0.5-0.6	20	0	14	0	6	70%
1419	8-6-91	S	PP	3.5	TANGENTIAL, 2.75" BAFFLE	4.48	3mm/#6/0.5-0.6	20	0	9	0	11	45%
1420	8-6-91	M	PP	3.5	TANGENTIAL, 2.75" BAFFLE	2.36	3mm/#6/0.5-0.6	20	0	7	0	13	35%
1421	8-6-91	F	PP	3.5	TANGENTIAL, 2.75" BAFFLE	1.54	3mm/#6/0.5-0.6	20	0	1	0	19	5%
1422	8-6-91	S	PP		TANGENTIAL, 2.5" BOTT, 3.5" TOP	4.47	3mm/#6/0.5-0.6	20	0	7	1	12	35%
1423	8-6-91	M	PP		TANGENTIAL, 2.5" BOTT, 3.5" TOP	2.37	3mm/#6/0.5-0.6	20	0	3	3	14	15%

CONICAL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1574	8-16-91	S	PP	CONE 1, UPPER INLET		3mm/#6/0.5-0.6	20	0	17	1	1	89%		
1575	8-16-91	S	PP	CONE 1, UPPER INLET	4.11	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1576	8-16-91	S	PP	CONE 1, UPPER INLET	4.17	3mm/#6/0.5-0.6	20	0	5	0	15	25%	75%	29.9%
1577	8-16-91	S	PP	CONE 1, UPPER INLET	4.01	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1578	8-16-91	S	PP	CONE 1, UPPER INLET	4.36	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1579	8-16-91	M	PP	CONE 1, UPPER INLET	2.04	3mm/#6/0.5-0.6	20	0	17	2	1	85%		
1580	8-16-91	M	PP	CONE 1, UPPER INLET	1.86	3mm/#6/0.5-0.6	20	0	12	0	8	60%		
1581	8-16-91	M	PP	CONE 1, UPPER INLET	1.92	3mm/#6/0.5-0.6	20	0	17	0	3	85%	80%	11.7%
1582	8-16-91	M	PP	CONE 1, UPPER INLET	1.83	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1583	8-16-91	M	PP	CONE 1, UPPER INLET	1.97	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1584	8-16-91	F	PP	CONE 1, UPPER INLET	1.4	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1585	8-16-91	F	PP	CONE 1, UPPER INLET	1.78	3mm/#6/0.5-0.6	20	0	14	0	6	70%		
1586	8-16-91	F	PP	CONE 1, UPPER INLET	1.47	3mm/#6/0.5-0.6	20	0	16	0	4	80%	77%	8.4%
1587	8-16-91	F	PP	CONE 1, UPPER INLET	1.59	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1588	8-16-91	F	PP	CONE 1, UPPER INLET	1.44	3mm/#6/0.5-0.6	20	0	15	1	4	75%		
1589	8-16-91	S	PP	CONE 1, LOWER INLET	4.01	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1590	8-16-91	S	PP	CONE 1, LOWER INLET	3.99	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1591	8-16-91	S	PP	CONE 1, LOWER INLET	2.86	3mm/#6/0.5-0.6	20	0	12	0	8	60%	82%	14.4%
1592	8-16-91	S	PP	CONE 1, LOWER INLET	3.01	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1593	8-16-91	S	PP	CONE 1, LOWER INLET	3.93	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1594	8-16-91	M	PP	CONE 1, LOWER INLET	1.64	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1595	8-16-91	M	PP	CONE 1, LOWER INLET	1.6	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1596	8-16-91	M	PP	CONE 1, LOWER INLET	1.66	3mm/#6/0.5-0.6	20	0	15	1	4	75%	86%	8.9%
1597	8-16-91	M	PP	CONE 1, LOWER INLET	1.57	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1598	8-16-91	M	PP	CONE 1, LOWER INLET	1.64	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1599	8-16-91	F	PP	CONE 1, LOWER INLET	1.2	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1600	8-16-91	F	PP	CONE 1, LOWER INLET	1.18	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1601	8-16-91	F	PP	CONE 1, LOWER INLET	1.23	3mm/#6/0.5-0.6	20	0	13	0	7	65%	75%	7.9%
1602	8-16-91	F	PP	CONE 1, LOWER INLET	1.18	3mm/#6/0.5-0.6	20	0	16	1	3	80%		
1603	8-16-91	F	PP	CONE 1, LOWER INLET	1.2	3mm/#6/0.5-0.6	20	0	14	0	6	70%		

CONICAL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1614	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC	4.99	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1615	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC	5.02	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1616	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC	4.89	3mm/#6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1617	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC	4.92	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1618	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC	5.16	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1619	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC	1.89	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1620	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC	3.24	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1621	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC	2.04	3mm/#6/0.5-0.6	20	0	20	0	0	100%	92%	9.1%
1622	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC	2.22	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1623	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC	1.92	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1624	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC	1.63	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1625	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC	1.96	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1626	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC	1.68	3mm/#6/0.5-0.6	20	0	18	0	2	90%	84%	8.2%
1627	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC	1.93	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1628	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC	1.8	3mm/#6/0.5-0.6	20	0	15	0	5	75%		
1629	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	5.4	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1630	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	5.27	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1631	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	5.08	3mm/#6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1632	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	5.19	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1633	8-19-91	S	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	5	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1634	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.58	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1635	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.38	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1636	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.65	3mm/#6/0.5-0.6	20	0	20	0	0	100%	97%	2.7%
1637	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	3.18	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1638	8-19-91	M	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.62	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1639	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.04	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1640	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.11	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1641	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.19	3mm/#6/0.5-0.6	20	0	20	0	0	100%	97%	4.5%
1642	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.16	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1643	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, OVERFLOW OC (tan)	2.09	3mm/#6/0.5-0.6	20	0	18	0	2	90%		

CONICAL SWIRL CHAMBER RUNS

RUN	DATE	PR RT	INC INT	SETUP	FILL	INCLUSION DATA SIZE/REF #/S.G.	DROP	A	B	C	D	CHAM EFF	AVE EFF	STND DEV
1644	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	5.01	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1645	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	4.98	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1646	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	4.97	3mm/#6/0.5-0.6	20	0	20	0	0	100%	100%	0.0%
1647	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	4.9	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1648	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	4.89	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1649	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.49	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1650	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.51	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1651	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.43	3mm/#6/0.5-0.6	20	0	20	0	0	100%	99%	2.2%
1652	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.6	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1653	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	3.46	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1654	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.16	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1655	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.28	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1656	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.15	3mm/#6/0.5-0.6	20	0	17	0	3	85%	96%	6.5%
1657	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.13	3mm/#6/0.5-0.6	20	0	20	0	0	100%		
1658	8-19-91	F	PP	CONE 1, LOWER INLET, 50% IC, SIDEFLOW OC (rad)	2.11	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1790	8-30-91	S	PP	CONE 2, RADIAL OUTLET	4.08	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1791	8-30-91	S	PP	CONE 2, RADIAL OUTLET	3.94	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1792	8-30-91	S	PP	CONE 2, RADIAL OUTLET	2.94	3mm/#6/0.5-0.6	20	0	16	0	4	80%	88%	7.6%
1793	8-30-91	S	PP	CONE 2, RADIAL OUTLET	4.06	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1794	8-30-91	S	PP	CONE 2, RADIAL OUTLET	3.5	3mm/#6/0.5-0.6	20	0	16	0	4	80%		
1795	8-30-91	M	PP	CONE 2, RADIAL OUTLET	1.7	3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1796	8-30-91	M	PP	CONE 2, RADIAL OUTLET	1.63	3mm/#6/0.5-0.6	20	0	17	0	3	85%		
1797	8-30-91	M	PP	CONE 2, RADIAL OUTLET	1.66	3mm/#6/0.5-0.6	20	0	19	0	1	95%	87%	10.4%
1798	8-30-91	M	PP	CONE 2, RADIAL OUTLET	1.68	3mm/#6/0.5-0.6	20	0	14	1	5	70%		
1799	8-30-91	M	PP	CONE 2, RADIAL OUTLET	1.65	3mm/#6/0.5-0.6	20	0	18	0	2	90%		
1800	8-30-91	F	PP	CONE 2, RADIAL OUTLET	1.31	3mm/#6/0.5-0.6	19	0	17	1	1	89%		
1801	8-30-91	F	PP	CONE 2, RADIAL OUTLET	1.32	3mm/#6/0.5-0.6	21	0	15	0	6	71%		
1802	8-30-91	F	PP	CONE 2, RADIAL OUTLET	1.48	3mm/#6/0.5-0.6	20	0	18	0	2	90%	85%	9.4%
1803	8-30-91	F	PP	CONE 2, RADIAL OUTLET		3mm/#6/0.5-0.6	20	0	19	0	1	95%		
1804	8-30-91	F	PP	CONE 2, RADIAL OUTLET	1.55	3mm/#6/0.5-0.6	20	0	16	0	4	80%		

			fill	ave			part cavity					ave.	stnd
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic	dev
2200	radial, plain	S			3	16	1				94%		
2201		S	18.00		7	8	2	1	2		62%		
2202		S	19	18.5		16	1	1	1	1	80%	79%	11.9%
2203		S			2	15	1	2			83%		
2204		S			1	14	3	2			74%		
2205		M				4	3	7	1	5	20%		
2206		M				5	4	3	6	2	25%		
2207		M	9	10.5		8	1	3	4	4	40%	28%	8.9%
2208		M	12			7	1	5	4	3	35%		
2209		M				4	3	6	5	2	20%		
2210		F				6	3	5	4	2	30%		
2211		F				3	2	3	6	6	15%		
2212		F	2.25	2.2		9	1	2	5	3	45%	33%	11.0%
2213		F	2.13			7	4	3	4	2	35%		
2214		F				8	2	4	4	2	40%		
2215	radial, plain	S			2	13	3	2			72%		
2216	50% IC	S	30		6	11	3				79%		
2217		S	32	31.0	4	12	2	2			75%	83%	10.4%
2218		S			4	15	1				94%		
2219		S			2	17	1				94%		
2220		M				10	4	3	2	1	50%		
2221		M				11	6	3			55%		
2222		M	13	12.0		6	8	2	4		30%	53%	16.7%
2223		M	11			14	3	1	1	1	70%		
2224		M				12	3	4	1		60%		
2225		F	2.66			10	6	3	1		50%		
2226		F	3.19			11	3	2	4		55%		
2227		F	2.31	2.7	1	9	3	2	3	2	47%	43%	11.8%
2228		F				6	4	4	3	3	30%		
2229		F				7	3	3	6	1	35%		
2230	radial, well	S			15	5					100%		
2231		S	26			15	3	1	1		75%		
2232		S	25	25.5		13	3	1	2	1	65%	63%	21.6%
2233		S				10	5	3	2		50%		
2234		S			1	9	1	3	4	1	50%		
2235		M				10	2	4	3	1	50%		
2236		M	10.36			11	4	3	2		55%		
2237		M	12	11.2	1	8	4	2	3	2	42%	55%	8.9%
2238		M				9	1	3	1	5	47%		
2239		M				16	2	2			80%		
2240		F				13	2	3	2		65%		
2241		F				13	3	3	1		65%		
2242		F	1.8	1.8		10	4	1	5		50%	59%	6.8%
2243		F	1.73			11	1	2	6		55%		
2244		F				12	1	5	2		60%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2245	radial, well	S	25		7	12	1				92%		
2246	50% IC	S	26		1	19					100%		
2247		S	18	23.8		17	3				85%	90%	9.7%
2248		S	29		1	15	4				79%		
2249		S	21			19	1				95%		
2250		M	10			18	2				90%		
2251		M	12			19	1				95%		
2252		M	12	10.6		20					100%	88%	9.0%
2253		M	10			16	4				80%		
2254		M	9			15	3	2			75%		
2255		F	5			17	1	1	1		85%		
2256		F	4			17	2	1			85%		
2257		F	4	4.2		17	1	1	1		85%	88%	2.9%
2258		F	4			18	2				90%		
2259		F	4			17	1				94%		
2260	radial, well	S	16.07			16	1	2			84%		
2261	50% IC, insert #1	S	15.5			15	3	1	1		75%		
2262		S	16.58	15.9		16					100%	81%	10.1%
2263		S			1	16	1	3			80%		
2264		S	15.64			14	4	2			70%		
2265		M	8.32			18	1				95%		
2266		M	8.2			17	1				94%		
2267		M	6	7.5		18	1				95%	93%	2.3%
2268		M	7			19	1				95%		
2269		M	8			17	1	2			85%		
2270		F	3.5			11	1	4	2	2	55%		
2271		F	3.6			18	1	1			90%		
2272		F	3.4	3.4		14	2	2	1	1	70%	77%	18.4%
2273		F	3.09			19	1				95%		
2274		F	3.3			15	2	1	1	1	75%		
2275	radial, well	S	14			9	3	3	3	2	45%		
2276	insert #1	S	11.9		1	11	1	2	2	3	58%		
2277		S	11.4	12.1		11	3	3	3		55%	45%	8.4%
2278		S	11			10	1	2	3	5	48%		
2279		S	12.2			4	3	4	4	5	20%		
2280		M	6.41			7	1	2	4	6	35%		
2281		M	6.83		1	13		1	2	3	68%		
2282		M	6.53	6.6		3		5	6	6	15%	46%	24.0%
2283		M	6.62			13	1	1	2	3	65%		
2284		M	6.58			10		3	4	4	48%		
2285		F	1.82			12		1	2	5	60%		
2286		F	1.91			7		1	4	8	35%		
2287		F	2.08	1.9		9		1	1	9	45%	52%	10.8%
2288		F	1.78		1	11	1	1	1	5	58%		
2289		F	1.87			12		1	3	4	60%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2290	radial, well	S	12.8			19	1				95%		
2291	50% IC	S	14.66			17	1	1			89%		
2292	overflow outlet chokes	S	13.61	14.2		20					100%	93%	4.3%
2293		S	14.35			19	1				95%		
2294		S	15.8			17	3				85%		
2295		M	5.56			17	1	1	1		85%		
2296		M	5.64		1	19					100%		
2297		M	5.49	5.6		19	1				95%	96%	6.5%
2298		M	5.56			20					100%		
2299		M	5.59			20					100%		
2300		F	2.83			13	1	1	1	4	65%		
2301		F	2.89			9	1	1	4	5	45%		
2302		F	3.03	2.7		16	1	3			80%	63%	13.4%
2303		F	2.99			14	3	3			70%		
2304		F	1.62			11		1	3	5	55%		
2305	radial, well	S	14.5			19	1				95%		
2306	50% IC, insert #1	S	12.14			18	1	1			90%		
2307	overflow outlet chokes	S	10.46	12.0		18	1	1			90%	91%	3.5%
2308		S	9.45			19	1				95%		
2309		S	13.56			17	1	2			85%		
2310		M	4.89			20					100%		
2311		M	4.82			18	1	1			90%		
2312		M	5.13	5.1		18	1	1			90%	89%	11.3%
2313		M	5.16			15		1	2	2	75%		
2314		M	5.29			18	1	1			90%		
2315		F	2.96			16		2	2		80%		
2316		F	2.69			14	1	2	1	2	70%		
2317		F	2.77	2.8		17	1	1	1		85%	77%	5.7%
2318		F	2.59			15	1	1	2	1	75%		
2319		F	2.93			15		1	2	2	75%		
2320	radial, plain	S	9.1		1	15	2			2	79%		
2321	50% IC, insert #1	S	9.23			16	1		1	2	80%		
2322	overflow outlet chokes	S	9	8.7		16	2		2		80%	71%	10.8%
2323		S	7.96			12	5	1	2		60%		
2324		S	8			11	3		5	1	55%		
2325		M	4.6			10	5	1	4		50%		
2326		M	4.7			9	1	4	6		45%		
2327		M	5.5	5.0		12		3	2	3	60%	53%	5.9%
2328		M	5.2			10	2	3	2	3	50%		
2329		M	5.2			12	3	1	3	1	60%		
2330		F	2.2			4	5	2	4	5	20%		
2331		F	2.5			9	4	2	1	3	47%		
2332		F	2.3	2.2		10		5	2	3	50%	40%	13.6%
2333		F	2			10	1	1	2	6	50%		
2334		F	1.9			7	2	5		6	35%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2335	radial, plain	S	7.96		3	12		2	2	1	71%		
2336	50% IC, insert #1	S	10.36			11	1	1	1	6	55%		
2337		S	10.38	9.6		13	1		4	2	65%	57%	9.9%
2338		S	9.92			10	6	1	3	1	48%		
2339		S	9.3			10	4	2	0	4	50%		
2340		M	4.49			13		3	2	2	65%		
2341		M	4.87			9	5	2	1	3	45%		
2342		M	4.09	4.5		15	1		3	1	75%	57%	13.0%
2343		M	4.69			9	3	1	4	3	45%		
2344		M	4.19			11	2	1	4	2	55%		
2345		F	2.14			8	4	4	2	2	40%		
2346		F	2.05			9	2	3	3	3	45%		
2347		F	2.05	2.1		7	3	3	2	5	35%	38%	8.4%
2348		F	2.28			9	3	2	3	3	45%		
2349		F	2.1			5	1	3	7	4	25%		
2350	radial, cap	S	14.5		1	8	5	2	4		42%		
2351	50% IC, insert #2	S	18.38			14	2		2	2	70%		
2352		S	17.32	16.13		14	3		2	1	70%	56%	16.1%
2353		S	14			7	4	1	5	3	35%		
2354		S	16.45			12	3	2	1	2	60%		
2355		M	5.17			10	1	2	5	2	50%		
2356		M	6.72			10	2	2	4	2	50%		
2357		M	5.5	5.93		9	1	1	5	4	45%	49%	4.2%
2358		M	6.38			11	3	2	2	2	55%		
2359		M	5.88			9	2	3	5	1	45%		
2360		F	2.95			10	4	3	1	2	50%		
2361		F	2.81			10	1		3	6	50%		
2362		F	2.72	2.774		6	1	2	1	10	30%	41%	12.4%
2363		F	2.69			5	4	3	5	3	25%		
2364		F	2.7			10	5	1	1	3	50%		
2365	radial, well	S	11.22			18			1	1	90%		
2366	50% IC, insert #2	S	11.61			17	2		1		85%		
2367		S	12.34	11.91		15	3	1	1		75%	83%	5.7%
2368		S	12.2			17	2	1			85%		
2369		S	12.2			16	1	1	2		80%		
2370		M	6.05			19	1				95%		
2371		M	5.93			16	2		1		84%		
2372		M	5.89	5.78		19			1		95%	91%	4.5%
2373		M	5.61			18			1	1	90%		
2374		M	5.42			18		1	1		90%		
2375		F	2.92			17	1		2		85%		
2376		F	2.78			14	2	1	1	1	74%		
2377		F	2.9	2.838		13	1		1	5	65%	73%	8.3%
2378		F	2.86			13	1		4	2	65%		
2379		F	2.73			15	2		2	1	75%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2380	tangential, well	S	14.13		1	16			3		84%		
2381	50% IC	S	14.5			20					100%		
2382		S	12.71	13.83		18		1		1	90%	89%	9.7%
2383		S	13.05			15	1	1	1	2	75%		
2384		S	14.77			19				1	95%		
2385		M	5.44			18			1	1	90%		
2386		M	6.22			17	1		1	1	85%		
2387		M	5.69	5.806		19	1				95%	90%	5.0%
2388		M	6.1			17	1		2		85%		
2389		M	5.58			19			1		95%		
2390		F	2.87			13	6		1		65%		
2391		F	3.19			11	3	1	4	1	55%		
2392		F	2.75	2.96		12		3	5		60%	58%	8.4%
2393		F	2.93			9	3	1	7		45%		
2394		F	3.06			13	2	1	2	2	65%		
2395	tangential, well	S	13.62			11		2	5	2	55%		
2396	50% IC, insert #2	S	12.4			11	2	3	3	1	55%		
2397		S	13.29	13.41		12	5	2	1		60%	60%	8.7%
2398		S	13.8			11	1	3	3	2	55%		
2399		S	13.92			15		5			75%		
2400		M	6.58			11	1	4	3	1	55%		
2401		M	7.9			13	3	1	2	1	65%		
2402		M	7.75	6.772		9		3	5	3	45%	63%	13.0%
2403		M	6.06			15	1			4	75%		
2404		M	5.57			15	4			1	75%		
2405		F	2.66			12	3		3	2	60%		
2406		F	2.95			10	3	1	5	1	50%		
2407		F	2.67	2.786		10	5	1	3	1	50%	56%	6.5%
2408		F	2.64			13	4		3		65%		
2409		F	3.01			11	4	1	4		55%		
2410	tangential, well	S	11.45			14	1	1	2	2	70%		
2411	50% IC, insert #2	S	12.36			14	1	2	2	1	70%		
2412	overflow outlet chokes	S	13.74	12.27		14	4	1	1		70%	69%	2.2%
2413		S	12.5			14	2		2	2	70%		
2414		S	11.3			13	2		4	1	65%		
2415		M	5.66			16		3	1		80%		
2416		M	6.43			14	2	2	1	1	70%		
2417		M	5.43	6.024		15	1	2	1	1	75%	72%	10.4%
2418		M	6.23			11	1	4	4		55%		
2419		M	6.37			16			4		80%		
2420		F	2.94			13	1	2	3	1	65%		
2421		F	2.85			13	3	1	3		65%		
2422		F	2.84	2.862		15	3		2		75%	64%	7.4%
2423		F	2.77			11	4	1	4		55%		
2424		F	2.91			12	3	3	2		60%		

			fill	ave			part cavity					ave.
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic
2425	tangential, well	S	11.48			19			1		95%	
2426	50% IC	S	13.41			19			1		95%	
2427	overflow outlet chokes	S	9.49	12.1		19			1		95%	94%
2428		S	13.34			19				1	95%	
2429		S	12.78			18	1		1		90%	
2430		M	5.63			20					100%	
2431		M	5.86			19			1		95%	
2432		M	6.89	5.96		19		1			95%	94%
2433		M	5.5			18			2		90%	
2434		M	5.92			18	1	1			90%	
2435		F	2.63			10	6	1	3		50%	
2436		F	2.69			15	3		1	1	75%	
2437		F	2.65	2.704		17	1		2		85%	71%
2438		F	2.69			13		1	6		65%	
2439		F	2.86			16	2	2			80%	
2440	tangential, plain	S	8.39			10	2		4	4	50%	
2441	50% IC	S	11			9	1	3	3	4	45%	
2442	overflow outlet chokes	S	8.98	10.42		9	2	1	5	3	45%	43%
2443		S	10.12			10	3	1	3	3	50%	
2444		S	13.63			5	4	3	4	4	25%	
2445		M	4.47			3	6	3	5	3	15%	
2446		M	4.77			2	7	5	4	2	10%	
2447		M	4.86	4.83		4	3	5	7	1	20%	15%
2448		M	5.49			2	8	5	4	1	10%	
2449		M	4.56		1	4	5	5	2	3	21%	
2450		F	2.51			2	3	9	3	3	10%	
2451		F	2.48			3	3	4	3	7	15%	
2452		F	2.33	2.43		0	4	9	3	4	0%	11%
2453		F	2.37			4	4	5	3	4	20%	
2454		F	2.46			2	5	6	5	2	10%	
2455	tangential, plain	S	9.41			13	2	1	2	2	65%	
2456	50% IC, insert #1	S	10.17			16	1		2	1	80%	
2457	overflow outlet chokes	S	9.58	10.18		13	1	3	2	1	65%	66%
2458		S	11.59			12	2	1	2	3	60%	
2459		S	10.17			12	1		4	3	60%	
2460		M				6	3	4	3	4	30%	
2461		M	4.62			4	5	2	5	4	20%	
2462		M	3.92	4.05		4	4	5	4	3	20%	25%
2463		M	3.96			6	4	2	5	3	30%	
2464		M	3.7			5	4	3	6	2	25%	
2465		M	4.56			4	3	1	11	1	20%	
2466		F	2.48			0	6	3	4	7	0%	
2467		F	2.45	2.505		4	3	2	3	8	20%	7%
2468		F	2.53			0	6	3	1	10	0%	
2469		F	2.56			2	5	3	2	8	10%	

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2470	tangential, plain	S	9.6			13	1		3	3	65%		
2471	50% IC	S	12.7			6			10	4	30%		
2472		S	9.9	10.73		6	6	1	3	4	30%	38%	16.0%
2473		S				8	2	4	4	2	40%		
2474		S				5	4	0	8	3	25%		
2475		M	3.8			5	8	4	1	2	25%		
2476		M	3.6			7	6	6	1		35%		
2477		M	3.4	3.725		4	4	5	4	3	20%	23%	9.1%
2478		M	4.1			2	6	4	4	4	10%		
2479		M				5	6	5	2	2	25%		
2480		F	1.9			1	6	3	7	3	5%		
2481		F	2			4	8	1	2	5	20%		
2482		F	2	1.925		1	3	7	5	4	5%	10%	6.1%
2483		F	1.8			2	3	5	3	7	10%		
2484		F				2	4	4	1	9	10%		
2485	anti-tangential, plain	S	10.09			16	1			3	80%		
2486	50% IC	S	12.31			12			2	6	60%		
2487		S	11.51	11.2		17	3				85%	70%	11.5%
2488		S	10.9			11	1	2	2	2	61%		
2489		S				13	2	3		2	65%		
2490		M	5.94			12	1	1	4	2	60%		
2491		M	5.17			17	2		1		85%		
2492		M	3.48	4.808		9	6	3	2		45%	64%	16.0%
2493		M	4.95			11	5	2	2		55%		
2494		M	4.5			15	4	1			75%		
2495		F	2.63			11	1	3	3	2	55%		
2496		F	2.58			10	3	3	3	2	48%		
2497		F	2.28	2.476		8	4	1	4	3	40%	45%	12.6%
2498		F	2.55			5	4	4	5	2	25%		
2499		F	2.34			11	3	1	1	4	55%		
2500	anti-tangential, well	S	13.86			19			1		95%		
2501	50% IC	S	11.35			19	1				95%		
2502		S	10.97	12.18		18	1		1		90%	94%	4.2%
2503		S	13.59			18	2				90%		
2504		S	11.14			20					100%		
2505		M	5.01		1	19					100%		
2506		M	5.59			19				1	95%		
2507		M	4.81	5.032		20					100%	99%	2.2%
2508		M	5.15			20					100%		
2509		M	4.6			20					100%		
2510		F	3.3		1	19					100%		
2511		F	3.5			18				2	90%		
2512		F	3.56	3.48		20					100%	94%	5.5%
2513		F	3.5			18			2		90%		
2514		F	3.54			18			1	1	90%		

			fill	ave			part cavity					ave.	stnd
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic	dev
2515	anti-tangential, well	S	12.89			16	1	2	1		80%		
2516	50% IC, insert #2	S	11.87			17	1	2			85%		
2517		S	13.14	13.03		16	2			2	80%	79%	8.2%
2518		S	14.43			13	5		1	1	65%		
2519		S	12.84			17	1	2			85%		
2520		M	5.11			19				1	95%		
2521		M	5.78			19			1		95%		
2522		M	4.82	5.28		17	1		1	1	85%	88%	6.8%
2523		M	5.58		1	16	1		1	1	84%		
2524		M	5.11			16	1			3	80%		
2525		F	2.73			13	1	2	2	2	65%		
2526		F	3.1			14	1	2	1	2	70%		
2527		F	3.24	2.99		15	1		2	2	75%	79%	12.9%
2528		F	3.16			18			1	1	90%		
2529		F	2.72			19				1	95%		
2530	anti-tangential, well	S	13.2			20					100%		
2531	50% IC, insert #1	S	12.3			17	3				85%		
2532	overflow outlet chokes	S	10.3	11.57		19	1				95%	92%	5.7%
2533		S	10.5			18	1	1			90%		
2534		S				18	1	1			90%		
2535		M	5.1			17			1	2	85%		
2536		M	4.9			18	1			1	90%		
2537		M	4.8	5		19			1		95%	91%	6.5%
2538		M	5.2			17	1		1	1	85%		
2539		M				20					100%		
2540		F	3.5			18		1		1	90%		
2541		F	3.1			16	3		1		80%		
2542		F	2.8	3.15		15	1	1		3	75%	84%	6.5%
2543		F	3.2			18		1	1		90%		
2544		F				17	1			2	85%		
2545	anti-tangential, well	S	14.85			20					100%		
2546	50% IC	S	13.65			20					100%		
2547	overflow outlet chokes	S	10.67	12.49		19				1	95%	99%	2.2%
2548		S	11.23			20					100%		
2549		S	12.03			20					100%		
2550		M	5.91			20					100%		
2551		M	6.03			20					100%		
2552		M	5.67	5.936		19		1			95%	99%	2.2%
2553		M	6.06			20					100%		
2554		M	6.01			20					100%		
2555		F	3.44			15	2		3		75%		
2556		F	3			17			1	2	85%		
2557		F	2.85	3.138		17			3		85%	86%	8.9%
2558		F	3			17	2			1	85%		
2559		F	3.4			20					100%		

			fill	ave			part cavity					ave.	stnd
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic	dev
2560	anti-tangential, well	S				20					100%		
2561	50% IC, insert #2	S				19		1			95%		
2562	overflow outlet chokes	S	11.89	11.68		20					100%	96%	6.5%
2563		S	11.12			20					100%		
2564		S	12.02			17	1	1	1		85%		
2565		M	5.62			19	1				95%		
2566		M	5.25			18		1	1		90%		
2567		M	5.08	5.316		19			1		95%	95%	3.5%
2568		M	5.35			19		1			95%		
2569		M	5.28			20					100%		
2570		F	3.13			18		1		1	90%		
2571		F	3.06			18			2		90%		
2572		F	3.02	3.074		16	1		1	2	80%	89%	7.5%
2573		F	3.12			16	1			2	84%		
2574		F	3.04			20					100%		
2575	anti-tangential, plain	S	9			13	4	1	2		65%		
2576	50% IC	S	9.2			13	1	2	4		65%		
2577	overflow outlet chokes	S	10.4	9.84		20					100%	81%	16.4%
2578		S	10.2			19				1	95%		
2579		S	10.4			16	1	1	1	1	80%		
2580		M	3.9			16		3	1		80%		
2581		M	4.3			14	2	2	1	1	70%		
2582		M	4	4.3		16	3		1		80%	76%	8.2%
2583		M	4.3			13	3	2	1	1	65%		
2584		M	5			17	1			2	85%		
2585		F	2.6			8	5	5	1	1	40%		
2586		F	2.6			8	4	4		4	40%		
2587		F	2.7	2.6		9	3	3	2	3	45%	50%	11.7%
2588		F	2.5			13	2	3	1	1	65%		
2589		F	2.6			12	5		3		60%		
2590	anti-tangential, plain	S				18		2			90%		
2591	50% IC, insert #1	S				18	1		1		90%		
2592		S				19	1				95%	90%	3.5%
2593		S				17	2		1		85%		
2594		S			1	17			1	1	89%		
2595		M				14	2	2	2		70%		
2596		M				15	2	2		1	75%		
2597		M				14		2	1	3	70%	69%	5.5%
2598		M				14	3		2	1	70%		
2599		M				12	3	3	2		60%		
2600		F				11	3	3	2	1	55%		
2601		F				11	1	4	2	2	55%		
2602		F				10	1	4	2	3	50%	51%	12.9%
2603		F				6	3	6	1	4	30%		
2604		F				13	1	3	1	2	65%		

run	setup	pour	fill time	ave fill	ds chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2605	radial, well	S			20					100%		
2606	50% IC	S			20					100%		
2607		S	10.27	10.69	19			1		95%	98%	2.7%
2608	top outer cone	S	10.06		19			1		95%		
2609		S	11.74		20					100%		
2610		M	5.87		19			1		95%		
2611		M	5.95		20					100%		
2612		M	5.29	5.812	20					100%	96%	4.2%
2613		M	6.55		19			1		95%		
2614		M	5.4		18			2		90%		
2615		F	3.37		20					100%		
2616		F	3.38		20					100%		
2617		F	3.48	3.434	20					100%	100%	0.0%
2618		F	3.27		20					100%		
2619		F	3.67		20					100%		
2620	radial, well	S			9		2	6	2	47%		
2621	50% IC, insert #2	S			12	1	2	4	1	60%		
2622		S			11	2	2	5		55%	53%	6.2%
2623	internal cone	S			9	4	3	3	1	45%		
2624		S			11	2	2	3	2	55%		
2625		M			11	4	1	2	2	55%		
2626		M			9	6	2		3	45%		
2627		M			9	5	2	1	3	45%	52%	6.7%
2628		M			12	4	2		2	60%		
2629		M			11	4	2	2	1	55%		
2630		F			15	1	1	1	2	75%		
2631		F			14	3	1		2	70%		
2632		F			11	2	4	1	2	55%	61%	10.8%
2633		F			11	8			1	55%		
2634		F			10	3	2	3	2	50%		
2635	radial, plain	S			3	4	3	8	2	15%		
2636	50% IC	S			8	2	4	5	1	40%		
2637		S			5	5	4	4	1	26%	24%	9.7%
2638	internal cone	S			4	4	2	7	3	20%		
2639		S			4	4	5	5	2	20%		
2640		M			6	3	9	1	1	30%		
2641		M			2	10	3	2	3	10%		
2642		M			7	3	5	2	3	35%	28%	10.4%
2643		M			6	4	8	1	1	30%		
2644		M			7	3	5	2	3	35%		
2645		F			12	1	5	1	1	60%		
2646		F			8	2	4	3	3	40%		
2647		F			8	7	5			40%	48%	8.6%
2648		F			10	1	1	4	3	53%		
2649		F			10	4	3	2	1	50%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2650	radial, well	S	8.54			7	1	4		8	35%		
2651	50% IC	S	12.64			5		5		10	25%		
2652		S	8.08	9.446		8	2	4	3	3	40%	33%	7.6%
2653	full inner cone	S	10.49			5	1	3	2	9	25%		
2654		S	7.48			8	3	4	1	4	40%		
2655		M	4.23		1	10	1	4	3	1	53%		
2656		M	4.96		1	14		2	2	1	74%		
2657		M	4.45	4.642		10	1	4	3	2	50%	62%	11.8%
2658		M	4.9		1	11	1	1	2	4	58%		
2659		M	4.67			15	1		3	1	75%		
2660		F	2.47			12	4	2	2		60%		
2661		F	2.31			10	4	3	3		50%		
2662		F	2.55	2.428		10	4	2	2	2	50%	56%	8.9%
2663		F	2.41			14		2	3	1	70%		
2664		F	2.4			10	3	2	2	3	50%		
2665	radial, well	S	8.86		1	13		1	2	3	68%		
2666	50% IC	S	7.76			15		1	2	2	75%		
2667	overflow outlet chokes	S	8.66	8.646		14	2	1	1	2	70%	72%	5.9%
2668	full inner cone	S	8.46			16	1	1	1	1	80%		
2669		S	9.49			13	2	2	1	2	65%		
2670		M	4.69			15		2	2	1	75%		
2671		M	4.15			17	1	1	1		85%		
2672		M	3.96	4.236	1	13		2	2	2	68%	76%	5.9%
2673		M	4.23			15	2		1	2	75%		
2674		M	4.15			15			4	1	75%		
2675		F	2.37			11	2	3	2	2	55%		
2676		F	2.36			12	1	2	2	3	60%		
2677		F	2.74	2.508		12	2	2	3	1	60%	59%	4.2%
2678		F	2.49			11	2	2	1	4	55%		
2679		F	2.58			13	3	2	1	1	65%		
2680	radial, extension	S				20					100%		
2681	50% IC	S	19.3			19			1		95%		
2682		S	17.4	18.22		18				1	95%	92%	8.0%
2683	full inner cone	S	19.26			18		1	1		90%		
2684		S	16.9		1	15	2	2			79%		
2685		M	11.46			18	1	1			90%		
2686		M	11.14			20					100%		
2687		M	10.11	10.43		13	1	3	3		65%	86%	12.9%
2688		M	9.65			18	1	1			90%		
2689		M	9.79			17	1		1	1	85%		
2690		F	4.37			18		1		1	90%		
2691		F	4			12	2	2		4	60%		
2692		F	4.1	4.206		8	5	5		2	40%	67%	24.4%
2693		F	4.44			19	1				95%		
2694		F	4.12			10	2	5	1	2	50%		

			fill	ave			part cavity					ave.	stnd
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic	dev
2695	radial, extension	S	18.36			19		1			95%		
2696	50% IC	S	17.68			16	1	3			80%		
2697	overflow outlet choke	S	15.89	16.8		17		1	1	1	85%	83%	11.5%
2698	full inner cone	S	15.89			18		1	1		90%		
2699		S	16.19			13		4		3	65%		
2700		M	8.43			17			2	1	85%		
2701		M	11.58			14	2	3	1		70%		
2702		M	8.97	10.07	1	13	3	1		2	68%	80%	11.0%
2703		M	9.96			16	2		1	1	80%		
2704		M	11.42			19		1			95%		
2705		F	3.86			12	4	3		1	60%		
2706		F	3.67			11	1	5		3	55%		
2707		F		3.923		12	2	4	1	1	60%	64%	11.9%
2708		F	4.11			17	1	1		1	85%		
2709		F	4.05			12	3	3	2		60%		
2710	radial, extension	S	15.69			20					100%		
2711	50% IC	S	15.4			19	1				95%		
2712		S	16.53	15.8		20					100%	99%	2.2%
2713		S	15.11			20					100%		
2714		S	16.28			20					100%		
2715		M	9.48			17	2		1		85%		
2716		M	10.89		1	18	1				95%		
2717		M	8.2	9.586		20					100%	94%	5.5%
2718		M	7.86			19	1				95%		
2719		M	11.5			19	1				95%		
2720		F	3.12			13		3	2	2	65%		
2721		F	3.78			15	2	1	1	1	75%		
2722		F	3.19	3.368		13		4		3	65%	63%	9.1%
2723		F	3.64			10	2	2	1	5	50%		
2724		F	3.11			12	4	1	1	2	60%		
2725	radial, extension	S	15			20					100%		
2726	50% IC	S	13.68			20					100%		
2727	overflow outlet choke	S	14.82	14.6		20					100%	100%	0.0%
2728		S	14.05			20					100%		
2729		S	15.45			20					100%		
2730		M	9.17			20					100%		
2731		M	8.72			20					100%		
2732		M	10.02	8.768		20					100%	100%	0.0%
2733		M	7			20					100%		
2734		M	8.93			20					100%		
2735		F	3.15			12	3	2	2	1	60%		
2736		F	3.03			5	4	4	4	3	25%		
2737		F	3.06	3.136		13	4	1	1	1	65%	58%	18.8%
2738		F	3.32			16	1		4	1	73%		
2739		F	3.12			13	2	2	2	1	65%		

run	setup	pour	fill time	ave fill	ds chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2740	radial, extension	S	15.59		20					100%		
2741	50% IC	S	17.42		15		4		1	75%		
2742	overflow outlet choke	S	16.27	16.37	17	1	1		1	85%	82%	11.0%
2743	top inner cone	S	16.67		15	1		2	2	75%		
2744		S	15.89		15		4		1	75%		
2745		M	10.85		17	1	2			85%		
2746		M	11.11		14	3	2		1	70%		
2747		M	13.94	11.2	19	1				95%	81%	9.6%
2748		M	9.01		16	1	1		2	80%		
2749		M	11.1		15	4	1			75%		
2750		F	5.68		14	1	2	3		70%		
2751		F	3.6		16		2	1	1	80%		
2752		F	3.74	3.99	17		1	1	1	85%	73%	9.1%
2753		F	3.42		13	4	2		1	65%		
2754		F	3.51		13	3	1	1	2	65%		
2755	radial, extension	S	16.07		17		2		1	85%		
2756	50% IC	S	17.72		15		4		1	75%		
2757		S	16.08	16.94	17		1		2	85%	82%	4.5%
2758	top inner cone	S	16.64		17		1		2	85%		
2759		S	18.18		16		1		3	80%		
2760		M	7.7		19		1			95%		
2761		M	9.63		19			1		95%		
2762		M	8.51	8.734	19		1			95%	94%	2.2%
2763		M	8.72		18		2			90%		
2764		M	9.11		19				1	95%		
2765		F	3.47		14	1	2	2	1	70%		
2766		F	3.74		13	2	2	3		65%		
2767		F	3.51	3.64	16	1	2		1	80%	77%	9.7%
2768		F	3.97		18		1	1		90%		
2769		F	3.51		16	1	2		1	80%		
2770	radial, extension	S	13.65		20					100%		
2771	50% IC, insert #2	S	12.69		20					100%		
2772		S	16.38	14.91	20					100%	100%	0.0%
2773		S	15.28		20					100%		
2774		S	16.57		20					100%		
2775		M	7.27		18	2				90%		
2776		M	8.22		19	1				95%		
2777		M	7.66	7.56	19	1				95%	90%	8.7%
2778		M	6.51		15	3			2	75%		
2779		M	8.14		19	1				95%		
2780		F	3.14		13	2	1	3	1	65%		
2781		F	3.08		10	3	1	4	2	50%		
2782		F	2.76	2.93	9	1	6	2	2	45%	51%	9.6%
2783		F	2.91		8	4	5	2	1	40%		
2784		F	2.76		11	4	2	3		55%		

run	setup	pour	fill time	ave fill	ds	chm	part cavity 1	2	3	4	effic	ave. effic	stnd dev
2785	radial, extension	S	14.26			20					100%		
2786	50% IC, insert #2	S	14.36			20					100%		
2787	overflow outlet choke	S	13.81	14.98		20					100%	99%	2.4%
2788		S	15.7			20					100%		
2789		S	16.75		1	18				1	95%		
2790		M	8.68			20					100%		
2791		M	8.18			19	1				95%		
2792		M	7.46	8.072		20					100%	99%	2.2%
2793		M	8.31			20					100%		
2794		M	7.73			20					100%		
2795		F	2.93			14	1	1	2	2	70%		
2796		F	3.01			11	4	1	4		55%		
2797		F	2.85	2.946		9	4	3	2	2	45%	59%	10.8%
2798		F	3.05			14	2	2	1	1	70%		
2799		F	2.89			11	5		4		55%		
2800	radial, well	S				18	2				90%		
2801	50% IC	S				20					100%	95%	7.1%
2802		S		late		10	5	1	3	1	50%		
2803	top outer cone	S		late	3	12	3	1	1		71%	61%	10.7%
2804	(same as 2605-2619	S		late		13	2	2	2	1	65%		
2805	but with some later	M				20					100%		
2806	inclusions)	M				20					100%	100%	0.0%
2807		M		late	2	12	2	1	3		67%		
2808		M		late		17	2		1		85%	74%	10.1%
2809		M		late	1	13	2		4		68%		
2810		F				20					100%		
2811		F				20					100%	100%	0.0%
2812		F		late	8	11	1				92%		
2813		F		late		7	6		3	4	35%	62%	29.0%
2814		F		late		14	1	1	4		70%		
2815	radial, well	S			6	13				1	93%		
2816	50% IC	S			2	18					100%		
2817	(same as 2245-2259 but	S			1	19					100%	97%	3.5%
2818	late inclusions)	S			3	16		1			94%		
2819		S			2	17			1		94%		
2820		M				20					100%		
2821		M				15	1	3	1		75%		
2822		M			2	18					100%	93%	10.4%
2823		M				19		1			95%		
2824		M				19			1		95%		
2825		F				18		1		1	90%		
2826		F				19	1				95%		
2827		F				20					100%	95%	3.5%
2828		F				19			1		95%		
2829		F				19				1	95%		

			fill	ave		part cavity					ave.	stnd
run	setup	pour	time	fill	ds chm	1	2	3	4	effic	effic	dev
2830	anti-tangential, well	S			15	1	1	2	1	75%		
2831	50% IC	S	13.71		12	4		3	1	60%		
2832	top outer cone	S	12.57	13.99	11	2	1	5	1	55%	64%	8.2%
2833		S	14.85		12	4		3	1	60%		
2834		S	14.81		14	3	1	1	1	70%		
2835		M	7.12		18			2		90%		
2836		M	7.51		19				1	95%		
2837		M	6.75	7.092	19			1		95%	91%	4.2%
2838		M	7.12		17	1	1	1		85%		
2839		M	6.96		18	1			1	90%		
2840		F	3.62		15	2		3		75%		
2841		F	3.72		19	1				95%		
2842		F	3.54	3.684	18				2	90%	89%	8.2%
2843		F	3.87		19			1		95%		
2844		F	3.67		18			2		90%		
2845	tangential, well	S	10.94		19		1			95%		
2846	50% IC	S	11.12		18	1		1		90%		
2847	top outer cone	S	10.85	10.99	18	1	1			90%	87%	6.7%
2848		S	11.37		16				4	80%		
2849		S	10.68		16	2	1		1	80%		
2850		M	6.31		18		1		1	90%		
2851		M	7.77		19	1				95%		
2852		M	6.98	6.95	18		2			90%	94%	4.2%
2853		M	6.92		19				1	95%		
2854		M	6.77		20					100%		
2855		F	3.75		13	1	2		4	65%		
2856		F	3.81		18				2	90%		
2857		F	5.36	4.086	16				4	80%	81%	10.2%
2858		F	3.73		18				2	90%		
2859		F	3.78		16				4	80%		
2860	radial, well	S	10.62		18			1	1	90%		
2861	50% IC, ice-cream cone	S	8.5		18	1		1		90%		
2862		S	7.24	8.88	18	1		1		90%	93%	4.5%
2863		S	7.94		19			1		95%		
2864		S	10.1		20					100%		
2865		M	5.15		20					100%		
2866		M	5.97		19			1		95%		
2867		M	5.64	5.642	17	2		1		85%	88%	9.7%
2868		M	5.76		17	1		2		85%		
2869		M	5.69		15		1	3	1	75%		
2870		F	3.5		13	2	4	1		65%		
2871		F	2.81		15	3		2		75%		
2872		F	3.08	3.156	16	1	3			80%	76%	6.5%
2873		F	3.18		16	2	1		1	80%		
2874		F	3.21		16	2	1	1		80%		

			fill	ave			part	cavity				ave.	stnd
run	setup	pour	time	fill	ds	chm	1	2	3	4	effic	effic	dev
2875	radial, well	S			2	17	1				94%		
2876	50% IC, ice-cream cone	S			4	13		1	1	1	81%		
2877	(same as 2860-2874	S			1	15	1	1		2	79%	91%	10.2%
2878	but late inclusions)	S			5	15					100%		
2879		S			1	19					100%		
2880		M			1	17			1	1	89%		
2881		M			1	16			1	2	84%		
2882		M			2	15	1			2	83%	89%	6.6%
2883		M			1	17				2	89%		
2884		M			3	17					100%		
2885		F				20					100%		
2886		F				20					100%		
2887		F				16		1	2	1	80%	94%	8.2%
2888		F				19				1	95%		
2889		F				19	1				95%		
2890	radial, well	S				20					100%		
2891	50% IC, ice-cream cone	S				20					100%	100%	0.0%
2892	(same as 2860-2874	S											
2893	but heavy inclusions)	S											
2894		S											
2895		M				19			1		95%		
2896		M				20					100%	98%	2.9%
2897		M				20					100%		
2898		M											
2899		M											
2900		F				20					100%		
2901		F				18	1		1		90%		
2902		F				19	1				95%	92%	7.5%
2903		F				16	1	2	1		80%		
2904		F			2	17	1				94%		

Appendix B: Inclusion information

INCLUSION ACQUISITION SUMMARY

Ref Number	Specific Density	Size* (mm)	Quantity	Cost	Material	Source
1	0.25	0.5-1.0 (12 mesh)	1000's 1/2 lb.	Free	Cork	Badger Cork Division Global Technology Systems 26110 110th Street P.O.Box 25 Trevor, WI 53179 Contact: Mark Beyer 414-862-2311
2	0.25	1.0-3.0 (60 mesh)	1000's 1/2 lb.	Free	Cork	same as (1) above
3	?	1.0-10.0 (slivers)	1000's	Free	Cedar chips	Prof. Larson
4	0.4/0.6**	4.9 (cubes)	50	$ 0.43	multi-color wood beads	Craft World 6th Street, Eugene
5	0.5/0.6	2.1-3.0	50	0.50	"	"
6	0.5/0.6	3	120	0.40	"	"
7	0.6/0.7	6	20	0.65	red wood beads	"
8	0.8/1.1	3	300	0.07	bright red plastic	"
9	1.0/1.1	3	300	0.07	fluorescent green plastic	"
10	1.0	4	200	0.03	faceted red plastic	"
11	1.1	5	100	0.01	solid black plastic	"

INCLUSION ACQUISITION SUMMARY CONTINUED

Ref Number	Specific Density	Size* (mm)	Quantity	Cost	Material	Source
12	1.2	1	20	0.90	pink acetate	Precision Plastic Ball Co.
						3000 N. Cicero Ave.
						Chicago, IL 60641
						312-777-6200
13	1.2	2	20	"	white acetate	"
14	1.2	3	20	"	"	"
15	1.2	5	20	"	"	"
16	2.0	3	100	1.63	white teflon	US Plastics Corp.
						1390 Neubrecht Rd.
						Lima OH 45801
						419-228-2242
17	2.2	3	3	15.00	ruby/glass	Sapphire Engineering, Inc.
						63 County Rd.
						N. Falmouth, MA 02556
						508-563-5531
						Contact: Donna Tarrant
18	2.2	3	3	15.00	"	"
19	2.2	3	3	15.00	"	"
20	2.2	3	0	0.05	clear glass	OSU Chemical Stores
					(black paint)	
21	2.2	6	3000		"	"

* Size is diameter, unless otherwise specified

** When two densities are given, this means that the bead has a hole for threading that usually retains an air bubble when submerged. The two values represent the effective density when the hole is "not filled/filled" with water.

Metal	Alloy Density, g/cm^3	Inclusion Type	Estimated Inclusion Density, g/cm^3	Relative Density [1]
Titanium	$\rho = 4.5$	Type I	9.9	2
		Type II	5.0	1
Ni-base alloys Fe-base alloys Co-base alloys	$\rho = 7.8 - 9$	Al_2O_3 (Alumina)	3.96	0.5
		$3Al_2O_3 . 2SiO_2$ (Mullite)	3.15	0.4
		SiO_2 (Silica)	2.3	0.3
		34% Cr_2O_3 47% SiO_2 17% MnO	2.85	0.3

This list is not comprehensive, but includes the more common inclusions. For titanium alloys, the inclusions usually are from the shell and take the the form of flakes or irregular particles. For the Ni-, Fe-, and Co-base alloys, predominant sources are the shell (flakes and irregular particles) and the melting crucible (irregular particles). "Dross" oxides from reactions between reactive elements in the metal and the oxide crucible walls are also possible, but have not been adequately characterized. In the particular case of air-melted alloys (e.g., some Co-base alloys), there may be spherical inclusions entrained in the melt. These are the last type of inclusion in the above table.

For purposes of modeling, the size range of interest is from 0.015 to 0.125 inch (approximately 0.38mm to 3.2mm). PCC would be interested in modeling a distribution of sizes, or at least a small and large size. Of course, the capability to resolve the particles during filming is a factor which determines the smallest size used in the model. Still, agglomeration of smaller particles is also known to occur during metal casting, so this would correlate to a realistic condition if it can be investigated.

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1 Relative density = $\rho_{inclusion}/\rho_{metal}$