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An Investigation Into Optimization of Melting Processes Variables to Reduce the Scrap Rate of Aluminum Castings

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AN INVESTIGATION INTO OPTIMIZATION OF MELTING PROCESSES VARIABLES TO REDUCE THE SCRAP RATE OF ALUMINUM CASTINGS

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by
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Introduction

Scrap castings produced at the melting stage of production can be easily avoided with the proper melting practices. The major enemies in the battle to obtain optimum melt cleanliness for a given process include oxides and hydrogen. Oxides and hydrogen come from various sources: hand ladles, skimmers, pour housekeeping with respect to reverb furnaces, improper melt handling, and the atmosphere. Of those, the biggest problem source associated with molten aluminum is the atmosphere surrounding the furnace.

Molten aluminum and oxygen bond in a matter of milliseconds to form a Al_2O_3, a protective layer on the surface of the melt. However, this protective barrier can work against the melt, in that, if broken up by turbulent handling of the molten aluminum, dross formation will occur. Dross is a crumpled film, usually formed after skimming, plunging, or degassing, with various contaminants trapped inside. Dross contains, in the greatest amount, crumpled Al_2O_3 film, then unoxidized aluminum, inclusions from the bath, flux constituents, ash, sludge particles and oxidation products from the contained metallic aluminum.

Dross can be one of two forms, wet dross or dry dross. Wet dross is the most detrimental to the melt, in that, inclusions as part of the dross can be introduced to a melt due to the low differential in interfacial energy barrier. On the other hand, dry dross, although it can contain up to 50% aluminum, is less detrimental because contained oxides cannot readily enter the molten aluminum. Dry dross is usually suspended on the surface of the molten aluminum. Flux is an important constant in converting wet dross to dry dross.

Besides oxides and dross, hydrogen can be a guilty of scrapping parts. Hydrogen is the only gas that is appreciably soluble in molten aluminum. It is most abundant in the form of H_2O, and as much one trys to control the melt process he/she cannot control the amount of hydrogen in the atmosphere, with the exception of working in a vacuum furnace. H+ will be absorbed into the melt after it is reduced from the reaction between H_2O and Al3+ creating 6H+ and Al_2O_3. The effects of this absorbed hydrogen can very detrimental. Failure to reduce hydrogen in the melt, will result in porosity: either microporosity or larger porosity defects.

Microporosity, in certain cases can be overlooked, with the exception being in parts that require pressure tightness. Larger porosity defects will appear as blowholes and cracks. Besides the before mentioned defects, the presence of porosity in a casting will reduce its overall mechanical properties.

Statement of the Problem

The problem of this research was in determining sources of variation in an aluminum melting process, as a means to supply customers with their as-specified products.

Significance Of The Study

The research was significant, in that, it provided a foundation of information related to reverbratory and electric furnace melting of numerous aluminum alloys. Specifically, it assisted an organization, focused on total quality management, shift from melting as an art to melting as a science, based on statistical process control.

Research Questions

The research was to provide answers to the following questions:

1. What are the different types of fluxes? How efficient are they in eliminating contaminants in reverb and induction melting?
2. What amount of flux is optimal as a means to provide a defect free end product?
3. What are the different types of degassing methods? How efficient are they in removing oxides from an electric furnace melt?
4. What is the optimal degassing time for electric furnace melting as means to provide the desired mechanical properties of the end product?
5. What is the optimal holding time of flux in an electric furnace melt?
6. How are the melters assuring that the melt is contaminant free? (i.e., are they preheating skimming tools? Are they keeping agitation to minimum upon skimming?)
7. What is the chemical composition and cleanliness of ingots being introduced to reverb furnaces? Is there a difference between suppliers?
8. Are the measuring apparatuses effective as on the floor units?
9. What are the different types of filters used for the sand mold and permanent mold? How can they be tested in this research to determine the filters efficiency?

Delimitations

The research was difficult because I had limited control: the research took place on the shop floor, during production. Trying to coordinate research with production was a very difficult task, however, it was the only way to get the data as outlined by the objectives. The greatest obstacle was the melters, who were resistant to an intern impeding on their work. They felt like the research was going to prove them wrong in their jobs, hence their resistance.

Next, I had difficulty following the original timeline. Again, this was a result of doing research in a production setting, where production was the first priority.

Definitions

According to Zalensas (1993), the following are definitions of fluxes:

Covering Flux: Used to prevent gas pickup and to reduce dross formation by oxidation (and thereby reduce metal loss) (p. 26).

Cleaning Flux: Used to remove solid nonmetallic inclusions (p. 26).

Degassing Flux: Added to the melt to remove the entrapped gases (especially hydrogen) that can contribute to casting porosity (p. 26).

Drossing-off flux: Are use to recover metal from drosses (p. 26).

Degassing: ". . .carried out by introducing a sparging gas into the molten aluminum. As gas bubbles move up through the bath, hydrogen diffuses into the bubbles because of the difference between partial pressure in the bath and its partial pressure in the bubbles" (Zalensas (1993) p. 22).

Reverbatory Furnace: "A furnace in which the flame is used for melting the metal does not impinge on the metal surface itself, but is reflected off the walls of the roof of the furnace. The metal is actually melted by the generation of heat from the walls and roof of the furnace." (ASM International, 1996, p.10).

Electric Furnace: "A metal melting or holding furnace that produces heat from electricity. It may operate on the resistance or induction principle." (ASM International, 1996, p.5). In the research it was used as a holding furnace for secondary metallurgy.

Argon RID Unit: A degassing apparatus that functions to introduce Argon into the aluminum melt being held in an electric furnace. It operates by lowering a steel-graphite coated shaft into the melt and turned and ditributes Argon gas by rotating and collects hydrogen through the different partial pressure in the two gases.

Wedron Fluxmobile: A mobile aluminum melt cleaning apparatus that elimanates the need for manual flux addition

Methods

Designing the experiment to optimize melt process control for permanent mold and sand casting, a number of parameters had to be measured. First, the overall cleanliness of the aluminum had to somehow be measured before any flux addition or degassing time; measured after flux addition; measured after a desired degassing time. Fortunately, there is a instrument designed specially for determining the cleanliness of aluminum. This instrument can be used on the melt area floor, at all stages of the melt process; with relative ease of use. This crucial data collection device is know as Qualiflash produced by Bomen.

Apparatus

Qualiflash was crucial for this research for it determined the aluminum cleanliness at all stages of the melt process. It can determine the melt cleanliness right from the reverbab, next it can determine melt cleanliness after a desired flux addition, and last, it can be used after a desired degassing time to determine the overall molten aluminum cleanliness. For this reason, Qualiflash was a crucial data collection device going into the experiment.

The Qualiflash is a very simple machine to use and operate, for it comes with a few basic components. Qualiflash is setup whereby a ladle of molten aluminum is dipped from the melt, and taken quickly to the unit. With the sample at the Qualiflash unit, the melt temperature is taken with a thermocouple, then poured into a funnel, through a filter, and into a ingot step mold. The bottom plate of the funnel is interchangeable between a large choke or small choke, depending on the melt temperature. After solidification of both the aluminum in the mold and in the funnel, they are knocked out with specially designed tools. The number of steps filled out and mass of the mold can be determined after knockout.

In conjunction with the use of Qualiflash, there was a need to determine the amount of gas in the melt. The amount of gas in the melt was crucial to the research, for it was to reveal any or no correlation between aluminum cleanliness and the amount of gas present in the melt. As a means to measure the gas, two units, or tests, were implemented to add data to the research process. The first test was a specific gravity test. The specific gravity test is used to determine the presence, or lack thereof, of hydrogen in the melt. This simple and accurate test was available using the Reduced Atmosphere Testing System and a water displacement unit.

Along with the simple specific gravity test, a unit being leased by Progress Casting Group was also at the disposal of research. The unit was the DPM Gas Tester by GKS Engineering. This gas analyzer, one of very few on the market, was used to measure the gas content and gas pressure at varying stages of the melt process. The DPM Gas Tester, along with the specific gravity test would be able to provide enough data, whereby conclusions could be made on the correct process for the melt departments.

As a means to measure the percent humidity in the air, along with the temperature, a digital thermometer with a percent humidity reading, was present during all facets of testing. This is important for it will show a relationship, or lack thereof between its readings and that of Qualiflash, the gas tester, and specific gravity.

Procedure

Working in conjunction with melters and molders, melt samples were taken at predetermined stages of the melt process. The melt processes were manipulated daily as a means to get melt samples that functioned as data comparison. Then, the melt samples from the manipulated melt practices were then compared and contrasted for the purpose of honing in on the optimum process.

First, the traditional melt practices were manipulated for research purposes in the sand foundry. These manipulations included varying the flux amount from 0 oz. flux continuing with 1 oz. flux, 2 oz. flux, 3 oz. flux, and 6 oz. flux variations. Also, degassing time varied from 0 minutes, 10 minutes, 15 minutes, and 20 minutes, with flux amounts being equal at 3 oz. Comparisons between these applications were done by collecting data through the use of Qualiflash, gas content analysis, and specific gravity.

Also in the sand foundry the usual process of manual addition of flux, and degassing using the argon RID unit, were compared to the Wedron Fluxmobile. Again, comparisons will be made in melt cleanliness using Qualiflash, gas content, and specific gravity.

Next, in the permanent mold operation, the Senco gun permanant molding station was the focus of boiling flux tests. Various boiling fluxes were used in the Senco gun process, as a replacement to a potato. The potato has been used by Progress Casting Group, as a means to introduce hydrogen into the melt. If there was an absence of hydrogen the rapid solidification of the permananent mold will result in an incomplete filling, or a misrun casting. Therefore, hydrogen introduction is necessary to "push" the solidifing aluminum to the mold walls.

The boiling fluxes were plunged into the ladle well of a reverbatory furnace, with the researcher taking specific gravities every half hour during an eight hour shift. The results of the specific gravity testing, were then compared against the number of scrap castings for that shift. This allowed the operator to focus on a correct amount, and accurate boiling flux addition intervals, if indeed it did prove to be a fair replacement to the potato.

Besides the goal involving the boiling flux and Senco gun quality, research focused on the Harley-Davidson crankcases. The goal was to follow 319 Harley-Davidson crankcases melting process for 2 days, and monitor cleanliness level versus casting quality; check Qualiflash reading and specific gravity every two hours during a shift. This research attempted to solve the problem of oxides in the crankcases.

Finally, research on filter efficiency needed to be performed in the sand foundry. However, the difficulty was coming up with different filters, besides the Qualiflash provided filter, that will work as part of the Qualiflash apparatus. A design whereby different filters could be tested using Qualiflash was the first step in accomplishing this goal.

Results of Sand Foundry Research

1. Variable Flux Additions and Degassing Time

Data

Refer to Appendix A.

Discussion

Figure 1, organizes the data in which flux additions were varied using 1 oz., 2 oz., 3 oz., and 6 oz., in combination with a set degassing time of 15 minutes.

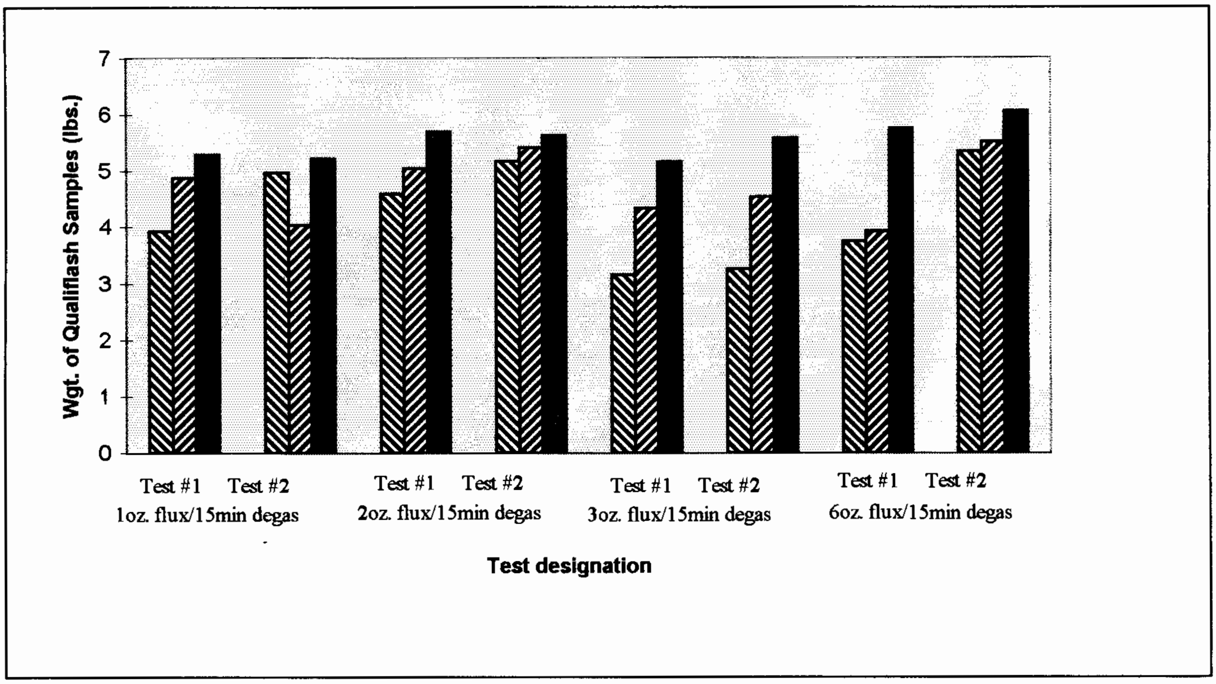

Figure 1. At various levels of flux addition to the aluminum melt in an electric furnace. The degas time is held steady at 15 minutes using an Argon RID unit.

The weight of the Qualiflash samples increased by 37 % and 39% after the 3 oz. flux addition. These percentages can be compared to a 36% increase and 18% decrease after the 1 oz. flux addition, a 6%, 3% increase after the 6 oz. flux addition, and a 9%, 5% increase after the 2 oz. flux addition.

Also in Figure 1, the percent improvement after 15 minutes of degassing is documented. The combination of 3 oz. flux and 15 minutes degassing improved the melt cleanliness(weight of the Qualiflash samples, lbs.) by 64% and 71%. These data can be compared to a 10% and 13% increase with a 15 minute degas, in the absence of any flux, a 47% and 5% increase after 1 oz.flux/15 minute degas, a 24% and 10% increase after 2 oz. flux/15 minute degas, and a 54%, 5 % increase in the 6 oz. flux/15 minute degas test.

The largest difference while looking at all the data, is the difference in melt cleanliness coming from reverb 6 (Reverb 6 was the furnace used for the sand foundry operation), then melt was tapped into an electric furnace for secondary metallurgy. According to the data, the cleanliness levels were as low as 3.15 lbs. on 6-27, to as high as 5.52 lbs. on 7-14. The humidity along with the temperature were taken in the immediate area around the electric furnaces. As the line graph reveals, the number of steps completed do not correlate to the percent humidity in the air.

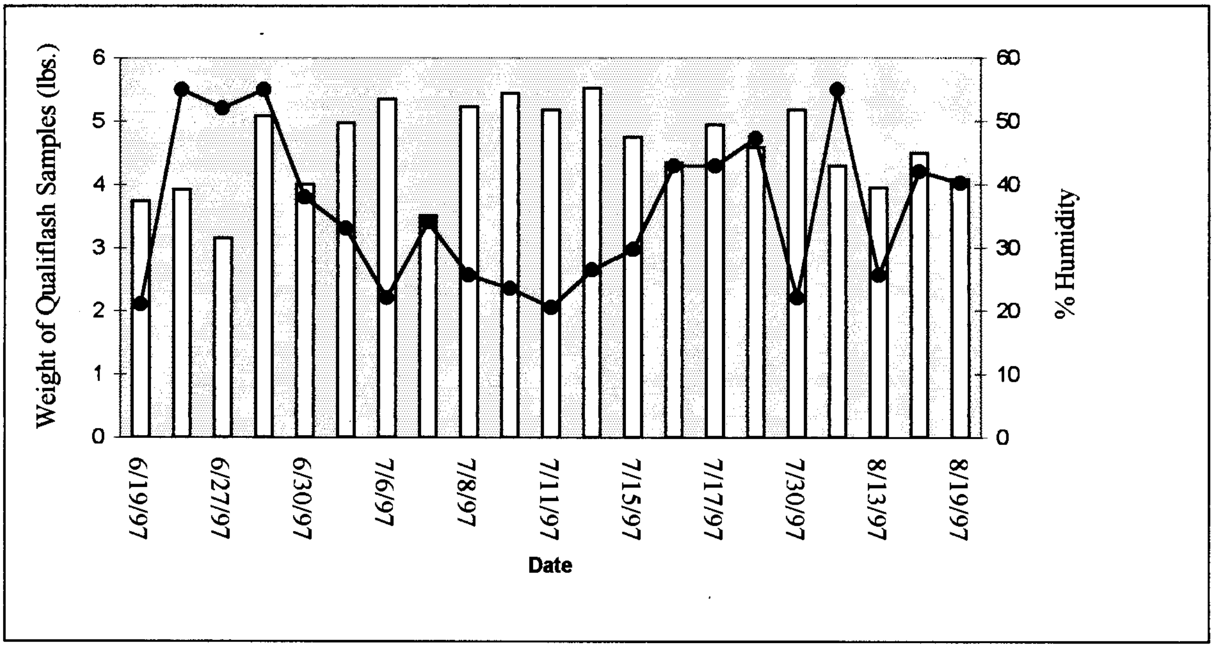

Figure 2. The cleanliness of the aluminum melt from Reverbatory furnace #6. The percent humidity was also recorded and graphed.

The next phase of research involved keeping the flux amount fixed at 3 oz., while varying the degassing time. After a 3 oz. flux addition, two tests each were done for the following degassing times: 10 minutes, 15 minutes, and 20 minutes. According to the data the greatest improvement of melt cleanliness, came in the tests where 15 minutes of degassing time was combined with 3 oz. of flux (See Figure 3). After the 3 oz. flux addition, the melt cleanliness improved by 37% and 39%. Following the 15 minutes of degassing the percent improvement of melt cleanliness in the two tests was 64% and 71%. The next best improvement was seen after 20 minutes of degassing, in which this first test revealed there was a 22% melt cleanliness improvement. However, the melt cleanliness percent improvement decreased after the 20 minute degassing period to 22%. Also, was a decrease in melt cleanliness in the second test after 20 minutes of degassing. The overall increase after the flux is 1%, but decreases by 4%, and the actual weight dropped from 4.94 to 4.81. The third greatest improvement came in the second test, after degassing for 10 minutes, in which there was a 14% improvement in melt cleanliness.

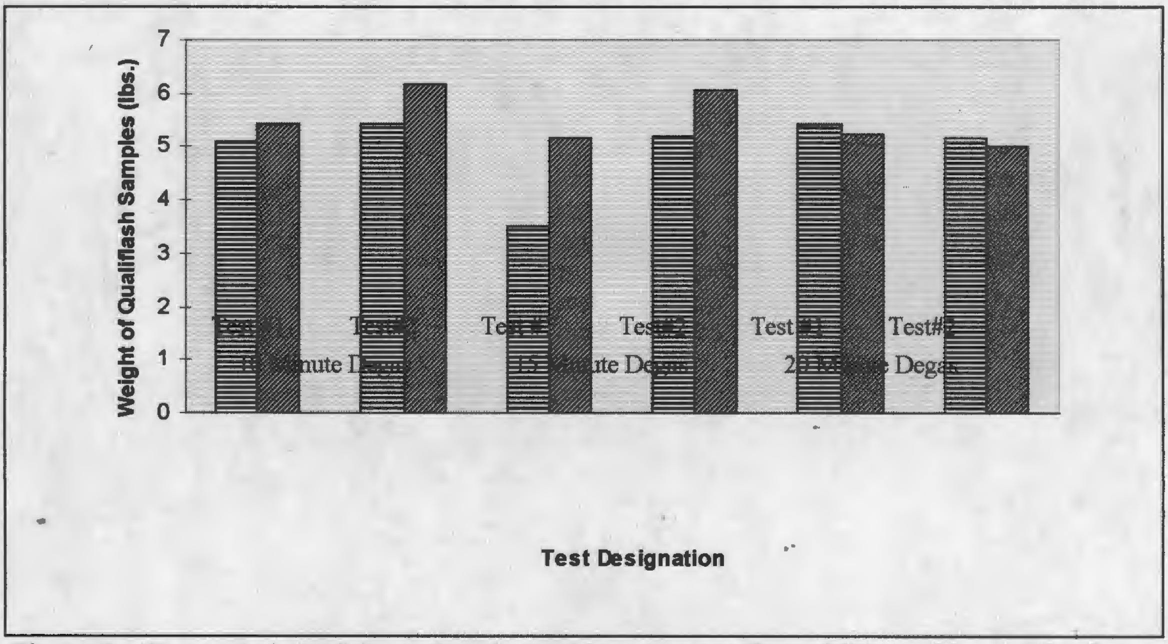

Figure 3. The variation of degassing time with a constant flux addition of 3 oz. The flux type is NS411 and the degassing unit is the Argon RID Unit.

2.Argon RID unit vs. Wedron Fluxmobile

Data

Refer to attached pages

Discussion of data

For the first test, the melt cleanliness was the approximately the same(4.38 for Wedron and 4.39 for Ar), but the specific gravity was greater using the argon RID unit. However, the second test proved specific gravity after Wedron application was higher (2.61 vs. 2.57). Also as part of the second test, qualiflash samples revealed that melt cleanliness was better after Wedron application.

The data collected using these two aluminum melt cleaning practices, was not easy to breakdown due to the variation in melt temperature. It was very difficult to have two electric furnaces holding molten aluminum at approximately the same temperature, especially when the test covered several days. However, in Qualiflashes newest instruction manual, there is a section titled Quality Temperature Index (QTI).

The QTI is a method to analyze melt samples at different temperatures. The QTI became a crucial bit of information when comparing Argon RID unit and Wedron Fluxmobile. When comparing QTI numbers, the lower the number, the greater the melt cleanliness. For example, a sample with a Q2 will have greater melt cleanliness than a sample with a Q5.

The QTI became crucial in the second day of testing when the melt temperature range was between 1332 and 1365. Logically thinking, the lower the melt temperature the less fluid the molten aluminum will be. Reduced fluidity will result in poor performance in the step ingot mold. This was proven in the weight of the samples, with the samples taken after argon RID unit weighed an average of 4.84 pounds, compared to 4.53 lbs. after Wedron application. Note, the samples after Wedron process were poured at much lower temperatures. Despite the difference in pouring temperatures by applying QTI, the numbers can be compared. When analyzing the QTI numbers in the data tables, the average of the three samples is Q3, for both Wedron and RID unit.

Conclusions Pertaining to Melt Process- Sand Foundry

After approximately one month of research, and close analysis of the data, the conclusion effecting the sand foundry: the in-place process is the optimum process. Specifically, a 3 oz. flux addition for every 100lbs. of molten aluminum, followed by 15 minutes of degassing.

If the in-place process is the correct process, then the flux measuring scoops in place are measuring too much flux. As a result of that finding new and accurate flux scoops were ordered, with one scoop having the ability to measure for both 1000lbs. and 750lbs. furnace. The implementation of the new ladles will reduce overall flux consumption. The estimated monetary savings in flux for the sand foundry and permanent mold is $10,375. See attached page for the calculations of flux savings.

Also, the 3 oz. flux addition may need not be added when the melt cleanliness coming from the RV6 is above a Qualiflash sample weight of 5.0lbs. In situations in which flux was absent, and degassing was the only process applied, there was improvement in melt cleanliness. The melt cleanliness improvement was seen in the interval of 10-15 minutes degassing time. However, if the degassing time was around 20 minutes, this caused a decrease in melt cleanliness. The decrease can be explained by fact that the extra degassing time created extra turbulence, hence, the decrease in melt cleanliness (See Figure 1). Upon analysis of the data in this figure, all the samples weighed approximately 5 lbs. or above, with the exception of the first sample from the reverbatory furnace, which was approximately 3.51 lbs. Based on the initial samples, the improvement in melt cleanliness was substantial after 10 and 15 minutes of degassing. The first sample using a 10 minute degas interval was 3.51 lbs. coming form the reverb, increasing exceptionally by 47%, to 5.16 lbs. The second sample as part of the 10 minute degas test was above 5 lbs. coming from the reverb, but still increased by 19% to 6.08lbs. An observation made during these tests in the absence of flux, was one in which the dross skimmed of the top appeared more wet than normal. A key suggestion is to have a tracking system, whereby castings actually poured from a melt lacking flux are inspected to determine the actual quality.

Having analyzed the previous things it is a fact that melt cleanliness from RV 6 is variable. It was determined that this difference in melt cleanliness is caused by two things. First, the scrap/ingot ratio will have an effect on the melt cleanliness. Obviously the greater the scrap introduce to RV6, the less clean the melt will be. The second thing that could cause variation in the cleanliness in RV6 is the time interval between scrap/ingot introduction and filling of electric furnaces. The less the time between these two events, the less clean the melt will be. If this is the case, we must find a control point, whereby proper amounts of scrap and ingot are being charged at specific time intervals. Perhaps in the next phase of research, the melters can record specific data regarding charge material.

The use the Wedron Fluxmobile can be an effective replacement to the Argon RID unit. The basic conclusion that in both cases the test revealed that both processes improved melt cleanliness along with specific gravity. The question is, what process is better for overall melt cleanliness? Based on this research I don't think that questioned can be answered. Mainly, the basic conclusion is that nothing is lost by applying the Wedron fluxmobile, if the melter chooses to do so.

Finally, when working with the specific gravity apparatus located in the foundry office, it was concluded that significant improvements to the unit could be made. A few simple ideas could have the apparatus more user friendly. As a means to make it more user friendly, a new design was implemented. This design gives the specific gravity apparatus much more stability, resulting in greater accuracy in the specific gravity samples.

Results of Permanent Mold Research

1. A102-aluminum boiling flux as part of Senco gun process

The practice of introducing a potato in a permanent mold melt is unique and mostly an effective way of compensating for shrinkage. Due to the rapid solidification of molten aluminum in permanent molds, shrinks will occur at various sections of the casting. The potato will compensate for the shrink by introducing gas into the melt whereby the gas assists the metal in filling out the mold. Despite the positive effects of a potato, it must be eliminated for four reasons:

1. The potato is to difficult to control as part of the process. Questions of how often does a potato get added?, what is the optimum weight of potato?, and how much moisture does a given potato have? Ask those questions to various molders, and the answers differ based on individual feel.

2. The potato must be eliminated because ISO 9002 certification will be difficult to achieve in the absence of specific work instructions and processes for permanent mold.

3. Third, the importance of impressing a potential customer would be difficult with a dozens of spuds laying around.

4. In searching for a replacement to the potato, various fluxes are available that can not only introduce gas into the melt, but can create a cleaner melt by capturing various inclusions.

In an effort to eliminate the potato as part of the permanent mold melting process, data was collected using A102-Aluminum boiling flux, produced by AMCOR. The A102 boiling flux was substituted for the potato at the Senco gun permanent mold station. When the A102 boiling flux is employed it will provide two things. First, if plunged properly, the flux will boil causing a dispersion of gas bubbles and flux throughout the melt as means to compensate for shrinkage. Second, the flux agglomerates suspended oxide material at the melt surface, where proper skimming can provide a cleaner melt.

Data tables

Refer to Appendix A

Discussion of data

The data was collected covering four days. The first day was the control day in which the specific gravity, temperature, % humidity, and time of potato addition, was recorded as part of the normal process (using the potato). The next three tests were performed using the boiling flux at the Senco gun molding station.

Breaking down the data, there is essentially no correlation between specific gravity and humidity (See Figure 4). The main objective of the research was to keep the specific gravity within a certain limit, and then based on the specific gravity at a given time, tinker with the addition interval, as means to focus on the optimum flux addition interval. Also, to take the results of the four tests and track the Senco guns, produced while testing, through the process as a means to determine the scrap rate.

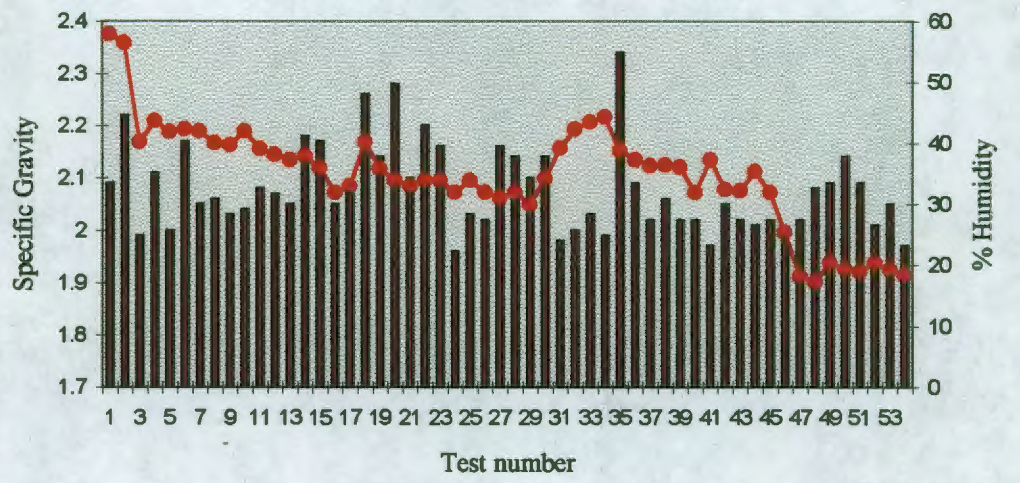

Figure 4. The specific gravity of the aluminum melt at the Senco Gun Permanent Mold Station: the potato versus A102 Boiling Flux.

Conclusions of the A102-boiling flux experiment

The conclusions of the A102 boiling flux experiment are very positive, however further research is needed. Using A102 as a replacement to the preferred russet potato, gave approximately lower specific gravities than the potato. However, when plunged properly, the Senco guns appeared to have less defects than guns made with the potato. The molder assigned to Senco Gun permanent mold operations visually inspects all the guns, and with the exception of 8-15, he threw less away due to shrinks while the boiling flux was part of the process.

The only problem was observed when the melter failed to plunge the 4 ounces of boiling flux, with the result being a significant boiling out of the melt in the holding cell.

2. Qualiflash/specific gravity test on H-D crankcases

Data Tables

Refer to Appendix A

Discussion of data

The data on the scrap report reveal that heat number 219 of the Harley-Davidson crankcases had 13 scrap castings, and heat 220 had 12 scrap castings. Heat number 220 had nine shrink defective castings and three oxide related defects. Those are compared to heat number 219, which also had nine shrinks, but one more oxide related defect totally thirteen total scrap. The average percent humidity on 8-7 was 36.9%, and 8-8 the percent humidity was 24.9%.

Conclusions on melt cleanliness at Harley-Davidson Crankcases

The conclusion for this portion of the research is that the scrap rate correlates with Qualiflash and specific gravity readings. The less scrap, albeit by one casting, was seen in the heat in which melt cleanliness measured by Qualiflash equaled 3.915 lbs. Comparing that to heat 219 which had an average Qualiflash weight of 3.415. The average specific gravity for heat 220 was 2.28 and for 219 it was 2.27. An interesting data point is the temperature/humidity readings for the days of 8-7 and 8-8. As would be expected, there is correlation between percent humidity and the cleanliness of the melt. The average percent humidity on 8-7 was 36.9%, compared to 8-8 were the percent humidity was 24.9%. Based on the averages, the lower the humidity the cleaner the melt was.

Research on Sand Foundry Filter Efficiency

The problem involving filter efficiency was the fact that in order to experiment with different filters and their efficiencies, sizes could not be ordered small enough to fit on the bottom of the funnel clapping system as part of the Qualiflash apparatus. Therefore, some type of design had to be implemented whereby different sized filters could work in conjunction with the Qualiflash unit. The design process began with a number one pouring basin. From that, the different filters could be glued in the pouring basin. Then, the pouring basin could be easily set on the Qualiflash funnel. With this design the melt sample will be poured into the pouring basin, then through the filter being researched, then into the funnel, through the standard filter, then into the step ingot mold.

Initially, there was a problem with this design due to the fact the metal sample in the ladle was not introducing enough metal into the pouring basin. As a result there was not sufficient head pressure to push the metal through the filter. From that two different designs were implemented. First, as a means to build up the head pressure, a 2" diameter riser sleeve was glued to the opening on the inside of the pouring basin, with the filter being glued to the bottom of the filter. This design worked, however, the problem arose when trying to pour the sample into a 2" diameter riser sleeve. It was decided something must be easier than that.

The final and best design was cutting a number one pouring basin in half with a core insert. The logic behind this is to create enough head pressure as means to push the melt through the filter. Also with this design, the filter was inserted on the inside of the pouring basin. This was to meant keep the filter from dropping out of the basin. This was the easiest design for pouring purposes, and metal pushed through the filter rather smoothly. However, there was some labor involved in making an insert on the inside of the basin for the filter. Even though there was little research involving filter efficiency, the design has laid the groundwork for the next phase of research.

Appendix A

				3 OZ. FLUX/10 MIN. DEGAS TEST						
TEST # 1	**BEFORE DEGASSING**									
Date 7-14-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 92.9	10:30	A 356	0 oz.	0 min.	803	1343	2.22	8	5.59	0.2891
Humidity 26.5	10:43	A 356	0 oz.	0 min.	800	1343	2.27	8	5.6	0.2391
	11:00	A 356	0 oz.	0 min.	799	1343	2.25	7	5.38	0.2337
				avg.	800.67	1343.00	2.25	7.67	5.52	0.25
	AFTER 3 OZ. FLUX ADDITION									
Date 7-14-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 93.2	11:20	A 356	3 oz	0 min.	797	1345	2.22	7	5.51	0.198
Humidity 23.5%	11:31	A 356	3 oz	0 min.	798	1345	2.28	7	5.09	0.196
	11:47	A 356	3 oz	0 min.	799	1346	2.29	7	5.35	0.193
				avg.	798.00	1345.33	2.26	7.00	5.32	0.20
	AFTER 10 MIN. DEGAS									
Date 7-14-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 101.8	1:00	A 356	3 oz	10 min.	805	1343	2.61	7	5.19	0.1772
Humidity 29.7%	1:15	A 356	3 oz	10 min.	805	1343	2.61	7	5.09	0.0831
	1:30	A 356	3 oz	10 min.	814	1344	2.61	8	5.43	0.0613
				avg.	808.00	1343.33	2.61	7.33	5.24	0.11

TEST # 2	***BEFORE DEGASSING***									
Date 7-15-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 101.9	1:00	A 356	0 oz.	0 min.	825	1333	1.86	6	4.37	0.2937
Humidity 29.7	1:15	A 356	0 oz.	0 min.	804	1342	2.02	6	4.76	0.1941
	1:30	A 356	0 oz.	0 min.	818	1338	2.19	7	5.11	plugged
				avg.	815.67	1337.67	2.02	6.33	4.75	0.24
	AFTER 3 OZ. FLUX ADDITION									
Date 7-15-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 106.5	1:55	A 356	3 oz.	0 min.	807	1342	2.08	6	4.71	
Humidity 19.5%	2:10	A 356	3 oz.	0 min.	811	1340	2.23	6	4.73	
	2:15	A 356	3 oz.	0 min.	809	1342	2.17	7	5.33	
				avg.	809.00	1341.33	2.16	6.33	4.92	#DIV/0!
	AFTER 10 MIN. DEGAS									
Date 7-15-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 109.1	2:45	A 356	3 oz.	10 min.	814	1340	2.6	8	5.54	
Humidity 18.3%	2:55	A 356	3 oz.	10 min.	810	1339	2.6	7	5.1	
	3:05	A 356	3 oz.	10 min.	803	1342	2.59	8	5.65	
				avg.	809.00	1340.33	2.60	7.67	5.43	#DIV/0!

				3 OZ. FLUX/20 MIN. DEGAS TEST						
TEST # 1	***BEFORE DEGASSING***									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 91.6	9:30	A 356	0 oz.	0 min.	814	1344	2.22	6	4.44	no carbon
Humidity 42.9%	9:40	A 356	0 oz.	0 min.	807	1344	2.21	6	4.67	plugs
	9:49	A 356	0 oz.	0 min.	808	1343	2.18	5	3.92	
				avg.	809.67	1343.67	2.20	5.67	4.34	#DIV/0!
	AFTER 3 OZ. FLUX ADDITION									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94	10:15	A 356	3 oz.	0 min.	815	1338	2.26	9	6.14	
Humidity 40.5%	10:22	A 356	3 oz.	0 min.	804	1344	2.28	7	5.03	
	10:30	A 356	3 oz.	0 min.	804	1344	2.29	7	4.98	
				avg.	807.67	1342.00	2.28	7.67	5.38	#DIV/0!
	AFTER 20 MIN. DEGAS									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 97.3	11:20	A 356	3 oz.	20 min.	808	1345	2.6	7	5.27	
Humidity 37.4%	11:30	A 356	3 oz.	20 min.	806	1343	2.61	8	5.55	
	11:40	A 356	3 oz.	20 min.	801	1345	2.61	7	5.01	
				avg.	805.00	1344.33	2.61	7.33	5.28	#DIV/0!

TEST # 2	***BEFORE DEGASSING***									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 91.6		A 356	0 oz.	0 min.	814	1337	2.42	7	5.07	
Humidity 42.9%		A 356	0 oz.	0 min.	802	1338	2.43	8	4.22	
		A 356	0 oz.	0 min.	805	1339		6	5.52	
				avg.	807.00	1338.00	2.43	7.00	4.94	#DIV/0!
	AFTER 3 OZ. FLUX ADDITION									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94		A 356	3 oz.	0 min.	796	1339	2.32	8	5.47	
Humidity 40.5%		A 356	3 oz.	0 min.	807	1336	2.41	6	4.61	
		A 356	3 oz.	0 min.	804	1337		7	4.93	
				avg.	802.33	1337.33	2.37	7.00	5.00	#DIV/0!
	AFTER 20 MIN. DEGAS									
Date 7-17-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 97.3		A 356	3 oz.	20 min.	801	1330	2.64	6	4.4	
Humidity 37.4%		A 356	3 oz.	20 min.	807	1332		7	4.98	
		A 356	3 oz.	20 min.	801	1337		7	5.05	
				avg.	803.00	1333.00	2.64	6.67	4.81	#DIV/0!

			3 OZ. FLUX/15 MIN Ar DEGAS TEST							
TEST # 1	***BEFORE DEGASSING***									
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 96.1	10:10	A 356	0 oz.	0 min.	805	1338	2.28	6	4.4	Q3
Humidity 55%	10:30	A 356	0 oz.	0 min.	804	1335	2.31	6	4.29	Q3
	10:55	A 356	0 oz.	0 min.	811	1341	2.25	3	4.18	Q15
				avg.	806.67	1338.00	2.28	5.00	4.29	Q6.67
	AFTER 3 OZ. FLUX ADDITION/15 MIN RID UNIT DEGAS									
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 96	11:30	A 356	3 oz.	15 min	799	1342	2.62	7	5.14	Q8
Humidity 53%	11:55	A 356	3 oz.	15 min	811	1343	2.62	7	5.38	Q1
	12:10	A 356	3 oz.	15 min	801	1344	2.63	8	6.18	Q4
				avg.	803.67	1343.00	2.62	7.33	5.57	Q4
		FLUX/DEGAS USING WEDRON FLUXMOBILE								
TEST # 1	***BEFORE WEDRON FLUXMOBILE***									
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 92	1:00	A 356	0 oz.	0 min.	797	1341	2.28	5	3.65	Q7
Humidity 25.7%	1:15	A 356	0 oz.	0 min.	815	1338	-	5	4.2	Q7
	1:25	A 356	0 oz.	0 min.	804	1330	-	5	4.01	Q6
				avg.	805.33	1336.33	2.28	5.00	3.95	Q6.67
	AFTER 15 MIN. OF WEDRON FLUXMOBILE									
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 94	2:00	A 356	0 oz.	15 min	807	1330	2.59	6	4.71	Q2
Humidity 23.5%	2:10	A 356	0 oz.	15 min	800	1328	2.6	6	4.25	Q1
	2:21	A 356	0 oz.	15 min	808	1325	2.6	5	4.18	Q6
				avg.	805.00	1327.67	2.60	5.67	4.38	Q3

				3 OZ. FLUX/15 MIN Ar DEGAS TEST					
TEST # 2	**BEFORE DEGASSING**								
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 87.1	7:00	A 356	0 oz.	0 min.	806	1355	1.97	4	3.43	Q5
Humidity 42%	7:10	A 356	0 oz.	0 min.	807	1362	2.31	6	4.53	Q6
	7:25	A 356	0 oz.	0 min.	811	1365	-	8	5.53	Q1
				avg.	808.00	1360.67	2.14	6.00	4.50	Q3
	AFTER 3 OZ. FLUX ADDITION/15 MIN RID UNIT DEGAS									
Date 8-13-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 89	8:10	A 356	3 oz.	15 min	805	1350	2.55	7	4.92	Q1
Humidity 41.4%	8:21	A 356	3 oz.	15 min	797	1343	2.59	6	4.97	Q4
	9:00	A 356	3 oz.	15 min	797	1350	2.58	6	4.62	Q4
				avg.	799.67	1347.67	2.60	6.33	4.84	Q3
			FLUX/DEGAS USING WEDRON FLUXMOBILE							
TEST # 2	**BEFORE WEDRON FLUXMOBILE**									
Date 8-19-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 91	9:30	A 356	0 oz.	0 min.	800	1338	2.01	6	4.56	Q3
Humidity 40.2%	9:42	A 356	0 oz.	0 min.	807	1350	2.08	6	4.46	Q3
	9:53	A 356	0 oz.	0 min.	815	1335	-	4	3.21	Q10
				avg.	807.33	1341.00	2.05	5.33	4.08	Q6
	AFTER 15 MIN. OF WEDRON FLUXMOBILE									
Date 8-19-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	QTI
Temp 91.5	10:20	A 356	0 oz.	15 min	799	1337	2.61	7	5	Q1
Humidity 39.8%	10:32	A 356	0 oz.	15 min	799	1338	2.61	6	4.38	Q3
	10:47	A 356	0 oz.	15 min	807	1332	2.61	5	4.21	Q5
				avg.	801.67	1335.67	2.61	6.00	4.53	Q3

QUALIFLASH/SPECIFIC GRAVITY TEST *H-D CRANKCASES*

TEST # 1 Heat # 219

Date 8-7-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 85.2	9:00	319	795	1377	2.29	3	3.06	around 9 am M.T.=1453
Humidity 44.3	9:19	319	815	1440	2.25	2	1.93	
	9:25	319	801	1407		3	2.59	
		avg.	803.67	1408.00	2.27	2.67	2.53	

TEST # 2

Date 8-7-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 88.0	10:30	319	804	1430	2.29	3	3.02	M.T=1492
Humidity 38.2	10:45	319	806	1413	2.32	3	2.66	
	11:00	319	802	1424	2.42	4	3.36	Taken after skimming
		avg.	804.00	1422.33	2.31	3.33	3.01	

TEST # 3

Date 8-7-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 89.2	12:20	319	807	1427	2.28	5	4.42	
Humidity 36.8	12:30	319	797	1400	2.2	4	3.33	flux addition around 12:28
	12:45	319	805	1360	2.37	4	3.28	
		avg.	803.00	1395.67	2.24	4.33	3.68	

TEST # 4

Date 8-7-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 95.3	2:20	319	797	1362	2.22	3	2.48	M.T.=1429
Humidity 28.2	2:30	319	800	1360	2.25	3	2.75	
	2:40	319	802	1379	2.23	4	3.26	
		avg.	799.67	1367.00	2.24	3.33	2.83	
				Mean	2.27	3.415	3.012	

QUALIFLASH/SPECIFIC GRAVITY TEST *H-D CRANKCASES(day 2)*

Heat # 220

TEST # 1

Date 8-8-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 87.5	8:52	319	797	1420	2.28	4	3.23	skimmed 8:51
Humidity 36.8	9:02	319	799	1425	2.2	5	4.02	M.T.=1453
	9:14	319	798	1446	2.28	4	3.41	
		avg.	798.00	1430.33	2.24	4.33	3.55	

TEST # 2

Date 8-8-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 96.2	10:52	319	807	1414	2.25	4	3.18	M.T.=1452
Humidity 24.6	11:06	319	801	1445	2.27	4	3.19	10:47 A114,NS411 add
	11:17	319	808	1431	2.38	3	2.9	
		avg.	805.33	1430.00	2.26	3.67	3.09	

TEST # 3

Date 8-8-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 98.1	1:35	319	797	1434	2.25	4	3.66	M.T.=1450
Humidity 19.3	1:47	319	803	1440	2.32	4	3.55	skimmed at 1:37
	2:00	319	808	1438	2.27	5	4.08	
		avg.	802.67	1437.33	2.29	4.33	3.76	

TEST # 4

Date 8-8-97	Time	Alloy	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Comments
Temp 101	3:05	319	807	1451	2.35	4	3.7	skimmed at 3:00
Humidity 18.9	3:20	319	799	1428	2.29	3	2.43	
	3:35	319	805	1428	2.32	3	3.04	
		avg.	803.67	1435.67	2.32	3.33	3.06	
				Mean	2.28	3.915	3.36	

				BOEING PERMANENT MOLD TEST						
TEST # 1	***BEFORE Wedron Fluxmobile***									
Date 8-6-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 91.6	11:15	A 356	0 oz.	0 min.	796	1443	2.54	5	3.7	
Humidity 18.5%	11:30	A 356	0 oz.	0 min.	817	1445	2.58	6	4.56	
	11:45	A 356	0 oz.	0 min.	810	1435		5	4.06	
				avg.	807.67	1441.00	2.56	5.33	4.11	
TEST # 2	***AFTER Wedron Fluxmobile***									
Date 8-6-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 93.3	12:15	A 356	-	15 min	800	1450	2.6	6	4.63	
Humidity 17.9%	12:25	A 356	-	15 min	804	1449	2.61	6	4.74	
	12:40	A 356	-	15 min	797	1380	2.61	5	3.47	
				avg.	800.33	1426.33	2.61	5.67	4.28	

				NO FLUX/10 MIN. DEGAS TEST					
TEST # 1	***BEFORE DEGASSING***								
Date 7-7-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 85	12:53	A 356	0 oz.	0 min.	817	1342	2.61*	3	2.5	no readings
Humidity 34%	1:04	A 356	0 oz.	0 min.	813	1341	2.63*	4	2.92	
	1:17	A 356	0 oz.	0 min.	798	1340	2.6*	7	5.12	
				avg.	809.33	1341.00	2.61	4.67	3.51	
	AFTER DEGASSING									
Date 7-7-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 87.7	2:20	A 356	0 oz.	10 min.	815	1341	2.61*	8	5.58	0.4054
Humidity 32%	3:00	A 356	0 oz.	10 min.	814	1340	2.63*	7	5.04	0.291
	3:06	A 356	0 oz.	10 min.	804	1342	2.63*	7	4.85	0.257
				avg.	811.00	1341.00	2.62	7.33	5.16	0.32
TEST # 2	***BEFORE DEGASSING***									
Date 7-8-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 92	2:20	A 356	0 oz.	0 min.	806	1342	2.58*	9	6.11	0.2178
Humidity 25.7%	2:31	A 356	0 oz.	0 min.	799	1343	2.59*	6	4.7	0.1976
	2:45	A 356	0 oz.	0 min.	797	1342	2.6*	7	4.84	0.1506
				avg.	800.67	1342.33	2.59	7.33	5.22	0.19
	AFTER DEGASSING									
Date 7-8-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94.5	3:20	A 356	0 oz.	10 min.	803	1341	2.61*	9	6.58	0.1607
Humidity 22.5%	3:30	A 356	0 oz.	10 min.	806	1342	2.62*	8	5.97	
	3:40	A 356	0 oz.	10 min.	816	1341	2.6*	8	5.7	
				avg.	808.33	1341.33	2.61	8.33	6.08	0.16
							NOTE: * Indicates RPT was not used.			

				NO FLUX/15 MIN. DEGAS TEST						
TEST # 1	**BEFORE DEGASSING**									
Date 6-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 96.1	2:00	A 356	0 oz.	0 min.	806	1334	2.61*	6	4.96	
Humidity 55%	2:30	A 356	0 oz.	0 min.	803	1338		7	5.1	
	2:45	A 356	0 oz.	0 min.	805	1335		7	5.17	
				avg.	804.67	1335.67	2.61	6.67	5.08	
	AFTER DEGASSING									
Date 6-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 96	3:30	A 356	0 oz.	15 min	806	1336	2.6*	7	5.14	
Humidity 53%	3:45	A 356	0 oz.	15 min	799	1337		7	5.38	
	4:00	A 356	0 oz.	15 min	810	1335		8	6.18	
				avg.	805.00	1336.00	2.60	7.33	5.57	
TEST # 2	**BEFORE DEGASSING**									
Date 7-2-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 92	10:00	A 356	0 oz.	0 min.	810	1337	2.61*	8	5.79	
Humidity 25.7%	10:20	A 356	0 oz.	0 min.	809	1341		7	4.42	
	10:30	A 356	0 oz.	0 min.	807	1342		9	6.1	
				avg.	808.67	1340.00	2.61	8.00	5.44	
	AFTER DEGASSING									
Date 7-2-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 94	12:30	A 356	0 oz.	15 min	806	1342	2.61*	9	6.11	
Humidity 23.5%	12:40	A 356	0 oz.	15 min	813	1342		9	6.07	
	12:52	A 356	0 oz.	15 min	814	1342		9	6.34	
				avg.	811.00	1342.00	2.61	9.00	6.17	

				NO FLUX/20 MIN. DEGAS TEST						
TEST # 1	BEFORE DEGASSING									
Date 7-9-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94		A 356	0 oz.	0 min.	799	1342	2.25	8	5.78	0.3078
Humidity 23.5%		A 356	0 oz.	0 min.	807	1342	2.23	7	5.07	0.2979
		A 356	0 oz.	0 min.	809	1342	2.26	7	5.43	0.2585
				avg.	805.00	1342.00	2.25	7.33	5.43	0.29
	AFTER DEGASSING									
Date 7-9-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94		A 356	0 oz.	20 min.	805	1341	2.62	7	5.1	0.3421
Humidity 23.5%		A 356	0 oz.	20 min.	799	1338	2.61	6	4.79	0.2875
		A 356	0 oz.	20 min.	807	1339	2.61	8	5.81	0.2063
				avg.	803.67	1339.33	2.61	7.00	5.23	0.28
TEST # 2	BEFORE DEGASSING									
Date 7-11-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94	11:00	A 356	0 oz.	0 min.	806	1338	2.27	8	5.54	0.2992
Humidity 20.5%	11:10	A 356	0 oz.	0 min.	806	1340	2.25	6	4.52	0.271
	11:25	A 356	0 oz.	0 min.	797	1342	2.29	8	5.45	0.2499
				avg.	803.00	1340.00	2.27	7.33	5.17	0.27
	AFTER DEGASSING									
Date 7-11-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	gas content
Temp 94.7	1:10	A 356	0 oz.	20 min.	806	1344	2.6	8	5.49	0.3924
Humidity 19.8%	1:25	A 356	0 oz.	20 min.	793	1345	2.59	7	5.35	plugged
	1:38	A 356	0 oz.	20 min.	797	1344	2.6	6	4.22	
				avg.	798.67	1344.33	2.60	7.00	5.02	0.39

				1 OZ. FLUX/15 MIN. DEGAS TEST						
TEST # 1	***BEFORE FLUX ADDITION/DEGASSING***									
Date 6-24-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 91.5	11:00	A 356	0 oz.	0 min.	801	1342	2.57*	5	4.95	
Humidity 55%	11:15	A 356	0 oz.	0 min.				3	2.8	
	11:40	A 356	0 oz.	0 min.				6	4	
				avg.	801.00	1342.00	2.57	4.67	3.92	
	AFTER 1 0Z. FLUX ADDITION									
Date 6-24-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 91	12:10	A 356	1 oz.	0 min.	795	1342	2.59*	7	5.38	
Humidity 53.8%	12:20	A 356	1 oz.	0 min.	807	1335		6	4.32	
	12:30	A 356	1 oz.	0 min.	820	1343		7	4.95	
				avg.	807.33	1340.00	2.59	6.67	4.88	
	AFTER 15 MIN. DEGAS									
Date 6-24-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 92.3	1:00	A 356	1 oz.	15 min	804	1339	2.61*	8	5.76	
Humidity 32.4%	1:20	A 356	1 oz.	15 min	799	1343		7	4.68	
	1:30	A 356	1 oz.	15 min	813	1344		7	5.43	
				avg.	805.33	1342.00	2.61	7.33	5.29	

				2 OZ. FLUX/15 MIN. DEGAS TEST						
TEST #1	***BEFORE FLUX ADDITION/DEGASSING***									
Date 7-25-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 94.9	10:00	A 356	0 oz.	0 min.	813	1341	2.29	6	4.33	no readings
Humidity 47.3%	10:15	A 356	0 oz.	0 min.	811	1337	2.1	5	4.26	
	10:30	A 356	0 oz.	0 min.	807	1338	2.29	7	5.17	
				avg.	810.33	1338.67	2.23	6.00	4.59	
	AFTER 2 0Z. FLUX ADDITION									
Date 7-25-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 95.1	10:50	A 356	2 oz.	0 min.	798	1343	2.07	7	5.32	no readings
Humidity 42.1%	11:00	A 356	2 oz.	0 min.	799	1344	2.3	7	5	
	11:05	A 356	2 oz.	0 min.	802	1342	2.27	6	4.83	
				avg.	799.67	1343.00	2.21	6.67	5.05	
	AFTER 15 MIN DEGAS									
Date 7-25-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 96.2	11:40	A 356	2 oz.	15 min	805	1346	2.59	8	5.69	no readings
Humidity 39.9%	11:50	A 356	2 oz.	15 min	807	1344	2.6	8	5.5	
	12:00	A 356	2 oz.	15 min	795	1344	2.61	8	5.9	
				avg.	802.33	1344.67	2.60	8.00	5.70	

TEST # 2	***BEFORE FLUX ADDITION/DEGASSING***									
Date 7-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 90	10:30	A 356	0 oz.	0 min.	804	1342	2.16	7	5.3	out of range
Humidity 22%	10:45	A 356	0 oz.	0 min.	798	1344		6	4.76	0.4355
	11:00	A 356	0 oz.	0 min.	801	1344		7	5.44	0.386
				avg.	801.00	1343.33	2.16	6.67	5.17	0.41075
	AFTER 2 0Z. FLUX ADDITION									
Date 7-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 96.2	12:40	A 356	2 oz.	0 min.	806	1346	2.31	8	5.51	out of range
Humidity 17.6%	12:50	A 356	2 oz.	0 min.	805	1346		6	4.8	0.4243
	1:00	A 356	2 oz.	0 min.	812	1344		8	5.92	0.3825
				avg.	807.67	1345.33	2.31	7.33	5.41	0.4034
	AFTER 15 MIN DEGAS									
Date 7-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 97.6	1:30	A 356	2 oz.	15 min	803	1344	2.6	8	6.03	out of range
Humidity 16.7%	1:40	A 356	2 oz.	15 min	804	1344		7	5.22	out of range
	1:50	A 356	2 oz.	15 min	801	1344		8	5.63	0.4975
				avg.	802.67	1344.00	2.60	7.67	5.63	

TEST # 2	***BEFORE FLUX ADDITION/DEGASSING***									
Date 6-26-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 88	10:45	A 356	0 oz.	0 min.	807	1341	2.62*	7	5.47	
HumiditY 33%	11:15	A 356	0 oz.	0 min.	810	1341		6	4.36	
	11:30	A 356	0 oz.	0 min.	806	1341		7	5.08	
				avg.	807.67	1341.00	2.62	6.67	4.97	
	AFTER 1 0Z. FLUX ADDITION									
Date 6-26-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 90	12:55	A 356	1 oz.	0 min.	804	1343	2.58*	5	4.07	
Humidity 28%	1:10	A 356	1 oz.	0 min.	799	1342		4	3.21	
	1:20	A 356	1 oz.	0 min.	801	1342		6	4.84	
				avg.	801.33	1342.33	2.58	5.00	4.04	
	AFTER 15 MIN. DEGAS									
Date 6-26-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 92	2:00	A 356	1 oz.	15 min	800	1343	2.59*	6	4.45	
Humidity 25%	2:19	A 356	1 oz.	15 min	804	1342		7	5.1	
	2:35	A 356	1 oz.	15 min	798	1342		7	6.1	
				avg.	800.67	1342.33	2.59	6.67	5.22	

				3 OZ. FLUX/15 MIN. DEGAS TEST						
TEST # 1	***BEFORE FLUX ADDITION/DEGASSING***									
Date 6-27-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 88	12:00	A 356	0 oz.	0 min.	807	1341	2.59*	3	2.66	
Humidity 52%	12:10	A 356	0 oz.	0 min.	815	1341		4	3.29	
	12:20	A 356	0 oz.	0 min.	810	1341		4	3.5	
				avg.	810.67	1341.00	2.59	3.67	3.15	
	AFTER 3 0Z. FLUX ADDITION									
Date 6-27-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 89	1:05	A 356	3 oz.	0 min.	806	1341	2.6*	5	3.75	
Humidity 51%	1:21	A 356	3 oz.	0 min.	811	1342		7	5.41	
	1:35	A 356	3 oz.	0 min.	815	1340		5	3.83	
				avg.	810.67	1341.00	2.60	5.67	4.33	
	AFTER 15 MIN. DEGAS									
Date 6-27-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 89.3	2:05	A 356	3 oz.	15 min	809	1343	2.61*	7	5.4	
Humidity 50.3%	2:15	A 356	3 oz.	15 min	810	1339		6	4.74	
	2:28	A 356	3 oz.	15 min	805	1341		7	5.34	
				avg.	808.00	1341.00	2.61	6.67	5.16	

TEST # 2	***BEFORE FLUX ADDITION/DEGASSING***									
Date 6-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 91.8	10:10	A 356	0 oz.	0 min.	840	1341	2.62*	3	2.7	
Humidity 38%	10:30	A 356	0 oz.	0 min.	805	1341		5	3.81	
	10:40	A 356	0 oz.	0 min.	809	1341		4	3.27	
				avg.	818.00	1341.00	2.62	4.00	3.26	
	AFTER 3 0Z. FLUX ADDITION									
Date 6-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 92.1	11:05	A 356	3 oz.	0 min.	814	1342	2.61*	5	3.82	
Humidity 37.4%	11:20	A 356	3 oz.	0 min.	808	1342		7	5.34	
	11:40	A 356	3 oz.	0 min.	806	1342		7	4.46	
				avg.	809.33	1342.00	2.61	6.33	4.54	
	AFTER 15 MIN. DEGAS									
Date 6-30-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 93.4	12:45:00	A 356	3 oz.	15 min	815	1340	2.61*	8	5.52	
Humidity 35.9%	1:01	A 356	3 oz.	15 min	807	1342		7	5.34	
	1:15	A 356	3 oz.	15 min	809	1342		8	5.89	
				avg.	810.33	1341.33	2.61	7.67	5.58	

					6 OZ. FLUX/15 MIN. DEGAS TEST					
TEST #1	***BEFORE FLUX ADDITION/DEGASSING***									
Date 6-19-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 88	2:15	A 356	0 oz.	0 min.	806	1342	2.63*	3	2.84	
Humidity 21%	2:20	A 356	0 oz.	0 min.	813	1341		5	4.59	
	2:30	A 356	0 oz.	0 min.	801	1342		5	3.78	
				avg.	806.67	1341.67	2.63	4.33	3.74	
	AFTER 6 0Z. FLUX ADDITION									
Date 6-19-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 89	2:45	A 356	6 oz.	0 min.	801	1342	2.61*	5	3.78	
Humidity 20%	2:55	A 356	6 oz.	0 min.	801	1342		5	3.97	
	3:10	A 356	6 oz.	0 min.	815	1342		5	4.01	
				avg.	805.67	1342.00	2.61	5.00	3.92	
	AFTER 15 MIN DEGAS									
Date 6-19-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 89.5	3:30	A 356	6 oz.	15 min	797	1342	2.61*	7	5.24	
Humidity 19.8%	3:41	A 356	6 oz.	15 min	797	1344		7	5.26	
	4:00	A 356	6 oz.	15 min	805	1342		9	6.75	
				avg.	799.67	1342.67	2.61	7.67	5.75	

TEST # 2	***BEFORE FLUX ADDITION/DEGASSING***									
Date 7-6-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 90	8:44	A 356	0 oz.	0 min.	810	1342	2.63*	9	6.03	
Humidity 22%	9:03	A 356	0 oz.	0 min.	807	1334	2.62*	5	3.89	
	9:14	A 356	0 oz.	0 min.	799	1342	2.62*	9	6.1	
				avg.	805.33	1339.33	2.62	7.67	5.34	
	AFTER 6 0Z. FLUX ADDITION									
Date 7-6-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 93.2	9:40	A 356	6 oz.	0 min.	799	1342	2.61*	8	5.53	
Humidity 17.6%	9:51	A 356	6 oz.	0 min.	807	1342	2.63*	8	5.31	
	10:00	A 356	6 oz.	0 min.	806	1337	2.65*	8	5.68	
				avg.	804.00	1340.33	2.63	8.00	5.51	
	AFTER 15 MIN DEGAS									
Date 7-6-97	Time	Alloy	Flux amount	Degas time	Funnel temp	Metal temp	Specific Gravity	Steps	Mass(lbs.)	Gas Cont.
Temp 94.2	10:45	A 356	6 oz.	15 min	804	1342	2.65*	9	6.59	
Humidity 16.7%	10:55	A 356	6 oz.	15 min	796	1343	2.64*	8	5.78	
	11:15	A 356	6 oz.	15 min	800	1337	2.64*	8	5.8	
				avg.	800.00	1340.67	2.64	8.33	6.06	
							NOTE: * indicates that RPT was not used			

TEST 1. POTATO INSERTION AS PART OF NORMAL PROCESS

DATE: 7/31/97
MELT TEMP: ~1520-1550F
ALLOY: A356

TIME	TEMP, F	HUMIDITY, %	SPECIFIC GRAVITY	Time of potato addition
7:00			2.09	
7:30	88	56.5	2.22	
8:00	93	40.3	1.99	8:01
8:30	92	43.7	2.11	
9:00	93	42	2	8:50
9:30	94	42.4	2.17	
10:00	94	42.1	2.05	10:05
10:30	95	40.1	2.06	
11:00	96	39.8	2.03	11:10
11:30	98	42.1	2.04	
12:00	99	39.1	2.08	12:20
12:30			2.07	
1:00			2.05	1:05
1:30			2.18	
2:00			2.17	
avg.	95.125	41.4	2.08	

TEST 2. A102-ALUMINUM BOILING FLUX

DATE: 7/31/97	
MELT TEMP: ~1520-1550F	
ALLOY: A356	

TIME	TEMP, F	HUMIDITY, %	SPECIFIC GRAVITY	Time of flux addition
7:21			2.05	7:00
7:50	86	33	2.07	
8:20	93	40.3	2.26	8:05
8:47	83	36	2.14	
9:20	84	34	2.28	9:10
9:40	84	33	2.1	
10:12	84	34	2.2	
10:40	84	34	2.16	10:00
11:10	86	32	1.96	
11:40	86	34	2.03	11:00
12:15	85	32	2.02	12:15
12:45			2.16	
1:15			2.14	1:05
1:45			2.1	
avg.	85.44	34.4	2.13	

TEST 4. A102-ALUMINUM BOILING FLUX

DATE: 8/21/97
MELT TEMP: ~1520-1550F
ALLOY: A356

TIME	TEMP, F	HUMIDITY, %	SPECIFIC GRAVITY	Time of flux addition
7:13	86	37.3	1.97	7:15
7:50	84.7	32.5	2.05	8:15
8:30	85.7	32.3	2.02	
8:50	82.1	35.5	2.01	
9:25	89.2	32	2.02	
9:45	92.7	25.5	1.98	
10:15	99.3	18.2	2.02	10:10
10:45	100.2	17.3	2.08	
11:05	97.8	20.5	2.09	
11:30	99.5	19.4	2.14	
12:05	99.1	19	2.09	12:15
12:25	98	20.5	2.01	
12:50			2.05	
1:07			1.97	1:05
avg.	92.39	26.3	2.04	

TEST 3. A102-ALUMINUM BOILING FLUX

DATE: 8/15/97	
MELT TEMP: ~1520-1550F	
ALLOY: A356	

TIME	TEMP, F	HUMIDITY, %	SPECIFIC GRAVITY	Time of flux addition
8:00	94	34.3	2.14	8:28
8:31	88.4	39.2	1.98	
9:02	87.7	42.4	2	9:00
9:30	88	43.5	2.03	9:32
9:43	86.8	44.4	1.99	
10:00	91.8	38.8	2.34	
10:20	92.4	37.3	2.09	10:21
10:45	92.2	36.4	2.02	
11:00	92.3	36.5	2.06	
11:15	94.1	36.2	2.02	12:00
12:25	96.6	32	2.02	
avg.	91.3	38.3	2.06	

*Note: Through visual inspection Sam Clay scraped nine castings