Section 1:

Safety Warning:

Using ***Z-Met*** involves working with molten aluminum. Specific activities include collecting samples of molten aluminum, transferring molten aluminum in 2" x 2" crucible to ***Z-Met*** unit and removing solidified sample piece from the crucible. The operation, therefore, expose operator to all hazards associated with handling of molten aluminum and additionally all hazards associated with high temperature.

IT IS STRONGLY RECOMMENDED THAT BEFORE OPERATING THE ***Z-Met*** UNIT, THE PLANT & LABORATORY SAFETY DIRECTOR ISSUES SAFETY PROCEDURES PER PLANT'S OPERATIONAL SAFETY POLICY TO ALL PERSONNEL WHO ARE LIKELY TO COME IN CONTACT OR OPERATE THE ***Z-Met*** UNIT.

The Equipment is designed to be used by only those Operators who are fully trained in procedures pertaining to operational safety associated with molten aluminum handling.

Particular attention must be given to the following activities:

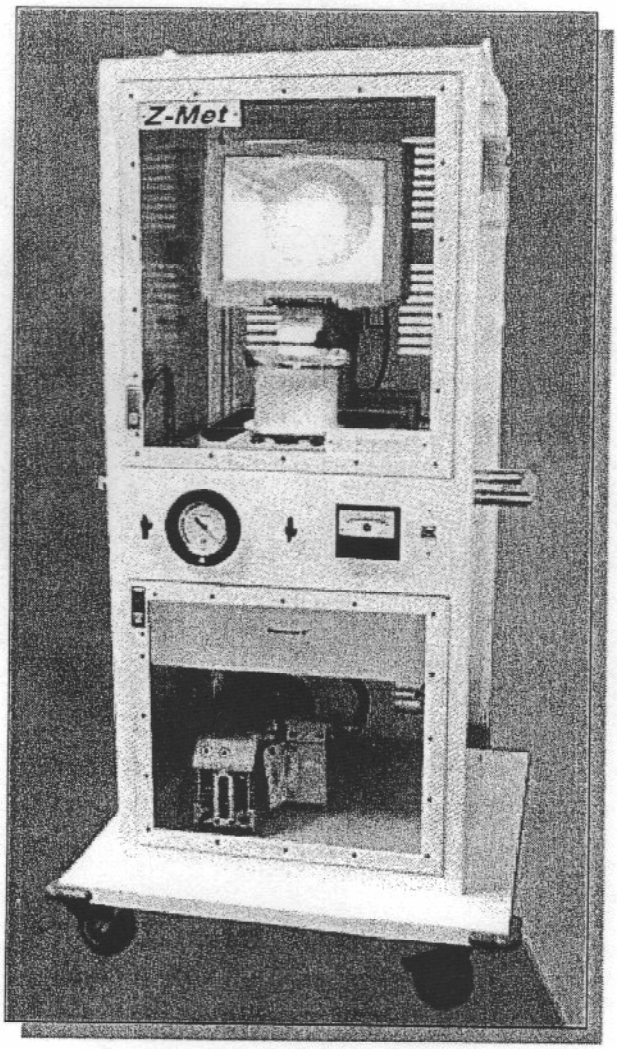
1) Drying of the crucible before collecting sample.
2) Wearing Aluminum Association approved protective clothing, goggles, face shield and gloves when collecting & transferring sample.
3) Avoid contact of water/moisture with molten aluminum.
4) Maintain safe distance from other operators on the shop floor when collecting & transferring sample.
5) For further information related to hazards pertaining to molten aluminum, please refer to Aluminum Association publication titled "Guidelines for Handling molten Aluminum" Issue 2003.Contact: The Aluminum Association, 900 19th St., NW, Washington D.C., 20006, Tel: 202-862-5100, Fax: 202-862-5164

NOTICE:

Working with molten Aluminum and its alloys is an extremely specialized operation involving substantial skills in many disciplines of the foundry practices and requires extensive prior hands-on experience on part of the operators and their managers to safely and effectively operate the subject equipment. The instructions given in this manual do not teach the art and science of working with molten aluminum and its

alloys. The manual only provides the equipment design and construction data, operation guidelines and maintenance procedures.

THE INFORMATION CONTAINED HEREIN IS OFFERED FOR USE BY TECHNICALLY QUALIFIED PERSONNEL AT THEIR DISCRETION AND RISK. ALL STATEMENTS, TECHNICAL INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED ON TESTS AND DATA WHICH WE BELIEVE TO BE RELIABLE, BUT ACCURACY AND COMPLETENESS THEREOF IS NOT GUARANTEED AND NO WARRANTY OF ANY KIND IS MADE IN RESPECT THERETO.



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Section 2:

Application:

Z-Met analyzes presence of dissolved hydrogen gas and inclusions inside molten aluminum on a qualitative real time basis. ***Z-Met*** is used by process metallurgists where immediate knowledge of cleanliness of molten aluminum is required for quality control and process correction. ***Z-Met*** has application in plants which manufacture highly sophisticated aluminum alloys and MMCs for aerospace, defense, Nuclear, automotive and electronic industry.

Method of Testing:

150 gms of molten aluminum (2" dia x 1" height) is collected in a specially designed crucible and vacuum chamber. The sample is solidified under ultra high vacuum generated very quickly in the solidifying chamber. The solidification process is viewed over a CTV screen. A video camera helps the operator to analyze the extent of release of hydrogen gas and the eruption of inclusions present in the sample. The ***Z-Met*** in-line test is extremely rapid and takes about 5 minutes from sample collection to completion of the test.

Z-Met Unit Specifications:

Size:	42" (1060 mm) x 42" (1060 mm) x 72" (1828 mm)
Weight:	200 lbs (91 kg) on mobile base
Voltage:	Available in 120/220 volts 50/60 Hz
Gas Detection:	From 0.08 cc/100 gms to 0.42 cc/100 gms
Inclusions:	From 20 microns to 3.0 mm qualitative
Size of sample:	About 0.3 lbs or 150 gms
Vacuum:	0.3 to 1.0 Torr for wrought alloys
	0.5 to 2.0 Torr for foundry alloys
Solidification Time:	1.5 to 3.0 Minutes depending on alloy and molten metal temperature.
Process Consumables:	None

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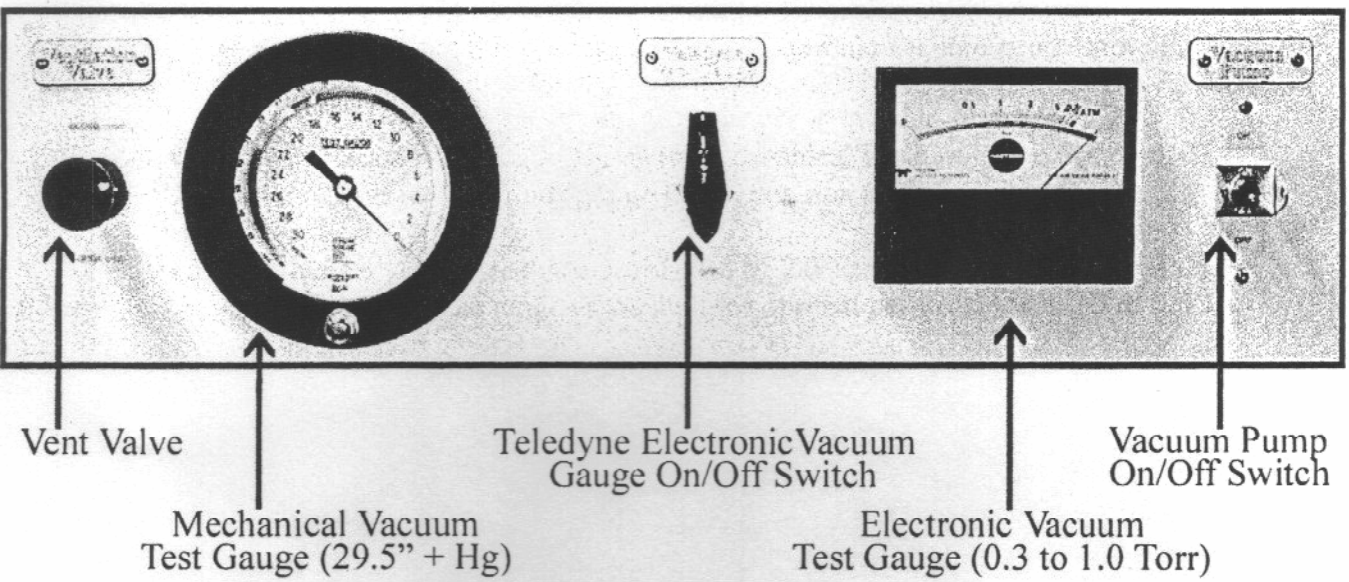
Section 3:

Operating Procedure:



3.1 Sample Collection

1) Make sure the crucible is clean & dry from inside and outside before deciding to use it for sample collection. The crucible should also have a light coating of release agent R20 or Boron Nitride on the inner surface.

2) Preheat the crucible for 30 seconds by holding it on top of molten aluminum about 0.25" (6mm) away from surface of the metal.

3) Preheat the crucible again from outside by dipping it 1" (25mm) deep inside molten metal for about 15 seconds.

4) Clean the molten aluminum surface skim from the area from where the sample is to be collected.

5) Collect the sample by tilting the crucible at about 30° angle and slowly dipping top edge below molten aluminum surface.

6) Collect about half crucible full of sample and immediately discard it.

7) Again collect a fresh sample per steps 4 & 5 of above and quickly transport the crucible to the vacuum chamber. Place the Pyrex observation glass on the "O" ring and start vacuum pump.

8) Make sure that the Vent Valve is fully closed while the vacuum is being generated. Also, at this time the lever for electronic vacuum gauge should in OFF position (pointing down).

9) When vacuum reaches 29" Hg on the mechanical vacuum gauge (round dial), turn the lever for electronic gauge to ON position (pointing side ways).

10) For Foundry Alloys, the vacuum should be 2.0 Torr or under. For Wrought Alloys, the desirable range of vacuum for optimal performance is 0.3 to 0.5 Tor

11) Observe the release of the gas bubbles and inclusions on the screen by directly viewing under the Pyrex glass. If the amount of gas in the metal exceeds 0.3 cc/100gms, the eruption of the bubbles can be extremely rapid and bubble counting may become difficult.

12) When the entire sample is solidified, turn the electronic gauge lever to OFF position (pointing down). Then switch the vacuum pump OFF and open the Vent Valve.

13) Remove the crucible from the chamber and separate the sample from the crucible. Inspect the interior of the crucible. If bare metal or scaling is visible, remove scaling and apply a light coat of release agent while the crucible is still hot.

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Section 4:

Sample Testing and Interpretation:

Application Background:

Molten aluminum alloys contain four types of impurities.

1) Dissolved hydrogen gas
2) Inclusions (metallic & non-metallic)
3) Dissolved alkali & alkaline earth metals
4) Salts of alkali & alkaline earth metals

These impurities have to be detected and removed prior to casting. ***Z-Met*** provides an immediate real time qualitative answer as to how much gas and inclusions are present inside molten aluminum. The ***Z-Met*** technique is based on the fact that, during solidification of the molten alloy under vacuum, the impurities behave in a definite manner. The solubility of hydrogen in the solidified metal is 20 times lower than its solubility in the molten metal. As a result, when vacuum is applied on top of solidifying melt, the hydrogen gas that is rejected ahead of the solidification front is lifted to the top of sample and the size of the gas bubbles and their number are directly proportional to the amount of gas present in the dissolved state. Rejected gas & inclusions are detected under the video camera. The hydrogen gas always preferentially nucleates at a site where an inclusion is present. Also, whether the inclusions are metallic or non-metallic (i.e. simple or complex ceramic particles) they are always floated to the top of the solidifying metal if vacuum is applied on the surface of the molten metal. Thus, the observation of the sample of molten metal "during" the solidification process reveals maximum information on the internal cleanliness of the molten metal.

For example, when gas content of molten alloy is 0.10 cc/100 gm, under 0.5 Torr vacuum, an alloy will show 3 small bubbles (0.1" dia) if inclusions are present or only one large bubble (0.25" dia) if the metal has low inclusion count. So the total number of bubbles released in the vacuum test gives a composite reading on the presence of gas and inclusions in the metal.

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The presence or absence of molten salts is also detected by virtue of the fact that the salt changes the surface tension of the alloy at the boundary of the gas bubble. A typical bubble under vacuum is allowed to grow to good extent inside the solidification chamber if the salts are present in the molten state of the alloy. In absence of the salt the bubble size remains relatively small before a break results in the surface of the bubble by the combined effect of vacuum and the buoyancy force of the hydrogen gas inside the bubble.

Therefore, by observing as to how long a bubble has remained as a bubble of same size (i.e. without growing or rupturing) in equilibrium with continuously applied vacuum an experienced operator can make qualitative decision regarding presence or absence of salts hand-in-hand with gas and inclusion detection. ***Z-Met*** thus provides a simultaneous qualitative determination of presence of impurities in the molten aluminum and allows process metallurgist to implement a process correction in the right direction.

A video recording device (available separately) can be attached to the camera or CRT screen output and batch to batch data can be maintained on the quality of the melt as a function of heat number.

It is to be noted that ***Z-Met*** device testing method is primarily based on observing the sample "during" the process of solidification. Therefore, ***Z-Met*** testing dose not require a post solidification sectioning of the sample to count the porosity bubbles (because most of the gas is already removed from the sample under ultra high vacuum conditions).

Specific gravity data could be maintained on the post solidified ***Z-Met*** samples, but because higher vacuum power is used in ***Z-Met***, a different set of numbers of density values are developed by each plant. Specific gravity values taken on ***Z-Met*** samples should not to be compared with plant's data taken on low vacuum devices.

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