SAFETY: 8

SAFETY PRECAUTIONS

The precautions. Outlined here, are well known to Melt Shop people. They are common to all metal melting operations and are not peculiar to induction melting. The following are offered as general precaution, applicable to the foundry and steel plant and cannot be constructed to cover all types of operations. We suggest that the user evaluate these precautions in light of their specific operations and expand or modify them as necessary.

* Access to melting and pouring operations should be limited to authorize personnel only.

* Personnel should wear safety glasses at all times and should use special light reducing glasses
When viewing metal at high temperatures.

* Heat and flame retardant safety clothing should be worn by personal who work at or near
Furnaces.

* The refractory that is used to line the furnace must be suitable for the material being melted
Refer to the refractory manufacture's specifications. Be sure that furnace linings have been
Thoroughly dried and sintered in accordance with manufactures recommendations.

* In induction melting, furnaces should be charged carefully to avoid bridging of the charge
Excessive temperature in the bath below the bridge can cause rapid erosion of the furnace
Lining and a dangerous run-through which could cause an explosion. To melt out a bridge
After it has formed. 1st tilt the furnace to 30 to 40^0C and the power supply should be run at
Lower power to prevent superheating. Normally about 25% above holding power is suffic-
lent to slowly melt out the bridge. Holding power is the power level required to maintain the

Molten metal in a fully molten condition at constant temperature. Till the molten metal come In contact with the bridge. After a hole has been melted through the bridge, return the furnace To the upright position. Then check temperature to make sure the molten metal is not super-Heated. Begin adding charge through the hole in the bridge to bring the molten metal into Contact with the bridge. Be careful not to superheat the molten metal during this procedure.

If you are unable to break through the bridge. Turn the power off and contact at Magnalenz.

GENERAL MELTING PRECAUTIONS:

* Regularly inspect furnace lining to minimize the possibility of a dangerous “run through “ Occurring.

* The furnace lid (where one is used) should be closed before the furnace is tilted.

* Charge materials must be dry and free of combustible materials and liquids. If submerged Under a molten bath, can vaporize and cause a possible boil-over or explosion.

* Care should be exercised when adding low melting point materials that have low vaporization Temperatures into high temperature baths. If such materials become submerged before they Melt, they can vaporize and cause a possible boil-over or explosion.

* Crucibles for lift coil or push out furnaces should be used only for those metals for which they Are suitable. Generally, crucibles are not designed for the high temperatures encountered in

Melting nickel, Monel, copper-nickel or ferrous materials (Refer to the crucible manufacturers
Specifications regarding the materials that may be melted in crucibles).

* When metal is to be transferred in a crucibles, a cradle that provides adequate bottom
Support for the crucible must be used.

* Be knowledgeable of the chemistry of your melt. Chemical reactions such as a rapid carbon
Boil can damage equipment and be dangerous.

FOR OPERATOR...

Ail induction heating/melting equipment uses high-voltage power during operation. Magnalenz
Built equipment is designed for safe, efficient and reliable operation with maintenance ease. If
Some simple rules of operation are observed.

Several safety features are built into Magnalenz equipment to provide operator protection. DO
NOT OVER LOOKED THESE SAFETY FEATURES.

* Keep all cabinet doors locked and make keys available only to those who require access to the
Enclosure.

* Keep shields, covers and other protective devices in place at all times. An open enclosure is a
Peril to personnel
* Don't depend on interlock devices for protection. Be sure power switches are in the "Off"
Position before any access with the panel.

* Put warning tags and padlocks on main power disconnects whenever working in cubicles,
Vaults, bus trenches, or furnaces to prevent anyone from mistakenly applying power to the
Equipment.

* Always switch power off when lifting, pouring or transporting furnaces.

WHEN CHARGING A FURNACE...

* Use only dry charge material.

* Be sure bundled or baled scrap is dry before adding to melt.

* Do not allow closed or partially closed containers that may contain liquids (beverage can Sheared tubing, etc.) to be mixed with the furnace charge. Liquids or pieces of combustible material can vaporize instantly upon contacting the melt and scatter molten metal.

* The above precautions are especially important with aluminum because scattered molten Particles can combine with oxygen which can result in a secondary explosion.

FOR MAINTENANCE PEOPLE...

* Study the Maintenance Manual.

* Become familiar with the unit an its dangerous areas before attempting maintenance of any Kind.

* Always use independent methods to support a tilted furnace whenever working on or near.

* Never enter the high risk zone like running crucible/ ON-SOLID state generator. Always work on electrical section of furnace with main Breaker off and keep fuses With while working.

MOLTEN METAL SPLASH

THE MOST VISIBLE HAZARD:

Wet charged materials are serious hazard in all foundries and steel plant. When molten Metal comes in contact with any water, moisture or liquid-bearing material, it instantaneously.
Turns to steam, expanding to 1600 times to its original volume and producing a violent explosion.
This occurs without warning and throws molten metal and possibly high-temperature solids out
Of the furnace and puts workers, the furnace itself and nearby plant and equipment at risk.

A water/metal explosion can occur in any type of furnace. For an induction furnace, however,
The after effect may be more serious and include the possibility of additional explosions caused
By liquid in a ruptured cooling system coming in contact with molten metal in the bath. (See Cooling system description below.)

Explosions also can occur if sealed drums or containers containing water/oil etc are charged into
An empty but hot Furnace. In this case, the force of the explosion will reject the newly charged
Material and quite likely damage the refractory lining as well.

The violent and unpredictable nature of a water/metal explosion makes the wearing of safety
Clothing by melt shop workers absolutely imperative. Such clothing can prevent disfiguring and incapacitating burns as well as fatal burns.

ELIMINATING WET SCRAP

In foundries where most of the charge originates as scrap, wet charge materials pose the greatest
Cause for concern. Some foundries reduce the possibility of water/metal explosions by storing

Scrap undercover for a least one day and then carefully inspecting bales and containers for any
Residual moisture. But a more reliable solution being used by an increasing number of foundries
Today is to use remote charging systems with charge dryers or pre heaters.

Remote charging systems permit the operators to be safely back from the furnace or behind
Protective screens during charging. Dryers and pre heaters maximize the removal of water and
Moisture before the scrap enters the bath.

SEALED CONTAINERS:

An easily overlooked danger is posed by sealed containers and sections of tubing or piping that
Are sheared closed in both ends. Obviously, containers holding combustible liquids or their fumes
Will explode lone before the scrap itself melts. Pre heating sealed materials will not prevent this
Hazard. In fact, there is a risk that a sealed container will explode inside the pre heating systems.
Operator vigilance is the only preventive measure. Sealed material must never be permitted into
The furnace or preheated. Sheared sections of scrap tube and pipe and apparently empty sealed
Containers may seem less dangerous, but can be equally hazardous. Even though they do not
Contain combustible liquids; the air inside them can rapidly expand in the heat. In extreme cases
The pressure buildup will up be sufficient to breach the container wall or escape through a sheared
Closed end. If this occurs, the forceful expulsion of gas propel that hot scrap out of the furnace or
Smash it into the furnace lining, causing damage.

OTHER HAZARDS:

Cold charge or tools and easily fragmented materials pose a special hazard for induction furnaces
And their operating personnel because they may contain a thin layer of surface or absorbed moisture.
On contact with the bath, the moisture turns to steam, causing spitting or splashing. Proper protective clothing and face and eye protection normally will protect the operator. Per heating the charge and
Tools prevent many splashing injuries.

In ferrous metal foundries the greatest splashing risk occurs toward the end of the melt. When a
Foundry man adds Ferro-alloys or introduces tools into the melt. Ferro-alloy materials can absorb
Moisture from their surroundings. Sampling spoons and slag rakes collect moisture as a thin film
Of condensation. Following manufactures instructions for storing alloying materials and pre heating
Tools minimize moisture accumulation, reducing the risk of splashing.

Ina nonferrous foundry, spitting or splashing can accompany the introduction of ingots into the
Melt, as surface condensation comes in contact with molten metal. Ideally, ingots should be only
Placed in an empty furnace or on top of solid foundry returns. Ingots added to a molten pool
Should be pre heated, or introduced using a remote charging system.

Since it is impossible to wring every bit of the humidity from the open air, there is always a potential
For moisture condensation and splashing. Moisture condensation and absorption tends to increase
With time between melts. The greatest splashing hazards therefore are likely to occur at the beginning
Of the working week or workday, or after a furnace have been taken out of service for maintenance.
Allowing more time for the initial melt during these start-up periods can help to reduce the potential
For splashing hazards.

CENTRIFUGALLY CAST SCRAP ROLLS:

Special steps need to be taken when charging a furnace with centrifugally cast scrap rolls. Ideally,
This type of scrap should not be melted in an induction furnace. The hazard stems from the possi
bility a roll may contain a ductile inner core surrounded by a brittle outer layer. The different rates
Of expansion can cause the surface material to explosively separate from the roll, damaging equi
pment and injuring personnel. If scarp are to be melted, the fragmenting hazard can be minimized
By breaking the scrap before charging.

PRIMARY CAUSES OF METAL SPLASH AND FURNACE ERUPTIONS:

1. We tor damp charge material.

2. Dropping heavy charge material into a molten bath.

3. Wet or damp tools or additives.

4. Sealed scrap or centrifugally-cast scrap rolls.

PRIMARY PROTECTION FROM SPLASH AND FURNACE ERUPTIONS:

1. Personal protective clothing and equipment.

2. Scrap drying and pre heating systems.

3. Remote charging systems.

FURNACE COOLING

For those unfamiliar with induction melting, it may seem unusual for a high-temperature furnace
To be equipped with a cooling system that operates by circulating water inside electrical conductors
Carrying thousands of amps of electric current. Yet without continuous cooling, induction furnaces
Cannot operate. Any event that interferes with normal furnace cooling can quickly lead to coil
Damage and may lead to a catastrophic explosion.

The furnace coil, which produces the electromagnetic field, is not designed to get hot. Although

Some heat is conducted from the molten bath through the lining to the coil, most of the heat Load on the coil is caused by the current flowing through it. This requires that it be continually Cooled, not only to increase its electrical efficiency, but also to prevent it from melting.

Typically the cooling system is built into coil itself, which is made of hollow copper tubing in which
The cooling water flows. The water picks up the heat caused by the current as well as heat conducted
From the metal through the refractory and carries it to a heat exchanger for removal.

If an electric or mechanical failure damages the pump that circulates the water, a dangerous heat
Buildup could lead to coil insulation damage, coil arcing and water leeks. These could then lead to
A major explosion that could occur within minutes. Therefore, induction furnaces should have a
Backup cooling system, such as battery-powered or engine-powered water pump or city water
Connection that can be engaged if normal pump operation fails.

REFRACTORY

KEEPING A SAFE REFRACTORY LINING:

Proper and well-maintained refractory linings are important for the safe operation of all metal
Melting furnaces. In induction furnaces, they are absolutely critical. The physics of electrical
Induction demands that the refractory lining between the induction coils and the bath be as thin
As possible. At the same time it must be thick enough to fully protect the coils and prevent metal
Run out in the face of attacks by molten metal, chemical agent's mechanical shocks. Assuring that
The furnace lining remains safely within manufacture-specified limits requires careful treatment
Of the lining during all furnace operations as well as comprehensive inspection and monitoring
Procedures.

Without question, metal run-out ranks among the most severe accidents that can occur during
Melting and holding operations. Run-outs occur when molten metal breaks through the furnace

Lining. If cooling, electrical, hydraulic, or control lines become damaged, there may be an immin
ent danger of a fire or water/metal explosion. Maintaining the integrity if the furnace lining is the
Key to preventing a run-out.

The integrity of the furnace lining can be compromised by the following:

* Installation of the wrong refractory material for a particular application.
* Inadequate or improper installation of refractory material.
* Failure to monitor normal lining wear and allowing the lining to become too thin.
* The sudden or cumulative effects of physical shocks or mechanical stress.
* The sudden or cumulative effects of excessive temperature or thermal shocks.
* Slag or dross buildup.

Any one of these situations can result in a metal run-out from an induction furnace. Therefore,
Careful attention to a furnace's lining is absolutely crucial to safe melting and holding.

CHOOSING THE RIGHT REFRACTORY

Refractory material consists of several chemical compounds. The bulk of any lining material
Consists of a class of compounds called oxides. Refractory linings used in induction furnaces
Are commonly made of alumina, silica, or magnesia, plus smaller amounts of binding materials.

Choosing the right refractory material for your specific melting or holding applications is crucial.
You must take into account the specific metal you will be melting the temperature you will be reaching, the length of your melt, how long you will be holding in the furnace, how much inductive stirring will take place, what additives or alloying agents you will be using and your furnace relining practices.

The best way to select the right refractory is thought close consultation with your refractory vendor. He or she will have the most current information on the specifications and performance charac
teristics of traditional and new refractory material.

PROPER INSTALLATION OF A FUNACE:

Proper installation of the lining is as important to the safe operation of the furnace as the selection
Of the right material for your application. If the refractory material is inadequately consolidated
During installation, voids or areas of low density may form creating a weak spot easily attacked by
The molten metal. If the crucible is created with a form or ram that is improperly centered, or one
That has been somehow distorted during storage or shipmen, lining thickness will be uneven. As a result, the lining may fail before the end of its predicted service life.

It is especially critical that the refractory manufacturer's procedures for drying and sintering be
Exactly followed, and never hurried. If sufficient time is not allowed for the refractory materials
To bond, the lining will be more prone to attack by molten metal and slag.

Coreless furnaces sometime use preformed crucibles for nonferrous melting in place of rammed linings. One advantage of crucibles is that they can be manufactured with a protective glaze. In addition to minimizing oxidation of the refractory material, the glaze can seal-over any small cracks that develop during routine foundry operation. The protective effects of the glaze last only so long
as the coating remains undamaged. Should it become chipped or otherwise compromised during installation or subsequent operations, a small crack will, rather than "self-heal" being to spread.
Metal run-out may then occur.

MONITORING NORMAL LINING WEAR:

In induction furnaces, refractory linings and crucibles are subject to normal wear as a result of the scraping action of metal on the furnace walls. This is largely due to the inductive stirring action caused by the induction furnace's electromagnetic field. (See box at bottom of page.)

In theory, refractory wear should be uniform, in practice this never occurs. The most intense wear occurs:

* At the slag/ metal interface

* Where side walls join the floor

* Thin spots caused by poor lining procedures.

The entire furnace should be visually inspected whenever it is emptied. Special attention should be paid to the high-wear areas described above. Observations should be accurately logged.

Although useful, visual inspections are not always possible. Nor can visual inspections alone reveal all potential wear problems. Some critical wear areas, such as the inductor molten metal loop of a channel furnace, remain covered with molten metal between relining. The presence of a low-density refractory area can likewise escape notice during visual inspections. These limitations make lining-wear monitoring programs essential.

Directly measuring the internal diameter of the furnace provides excellent information about the condition of the lining. Ideally, a base-line plot should be made after each relining. Subsequent measurements will show the precise rate of lining wear or slag buildup. Determining the rate at which the refractory material erodes will make it possible to schedule relining before the refractory material becomes dangerously worn. A word of caution. Calipers are insufficiently accurate for this purpose. And should not be used. Measurements should only be made using an accurately positioned center post equipped with a radial measuring arm.

In situations where visual inspections of coreless furnaces are impossible, when, for example, they are used for continuous holding and dispensing, operators should remain alert to the following important warning signs of lining wear.

* Attainment of maximum power at a lower than normal applied voltage.
* Furnace running at low pf indication with current limit.
* In a solid state power supply, when voltage and power starts dropping.
* Furnace draws less power and cause for slow melting.
* When furnace trips in ELU.
* Crucible temperature raises abroubptly.
* Higher slage generation cause of slower melting.

* Frequency of the operation going on increasing.

Useful though they may be, changes in electrical characteristics must never be thought of or used as a substitute for physical measurement of the lining itself.

Regardless of the instrument a foundry uses to monitor lining wear, it is essential to develop and adhere to a standard procedure. Accurate data recording and plotting will help to assure maximum furnace utilization between relining, while minimizing the risk of using a furnace with a dangerously thin lining.

PHYSICAL SHOCK AND MECHANICAL STRESS:

The sudden or cumulative effects of physical shocks and mechanical stress can also lead to a failure of refractory material.

Most refractory materials tend to be relatively brittle and weak in tension. Bulky charge material dropped into an empty furnace can easily cause the lining to crack upon impact. If such a crack goes unnoticed, molten metal may penetrate, leading to a run-out with the possibility of a water/metal explosion.

Bulky material should, if possible, always be lowered into the furnace. If it must be “dump charged”, be sure there is adequate material beneath the charge to cushion its impact. The charge must also be properly centered to avoid any contact with the sidewall.
Remotely controlled, automated charging systems are engineered to put charge materials into the furnace without damaging its lining.
Mechanical stress caused by the different thermal expansion rates of the charge and refractory material can be avoided by assuring, metal does not become jammed within the furnace. Except when it is done for safety reasons, dealing with a bridge for example, the melt must never be allowed to solidify in the furnace. In the event of a prolonged power failure, a loss of coolant event, or other prolonged furnace shutdown, the furnace should be emptied.

EXCESSIVE TEMPERATURES/THERMAL SHOCK:

Refractory manufacturers take furnace temperature extremes into account in formulating their products. For this reason it is important that refractory materials be used only in applications that match a product’s specified temperature ranges. Should actual furnace conditions heat or cool the lining beyond its specified range, the resulting thermal shock can damage the integrity of the lining. Cracking and spilling can be early warning signs of excessive thermal shock, and a potentially serious metal run-out.

Thermal shock can also be caused by excessive heating or improper cooling. The best way to avoid overheating is to monitor the bath and take a temperature reading when the charge liquefies. Excessive superheating of the bath must be avoided. Careful monitoring is essential. Temperatures exceeding the refractory's rating can soften its surface and cause rapid erosion
Leading to cata-strophic failure. The high heating rates of medium frequency coreless furnaces enable them to quickly overheat. Channel-type holding furnaces have low heating rates and thicker linings in the upper case. However, temperature control is also necessary because the inductor linings tend to be thinner. In all types of induction furnaces, kilowatt-hour counters, timing devices and computerized control systems can help prevent accidental overheating.

When working with a cold holding furnace be sure it is properly preheated to the refractory manufacturer's specifications before filling it with molten metal. In the case of melting cold charge material slowing the rate of the initial heat up until molten metal begins to form will minimize the risk of thermal shock to a cold furnace. The gradual heating of the charge allows
Cracks in the refractory to seal over before molten metal can penetrate. When cooling a furnace following a melt campaign follow the refractory manufacturer's recommendations.

MANAGING SLAG OR DROSS:

Slag or dross is an unavoidable by product of melting metal. Slag forms when rust, dirt and sand from the charge and refractory material eroded from the furnace lining, separate from the melt and rise to the top of the bath. Dross is created when oxides form during the melting of nonferrous metals such as aluminum. Chemical reactions between the slag or dross and the melt increase the rate at which the lining erodes.

A highly abrasive material, slag or dross will erode away refractory material near the level of the molten metal. It is not uncommon for this part of the furnace to be patched between scheduled relining. In extreme circumstances. This erosion may expose the induction coils, creating the risk of a water/metal explosion. Refractory linings in this condition should be removed from service immediately.

Although unavoidable, the effects of slag attack can be minimized by limiting the amount of rusty scrap in the charge shot blasting foundry returns and avoiding excessively high temperatures. Dross formation can be controlled through careful regulation of stirring, metal level and temperature.

ELECTRICAL MONITORING OF LINING WEAR

A limited amount of information about the condition of the refractory can be ascertained from changes in the furnace's electrical characteristics. An important limitation of these measurements is that they reveal average conditions. Electrical measurement will not isolate a localized problem, such as a gouge or a void beneath the lining surface.

The main bath or upper case refractory can be subject to chemical attack at the slag line. The slag line can be at any level in the furnace depending on how it is operated. The lining should be checked visually and also the outside if coil should be checked. If the refractory is thin, this will show as a hot spot on between two turns of coil. Once detected, the furnace lining should be carefully inspected. If the lining is severely eroded, the furnace should be removed from service immediately.

This precise melting control optimizes power usage by minimizing temperature over shooting saves time by reducing frequent temperature checks and enhances safely by reducing the chance of accidental superheating of the bath. This also serves to make for safer melting since accidental superheating can cause lining failure and the possibility of a furnace explosion.

PUSH-OUT SYSTEMS MINIMIZE REFRACTORY DUST DURING LINING REMOVAL

Before automated lining removal systems were developed, removing a furnace lining was a labor-intensive, time-consuming process which exposed workers to hazardous dust. Today, however, coreless induction furnaces equipped with lining push-out systems speed the lining removal process, lessen the risk of damage to the coil and reduce worker exposure to refractory dust.

These systems can be supplied with new furnaces or retrofitted to existing furnaces. They consist of a hydraulic ram and a pusher-block in the bottom of the furnace. These works together to remove the bottom and side refractory material.

BRIDGING

Bridging Situations Require Immediate Emergency Action to Prevent Run-out.

When cold charge material in the top portion of the furnace is not in contact with the molten metal the bottom of the furnace, the condition known as “BRIDGING” exists.

When bridging occurs, cold charge material is no longer serving to moderate the temperature of the bath during the melting cycle. Also, the air gap between the molten metal and the bridge acts as an insulator. The molten metal in the bottom of the furnace under the impact of full melting power will superheat. This superheating in an induction furnace will occur very rapidly and will soon raise the temperature of the bath above the maximum temperature rating of the refractory. Also, excessive stirring in the bottom of the furnace due to the small metal mass and high power density will combine with the high metal temperature to cause rapid lining erosion or possibly complete refractory failure.

Without immediate attention to a “bridging” condition, a run-out may occur. If the run-out is through the bottom of the furnace it can cause a fire under the furnace and it the pit area with loss of hydraulics control power and water-cooling.

If the molten metal melts through the furnace coil and water comes in contact with the molten metal the water instantaneously turns into steam with a expansion ratio of 1600 to 1. If the water gets under the molten metal this instantaneous expansion may produce an explosion which could cause injury or death and extensive damage to equipment.

Bridging can occur in any induction furnace and all furnace operators must be able to recognize bridging and its dangers. All operators also must know how to solve a bridging problem.

Bridging can be minimized by using proper charge material and by making sure the different sizes of charge material are added correctly. If a bridge occurs, power must be turned off until the bath temperature is known. It the bridge has completely sealed the top of the furnace pressure may build up between the molten metal and the bridge. If this has happened, it’s safest to allow the molten metal to freeze.

If it can be determined that the bridge has not sealed the top of the furnace and that pressure has not built up within the furnace, the furnace may be tilted to attempt to melt out the bridge. Put a ladle in front of the furnace to catch any metal that may spill out. Then tilt the furnace carefully until the molten metal is in contact with the bridge material (approximately 30 to 40 deg) the molten metal will then melt a hole in the bridge.

Power must be off while melting out the bridge and all unnecessary personnel should be kept away from the furnace. Do not stand in front of the furnace while melting out a bridge. Under no circumstances should an oxygen lance or burning bar be used to cut through the bridge!

After a hole has been melted through the bridge return the furnace to the upright position. Then check the temperature to make sure the molten metal is not superheated. Begin adding charge through the hole in the bridge to raise the bath level. This brings the molten metal into contact with the bridge melting it into the bath. Adding charge also will cool the molten metal and power may have to be reapplied to maintain the proper pouring temperature. However, power must not be turned on if there Is any one of the following conditions:

1. There has been a earth leakage trip, indicating metal penetration to the coil.

2. The solid-state power supply start running at low voltage and reduced power these conditions indicate an eroded lining.(at low pf indication running)

3. There is excessive surface slag visible. This is evidence of serious lining damage.

4. The water temperature in the coil is higher than normal.(more than 60^0 to 65^0)<u>Each of these conditions indicate that molten metal may be next to the coil and require immediate evacuation of the area until all of the metal in the furnace has solidified.</u>

If none of these conditions exist, melting the bridge can continue. Once the bridge has been melted away, the furnace should be poured empty as soon as possible so the lining can be examined for any signs of damage. If there is any doubt the integrity of the lining. Replace it!

WARNING SIGNS OF BRIDGING:

Bridging may reveal itself with one of several warning signs. The clearest warning sign that bridging has occurred is that the melt is taking longer time than calculated, furnace run at low PF mode. Rather than increase the power, the operator should switch off power immediately. Under no circumstance should the operator increase power. If ferrous metal is being melted, the chemical reaction, which it creates on contact with the furnace lining. Will under super heated conditions, produce carbon monoxide. This gas may reveal itself as small blue flames on or in the bridge. The appearance of these flames indicates the bridge may be pressurized, and it must not be breached. In the case of a nonferrous charge gas production will also occur, but there are no flames or other visible indications of its presence.

EARTH (GROUND) LEAK DETECTION SYSTEMS

The earth leak detector system for use with most coreless induction furnaces (except removable crucible furnaces) and power supply units crucial to safe melting and holding operations. The system which includes both a earth detector circuit associated with the power supply and a earth leak detector probe (ANTENNA) located in the furnace, is designed to provide important protection against electrical shock and warning of metal-to –coil penetration a highly dangerous condition that could lead to a furnace eruption or explosion.

EARTH LEAK PROBE KEY TO PROTECTION:

Key to this protection in furnaces with rammed linings or conductive crucibles is the earth leak detector probe (ANTENNA) in the bottom of the furnace. This ANTENNA is composed of an SS304 wire connected to earth which extend through the refractory and contact the molten bath. This system serves to electrically ground the molten metal bath (See figures ANNEX-B)

This probe configuration provides shock protection to melt deck workers by assuring that there is no voltage potential in the molten bath. If molten metal were to touch the coil, the ground leak detectors probe will conduct current from the coil to ground. The ELU circuit will detect this and the power will be shut off to stop any coil arcing. This also prevents high voltage from being carried by the molten metal or furnace charge. Such high voltage could cause serious or even fatal electrical shock to the operator if he were to come into conductive contact with the bath.(As a normal safety precaution power to the furnace always should be turned off during slugging sampling and measuring.)

It is important to check your furnace’s ground leak detector probe frequency because it can be covered during improper furnace relining can burn off, can be isolated by slag, or otherwise can be prevented from providing a sound electrical ground.

Your melting system’s ground detector circuit also should be checked at least daily. In a typical system this is done by pushing a test button on the detector which briefly simulates an actual ground fault.

Because of the crucial safety functions earth leak detection systems have in coreless induction melting and holding, your furnace should not be operated without a fully functional earth leak detection system.

MOLTEN ALUMINUM-LOWER TEMPERATURE HIGHER RISK

While molten aluminum melts at a lower temperature than ferrous metals it nevertheless presents a greater metal splash hazard to the foundry worker.

Small droplets of molten iron have a tendency because of their extremely high temperature typically greater than 2800^{0}F 750^{0}C to pop off of exposed skin due to moisture on the skin surface. Molten aluminum, however, sticks to bare skin, producing severe and possibly disfiguring burns. If larger amounts of metal are involved, the burns can be fatal.

Wearing proper protective clothing and equipment, including safety glasses, face shield head and body protection and foot and hand protection is as crucial to safety when working near molten aluminum as it is with ferrous metals.

Safely professionals advise that not all- protective clothing provides the same protection against all metals. For example they report that molten aluminum sticks to same fabrics and not to others. Also, some types of aluminized fabrics ignite when splashed with molten aluminum while others do not. They recommended that splash tests be conducted to evaluate new protective equipment before it is put into use.

SAFETY REVIEW

PERSONAL PROTECTIVE CLOTHING CAN SAVE YOUR LIFE:

If a melt shop person's first of defense against death or injury is safe equipment and training that enables him to operate it properly under both routine and emergency conditions, his final line of defense is his safely clothing. Various organizations that set national standards have established broad guidelines for the use of protective clothing in the metal casting & Steel industry. These organizations tend to agree on the basic types of personal equipment which provide workers with meaningful protection from molten metal exposure.

Many protective clothing manufacturers and distributions have refined industry guidelines. Armed with knowledge of the latest technological advances in protective materials and products, they can tailor safely- clothing programs to specific foundry needs.

There are two types of protective clothing worn in foundry, primary and secondary protective clothing.

PRIMERY PROTECTIVE CLOTH

PROTECTIVE CLOTHING : THE WEARS AND WHAT-FORS

Magnalenz would like to point out what is being done in the area of personal protective clothing to minimize the occurrence of molten metal-related accidents.

CURRENT STANDARDS

Various organizations that set national standards have established broad guidelines for the use
Of protective clothing in the metal-casting industry. They tend to agree on the basic types of personal equipment which provide workers with adequate protection from molten metal exposure.

We recommended the wearing of heat and flame retardant safely clothing and safely glasses by all personnel who are on or near furnaces.

In addition to the essential flame resistant undergarments, heavy flame retardant splash coats, hard hats, face shields, eye protection, heavy gloves, leather leggings (calf high), and metatarsal shoes (designed to protect the entire top of the foot). Where airborne hazards and noise pollution pose a threat, these committees also advocate the use respirators and hearing protection devices.

SUPPLIER RECOMMENDED

Many protective clothing manufacturers and distributors have refined these guidelines considerably. Armed with knowledge of the latest technological advances in protective materials and products, they are quite willing to tailor safely clothing programs to specific needs.

Outer garments. For protection against both heat and liquid metal contact, these suppliers suggest the use of aluminized glass outer wears. As they report, this apparel will reflect about ninety percent of the radiant heat away from the body, and will also shed molten metal splash and sparks.

<u>One manufacturer of protective apparel recommends the following safely garments:</u>

* Aluminized glass coat, 50” long.

* Fiberglass-framed helmet with aluminized glass cover, gold filmed heat resistant window, and
  Either ratchet-type or hard cap headgear.

* Gloves with chrome leather front and aluminum rayon back, aluminum rayon back, front
  Cuff, and thumb; fire resistant lining: 14” long.

* Aluminized glass leggings with leather flare.

* Metatarsal-guard safely shoes.

Undergarments. Fire resistant and washable clothing of cotton sateen is frequency prescribed for use underneath heavier outer garments. These fabrics are said to provide optimum operator protection without sacrificing comfort for restricting flexibility.

Some suppliers have also classified their protective garments by metal type. When melting ferrous and other metals at high temperatures, they advise using clothing which has undergone phosphorous-base treatment. However, for resistance to the clinging of molten splash from lower temperature melts. Such as aluminum these vendors recommended apparel of a non-phosphorous treatment base.

<u>PRIMARY PROTECTIVE CLOTHING:</u>

Primary protective clothing is the gear, which you wear over your secondary clothing when there is significant exposure to radiant heat, molten metal, splash and flame. It is designed to give you the greatest protection. Primary protective gear should by worn during work activates like charging, tapping, pouring, and casting operations, when there is close proximity to molten metal. Primary protective clothing includes safely glasses, a face shield, hard hat, jacket, apron, gloves, leggings, spats, cape and sleeves, and can be made of aluminized glass fabrics, leather, special synthetic fabrics or treaded wool. Melt shop person working with or directly exposed to molten metal, must wear primary protective clothing. Improper, flammable clothing is the number one cause of severe burns due to molten metal.

For eye/face protection, safely glasses with side shields would be the minimum requirement. For molten metal exposure, a face shield is needed in addition to safely glasses. Your eye is extremely susceptible to injury, and protection is so easy to provide.

For head protection from flying/falling objects, shocks, splashes, etc. a hard hat should be worn. Visitors should also be made to wear hard hats at all times irrespective of their duration of stay or place of visit.

Working near places where there is heat, heat resistant/flame retardant gloves should be worn. Cotton hand mill gloves are a minimum. In working near molten metal, foundry gloves, which extend above the wrists, should be worn.

For protection of the body, arms and legs, aluminized glass outerwear has been recommended by many clothing suppliers for protection against radiant heat and molten metal. Aluminized glass outerwear similar to that pictured here, will reflect about ninety percent of the radiant heat away from the body, while shedding molten metal splash and sparks.

USE LEGGINGS TO COVER YOUR LEGS

Pourer's or lace less safely boots is recommended for foot protection from molten substance exposures. They can be removed quickly in case of metal getting inside. Metatarsal-guard shoes protect the top of the foot. If laced boots are worn, they should be covered with spats, especially near the top where there is danger of the molten metal entering.

Several suppliers classify protective garments according to metal types. When melting ferrous and other metals at high temperatures, they advise clothing which has undergone phosphorous base treatment. However, for resistance to the clinging of molten splash from lower temperature melts, such as aluminum, these vendors recommended apparel of a non-phosphorous treatment.

SECONDARY PROTECTIVE CLOTHING

Secondary protective clothing is worn in areas where there is less hazard and is used to prevent ordinary clothing from igniting and burning. Flame resistant coveralls would be an example of secondary protective clothing. While secondary clothing is not a ticket to complete safely, it will help to reduce burns significantly. Many cases, serious burns and fatalities have occurred because ordinary clothing caught fire from a small spark or splash, not because of burns caused directly by molten metal.

Along with secondary protective clothing you also should wear natural fiber outer clothing, under-garments and socks. Some synthetic fabrics melt or catch fire and this can increase the bum hazard. Safety clothing suppliers recommend the use of washable, fire resistant undergarments. Cotton sateen is frequency recommended as offering the best or protection, without sacrificing comfort or restricting flexibility.

Certainly, foundries are hot places to work and protective clothing adds to the problem of heat related stress. But the clothing can save your life.

MASKS AND RESPIRATORS:

Where airborne hazards and noise pollution pose a threat, safely professionals also specify the use of respirators and heating protection devices. Silica dust particles are considered a health hazard when inhaled over time. But protecting yourself against this hazard is easy. Dust respirators should be worn when removing and installing furnace linings or where dust is prevalent. Be sure to use the appropriate mask for a given situation. Most masks protect against only certain types of dust and vapor.

Working with molten metal in a foundry is serious business and involves many hazards. Injuries ranging from minor burns to fatal burns can occur. But by being aware of the dangers and taking the appropriate steps to safeguard ourselves, we can reduce the day-to-day risks associated with our work.

* THREE KEYS TO PERSONAL SAFETY:

There are three primary ways to protect people from the dangers of molten metal. These are distance, protective barriers and safely clothing.

Distance is a very straightforward form of protection. The further away you are from the furnace or molten metal, the safer you are from metal splash. That's why furnace manufacturers problem features such as automatic charging systems and computer control. These systems enable people working with the furnace to stay for there away and still do their jobs. In all situations, people not directly involved in working with the furnace should stay out of the immediate area of the furnace during charging, melting and pouring operations.

Protective barriers can provide protection against heat and splash when distance isn't practical. An example of a barrier would be a screen around a pouring control station on the melt deck.

Wearing proper safely gear, however, is the most important step you can take as an individual to protect yourself from metal splash. Protective clothing has to be your primary line of defense.

THE FOLLOWING ARE SOME BASIC RULES FOR ELECTRICAL SFAETY ON THE MELT DECK:

* Only trained induction system operators should be permitted to run induction-melting equipment. A trained operator must be fully knowledgeable about the system's controls, alarms and limits, diagnostic functions, safety features and must be fully versed in the safely rules and procedures related to the system's operation.

* Induction melting equipment should not be run if any safely systems are inoperable.

* Unless a system operator is also a trained electrical service technician, he should never open the power supply cabinet doors or gain access to any secured high voltage area.

* Power supplies must be turned off whenever any process involving contact with the metal bath is taking place, such as taking samples, checking metal temperature or slagging. This is to prevent electrocution if safety system can be failed and the bath is a conductive contact with the induction coil.

SAFETY SUGGESTIONS FOR FOUNDRY SUPERVISORS AND MANGERS:

Supervisors need to be especially aware of electrical safety. Increased use of induction furnace technology has made it necessary for a growing number of maintenance and repair workers to come in close proximity to high current conductors. Many maintenance technicians, particularly those who work with low-voltage devices, such as control systems, do not fully appreciate the risk posed by the large amount of electric power used in induction melting. It is imperative these individuals be impressed with the fact that shortcuts, such overriding safety interlocks during trouble shooting, are absolutely unacceptable when working with even the smallest induction furnaces and power supplies.

Only fully trained personnel should have access to high-risk areas. A safety lockout system is another effective measure to prevent electrical shock.

The following procedures will help minimize the risk of electrical accident while servicing induction furnace coils, power supplies and conductors:

* Post warning notices for all systems that operate at high voltages.

* Allow only fully qualified and trained personnel to perform the maintenance or repair.

* Disconnect and lock out the power supply during maintenance.

* Forbid entry into any enclosures until the main circuit breaker is locked in the OFF position and breaker poles are confirmed to be open.

* Wait 5 minutes after opening a breaker before opening cabinet doors. This allows capacitors time to discharge.

* Test all bus bars for residual voltage before touching anything.

* If the power supply energizes more than one furnace, leads to the furnace undergoing maintenance or repair must be disconnected from both ends of the coil and the furnace induction coil grounded.

INDUCTAION POWER UNITS INCLUDE SOME OR ALL OF THESE SAFETY SYSTEMS:

Safety interlocks: Interlocks are designed to turn off power if automatically. Equipment should not be operated unless all interlocks are in proper working order.

Earth leak detector systems: these crucial systems turn off power if metal in the furnace comes close to or touches the induction coil or if inverter output is otherwise grounded.

Ultra-fast acting HRC fuses: The High Rupturing capacity semiconductor fuses isolates supply line from output in case of fault.

Over current, over voltage and over frequency protections: These protections stops flow of current in micro time of seconds to inverter in case of fault

Check Your Capacitors Weekly- A Creaked Weld Can Spell Trouble

OIL LEAKEAGE CAN LEAD TO EXPLOSION:

A crack in a capacitors weld may permit oil leakages, causing the unit to arc internally and generate gas. The gas may expand the capacitors, increase the crack, and fill the cabinet may lead to violent explosion, which can result in properly damage and possible injury to personnel.

INSPECT IMMEDIATELY:

Although the chance of a faulty weld is slight, you should inspect all capacitors in your induction melting unit immediately to be sure all capacitor welds are sound. If you find a defective weld, remove the capacitor from service and replace it promptly.

Capacitor welds should be inspected weekly to ensure continued safe operation. In addition, if your induction melting equipment automatically shuts down during operation, inspect the capacitors again for any weld cracking or swelling. Do not restart unit until any capacitors found to be faulty have been replaced.

OIL SAMPLING OF ENERGIZED TRANSFORMERS POSES POTENTIAL DANGER:

Sampling of transformer oil for PCB content or gas-in-oil analysis can be dangerous, warns the transformer departments of General Electric.
The warning involves “sealed tank” transformers, which are filled with oil at approximately 25^{0}C Up to about 90% of tank volume, leaving roughly 10% space for aor. This air space compresses or expends as oil volume increases or decreases with temperature.

A decrease in the oil level creates a small vacuum in the air space. Under normal conditions, oil weight compensates for this vacuum and forces oil out of the sampling value at the bottom of the tank.

The danger arises, however, with low temperature and light loads. The vacuum may then draw air into the valve, forming air bubbles in the oil. This lead to transformer failure and, in turn, to possible injury or death of operating personnel in the vicinity.

If you have any doubts as to the presence of a vacuum in a “sealed-tank” transformer, do not take any oil samples until your transformer has been de-energized.

SAFETY CLOTHING IT’S WORTH THE EFFORT

* All clothing should be 92% cotton base material or better. Wear full, long sleeve sweatshirts
Without pockets at all times. Do not wear pants with loose pockets or loops.

* All jackets, aprons, caps, glasses, face shields, gloves, spats, and shoes should be in serviceable condition and worn properly. Replace defective clothing and equipment immediately.

* Wear safely glasses with permanent side shields at all times in production areas. Do not wear flip-up glasses or contact lenses.

* Wear kick-off or Moulder’s-type safely shoes at all times.

* Wear dust respirators when knocking our furnace linings. Wearers should be trained in the

Care and use of respirators.

- Wear hearing protection at all times in the foundry area.
- Shoulder-length or longer hair must be tied back or covered.
- Wearing jewelry may be hazardous and is not recommended.
- **When pouring wear :**

➢ Full apron or chaps with jacket.
➢ Aluminized arm sleeves or jackets.
➢ Face shield over glasses. (One must be dark tinted.)
➢ Heat resistant and flame-proof gloves.
➢ Sparts

- **<u>Melters should wear :</u>**

➢ Full face shield over glasses (one must be dark tinted) when charging, deslagging, checking
➢ Temperature, pouring, or inoculation.
➢ Heat resistant and flame-proof jacket and apron.
➢ Arm sleeves.
➢ Heat resistant and flame- proof gloves.