**Casting Overview**

Metal Casting is the process of heating metal, and then pouring the molten metal into a mold to create a part out of solid metal. This is a manufacturing process that does not have the same limitations as various machining processes. It can also be used to convert otherwise unusable metal scrap into usable machinable stock, or create metal stock at sizes that would otherwise be prohibitively expensive to buy.

This process is easily attainable to use for metals such as aluminum, brass, bronze, zinc, lead, and pewter, and other metals with relatively low melting temperatures.

**Risks Associated with Metal Casting**

**Risk of Fire**

When casting, metal is heated to well above the flash point of wood and other combustible materials. There are also risks of fire when burning propane to operate the foundry. Given this risk, fire extinguishers and other equipment will be present on scene.

Especially when using wood boxes for molds and with a relatively small amount of sand for insulation, the heat transfer through casting sand to the wood can lead to the wood reaching ignition temperature. This is completely safe so long as this is accounted for when planning out a pour. Generally, fires in the boxes are burn out as they cannot sustain themselves after the heat from molten metal dissipates.

The foundry and all tools must be sufficiently cooled before being brought to an area for storage. If an item is too hot there is risk of fire.

**Severe Burn Risk**

The hot temperatures combined with the thermal mass of metal means the severity of burns due to metal splatter can be great. As such, full PPE is required, including all fire-retardant clothing with no exposed skin (Work pants, Welding jackets, work clothes or boiler suit under layer, etc), welding gloves, work boots (tucked under pant legs), safety glasses, and face shields when handling metal.

Tools used during casting can become very hot, and it is hard to distinguish if a given item is too hot to touch with bare hands. For this reason, tools are to be stowed on nonflammable surfaces, and always treated as though they are hot, meaning items cannot be handled without gloves and kept a safe distance from others.

**Molten Metal with Concrete and Wet Surfaces**

Molten metal spilled on a flat surface like pavement, if moisture is present, the molten metal will evaporate any water. The expansion of the water flashing to steam will cause molten metal to spatter and be flung into the air (called spawling). This can occur when pouring into molds, metal being spilled onto pavement.

To prevent this from happening, metal molds which molten material would be poured into must be preheated above the boiling point of water. For mitigation of metal spatter during a spill, casting should not be performed while the surrounding area is moist or wet. If outdoors, casting should not occur with eminent threat of rain in the weather forecast for the duration of time the casting would occur. Insulative barriers between where the casting operation is being performed and the ground should also be established.

**Respiratory Harm**

Melting metals involves fire and molten metal. The process of melting some of these metals can produce carcinogenic or toxic metal vapors (from aluminum, lead, and zinc from various lead, and zinc from various alloys), or other vapors produced through impurities in and on the melted metal burning off. Additionally, the exhaust gases produced through burning fuel required for casting must be removed from the environment if in an enclosed or restricted space.

To mitigate this, casting should only be done in an aerated space such as a space with a fume hood, or an open outdoor space. Additionally, the use of a respirator should be employed to prevent respiratory damage and mitigate risk of inhaling harmful fumes. If outside, people should situate themselves upwind of molten metal.

**Public Risk**

The public is at risk when casting is done in a public location. All risks observed by those casting is also present for a bystander. For this reason, the location where casting is done must have a perimeter clearly marked blocked off so that no one can accidentally approach an unsafe distance from the casting operation.

Given these risks, the following casting plan has been made to allow for safe casting to occur on campus at SUNY Maritime.

**Foundry Operations Plan**

**Location**

Foundry Equipment will be stored in the S&E Machine Shop or a room in the Strength of Materials Laboratory, but use of the foundry will occur outside. The map below shows locations near the S&E which would be suitable for casting. The most preferrable location would be on the blacktop over the “Maritime Wall” near the S&E. This location, although sees traffic running past it, does not have people travel through the area as the location is removed from the path by roughly 50 feet. The flat, open, and level surface is ideal for casting. There are no flammable objects in the surrounding area, and the location is close to and easy to access from the S&E, where the equipment would be stored.

**Example Outdoor Casting Set-Up**

In this set-up the foundry, insulated surfaces, pour station, and other tools are neatly laid out.

All casting equipment are placed a safe distance from combustible materials. The pour station could be further away, but in this instance the risk of fire was found to be low, and a vigilant fire watch was established to ensure a fire would not ignite or propagate.

1. Foundry, ingot mold placed on top to preheat
2. Slag collection on insulated surface
3. Hot tool bed on insulated surface
4. Insulated Surface for foundry lid to be placed
5. Crucible tong swap station with pouring tongs being the pair resting on the paver
6. Pouring station with water bucket nearby
7. Water bucket/fire extinguishing equipment (primed hose and fire extinguisher out of frame)

**General Safety**

As stated in the hazard outline, castings will only be done outside and in fair, dry weather and environmental conditions. It will be done in a safe location with minimal fire risk, with the area clearly marked as a hazardous zone for passersby. The casting operation will be accomplished with a student in charge, and a qualified faculty member overseeing the process. Casting will only be done by students deemed safe and responsible by the student and faculty member in charge. Everyone has a stop-work authority, and can call off the operation if conditions, practices, or anything about the process appears unsafe. Everyone participating in casting or in the nearby area will be wearing full PPE as outlined above. A fire watch will be maintained during the casting and clean-up process, and extinguishers will be on scene and easy to reach in the event that they are needed.

**Casting Process**

**Pre-casting Processes and Precautions**

Prior to casting, the following procedures should be followed:

Prior to the casting day

1. Ensure a casting plan is in place. Molds should be made, the appropriate amount of metal should be allocated to properly fill the molds with excess to be poured, and the crucible should be large enough to hold the metal (the foundry should not be used for a crucible that is too large either)
2. Check the forecast for the date the casting should take place a day prior
3. Inform facilities, the engineering department, and UPD that casting will be happening
4. Get a roster of all of those involved with the casting operation. Ensure they are aware of the casting, the associated risks, how to mitigate these risks, and are familiar with the casting process in its entirety
5. Ensure there is enough PPE for each individual participating in the operation

The day of the casting process

1. Gather all individuals for a briefing of the casting process and ensure all equipment is present and in good working order in order to proceed
2. Set the perimeter for the casting operation and ensure it is clearly marked so people do not accidently walk into it.
3. Set up the proper layout to perform the casting operation with the foundry, pour station, slag collection, insulated bed to put hot items, precautionary fire equipment, etc.
4. “dry run” of the casting process

**Casting Procedure: Melting the Metal**

1. With the space set up and ready to be fired, begin by lighting off the burner with the crucible inside. To light, start a fire with paper in the furnace first, and then admit propane through the burner. If propane is started first, and the flame is not light, propane can build up and form a fireball when light. This is done by starting a small fire with paper and turning on the gas to the burner. Once the gas enters the fire chamber, it will ignite with contact with the flame. If the burner fails to light, turn off the gas and allow the propane to ventilate before trying to light the burner again.
2. Place the lid on the foundry and leave it on low for 5 minutes to reduce thermal shock to the insulation and crucible
3. Turn up the propane admission to max, add metal to the crucible, wait for the metal in the crucible to begin to liquify. For aluminum this takes from 20-25 minutes.
4. Add more metal to the crucible until the desired amount is present
5. Place any metal molds over the foundry and allow them to heat up considerably to evaporate all water that might be present (preheating molds)
6. Remove slag from the molten metal by adding flux and skimming the metal. Discard of the slag in the slag collection bucket. This material is hot, and should not be handled until cooled.
7. Check the temperature of the metal. Allow to reach desired pour temperature before proceeding further

**Casting Procedure: Pouring the Metal**

1. Ensure all equipment is laid out so it can be used but will not be in the way while handling the metal. There should be a clear path to walk from the foundry to the pour station. Make sure all molds are in place and oriented correctly
2. Turn off the burner, remove the lid, and retrieve the crucible from the foundry with the retrieval tongs, and make it known that you are handling hot molten metal to all those present.
3. Walk the crucible over to the pour station. Place the crucible onto the insulated surface and switch from the retrieval tongs to the pouring tongs
4. Pick up the crucible with the pouring tongs and begin the pour. Fill mold completely with molten metal until the riser and air vents are filled with metal.
5. Pour excess metal into metal ingot mold to be added to a later melt

**Post Process Procedures**

1. With the foundry turned off, allow time for tools, casts, and equipment to cool. This may take several hours and should be done slowly to reduce thermal shock. Some casts may be doused if this is what is desired for the given cast.
2. Debrief of casting operation with participants to improve on casting process and procedures
3. Clean up. All usable sand from casting should be recovered while singed sand is discarded. Remove perimeter and store all tools and materials in their proper locations.