Light Metals 2011 *Edited by: Stephen J. Lindsay*
TMS (The Minerals, Metals & Materials Society), 2011

MOLTEN METAL SAFETY APPROACH THROUGH A NETWORK

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Keywords: Casthouse, aluminum, safety, explosion, approach

Abstract

Molten Metal explosion or splash is a major risk encountered in the aluminium casthouses. Alcan EP has had to face an accident in 2006, an explosion in one of its cathouses. Unfortunately an employee suffered 2nd degree burns on the face. After expertise of the accident and implementation of corrective action in the plant, it appeared that we had a potential of improvement in management of Molten Metal risk by sharing experience coming from the merged companies, Alcan, Pechiney and Algroup. The EP management decided to create a network constituted of experienced managers of most of the casthouses. It was key to look deeply into the details and to think about the practical aspects of every decision. A new approach of the management of Molten Metal risk was born in the company. The system was very powerful to align the whole organization on the objective to minimize risks.

Introduction

Environment, Health and Safety First (EHS First) is the EP management system for Environment, Health and Safety. When a big explosion occurred in one of a major casthouses, it was obvious that we had to make further progress on molten metal safety to keep our employees safe in our casthouses.

An explosion in a casthouse

During winter 2006 a big explosion occurred in a major casthouse of the company. Root causes were identified by a comprehensive incident investigation.

Description

A strong explosion occurred while loading plates and cuts from plate edges into a 50t furnace. One employee, who was operating the loading vehicle suffered 2nd degree burns at his face and injuries to his eyes. Fortunately he regained his eyesight. The ceiling of the furnace was completely destroyed and the roof and cladding of the casthouse building was seriously damaged. The main door of the 50 t furnace had already been opened for at least 10 minutes. The furnace had been emptied half an hour before by the previous cast. A forklift truck operator had filled the bucket of the loading machine with aluminium scrap plates and cuts (alloy 7212) of the fourth container, which belonged to the designated furnace load. The driver of the loading machine was sitting inside the cabin of the loader and pushed the content of the filled bucket into the furnace. Several witnesses indicated an enormous explosion with large flames of burning gas coming out of the furnace. Immediately afterwards, the atmosphere was filled with dust, leading to poor visibility. The explosion was heard also outside of the building. A lot of dust, insulation plates and other material fell down from the roof of the casthouse. No metal or any other material was ejected out of the furnace. The SECURIT glass disk of the loader burst and the employee was hit by the heat wave of the explosion. He climbed out of the vehicle and called for help. The driver of the fork truck had been on the cold-side and was not injured. An operator had been working about 8 meters away from the furnace door. He just fell down and was not injured. Both started immediately to help the injured employee.

Figure 1: After the explosion in the casthouse.

Conditions

The furnace had been emptied half an hour before the explosion. The tilting system was in maximum position. The inside of the furnace was controlled and there was only a pool of molten metal of usual size. The load was made of tubs of plates, of thickness about 8 cm. These tubs had been brought in the shop 48 h before. There was no instruction giving a minimum storage time inside the shop before loading. The outside temperature was -10°C.The first load was made of one plate of big dimensions. Then two tubs were loaded over it. The explosion occurred just after the fourth loading of plates. No water was seen when the tub went through the loading funnel.The inspection of the furnace showed that the first loads had not melt. That was normal, as only the holding burner was on. The molten metal depth was estimated at 7 cm when the explosion took place. So, taking into account the surfaces, the quantity of metal can be estimated at about 1500 kg when the explosion occurred. No alumina trace was found in the furnace. The weather was very cold with a lot of snow outside. The temperature scarcely got above – 5°C the days before. The inspection of the fifth tub, that was not loaded, showed ice and snow on the plates. The inspection of the inside of the box showed a few snow in an angle. All the inspected tubs were pierced of holes in the bottom. Like the other operator who loaded the loading vehicle, the injured operator (on the vehicle) attested that the load was not particularly wet, and no water fell down from the tub when he loaded it. Also he attested there was only one explosion.

Explanation

The further investigation on the site confirmed the hypothesis of a physical-type reaction between water (ice) and molten aluminum in a confined space and the with the generated vapour put under pressure. The explosion intensity may be explained by the fact that there was water in the form of ice. The lower the water temperature is, the more violent the explosion is (Fig 2). The mechanical impacts due to the loading operation could be a factor that trigged off or aggravated the explosion intensity.

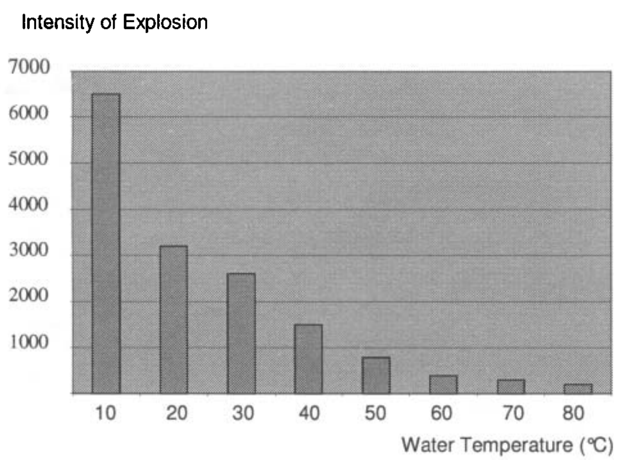

Figure 2 : Intensity of explosion related to the water temperature

What we learnt from this accident.

Referring to the Aluminum Association statistics, this accident belongs to the too numerous family of serious injury cases in rolling plants during the melting operation. (Table 1).

Table 1: Statistics of accidents in the casthouses, from the AA.

AA 1980-2006	total	melting	casting	transfer
Smelters	1177	273	443	303
Rolling / extrusion	867	**274**	282	195
Total	2482	931	809	564
Fatality	65	40	19	6
Serious injury	305	**97**	144	64
(Fat+Ser)/Total	15%	15%	20%	12%

This casthouse was initially in a smelter plant. The smelting part had closed and the casthouse was operating by recycling scraps. It appears that it had not learnt enough from the other casting plants of the company to completely avoid the risk of explosion.

At this time it was decided by the Alcan EP management to create a Molten Metal Safety network which was constituted of the casthouse managers, experts and EHS managers. Its mission was to write a Directive and to ensure its application at all cathouses. By sharing their casthouse experience and using existing documents the members of the network developed a molten metal safety directive and a guideline for audits.

EHS Directive

This directive establishes EP's program requirements for molten metal safety [1]. It applies to all Alcan Engineered Products sites. It takes into account a series of existing reference documents, [2], [3], [4], [5], [6], [7].

Definitions

Primary Protection PPE is personal protective equipment designed to be worn for work activities during which significant exposure to molten substance splash, radiant heat, flame, and hot surfaces is likely to occur. Secondary Protection PPE is designed for continuous wear. This applies to all work activities in designated locations in which infrequent exposure to molten substance splash, radiant heat and flames sources is possible.

Risk Management

The site shall identify potential molten metal hazards utilizing the hazard identification, risk assessment and risk control process (HIRARC).For each job task the current and potential molten metal explosion hazards must be identified and documented. Identified molten metal hazards are assessed initially and reviewed on an ongoing basis, at a minimum annually (severity and probability). Risks are prioritized. Molten metal requirements identified during the assessment are documented, addressed by the `EHS Corrective and Preventive Action Plan´, or integrated in the Standard Operating Procedures (SOP) and communicated to the appropriate parties. Material related hazards have to be considered in the risk assessment. They are related to the nature of scrap. They cannot be fully described here. Here is only a short list: Trapped water, surface moisture oxides on product surface, foreign and hollow objects, reagents, product shape.

Procedures of the EHS Directive

To illustrate the accident described before, the procedures related to the loading of scrap, including the upstream process, are presented here.

Material Purchase

All materials (e.g. ingots, alloying materials, aluminum scraps) must be purchased with a specification which includes requirements regarding safety, packaging, storage conditions and transportation. The specifications must be integrated in each order. External and internal suppliers must be audited.

Material Reception and Inspection

Inspection: All shipments of materials to be charged into furnaces and/or in contact with molten metal must be inspected prior to acceptance of the material. Step 1 inspection "Before unloading": Materials, shipping containers and delivery vehicles (trucks, railcars) must be inspected for contamination. Step 2 inspection "After unloading": After the materials have been unloaded they must be inspected.

Quarantine: The quarantine process of a hazardous material must be described in a procedure. The load has to be tagged (do not charge tag ...), isolated and thoroughly investigated if any of the following conditions are detected: Residual fertilizers, dry fire extinguishing powders, reactive chemicals (nitrates, sulfates, oxidizing material, etc.) if found on the metal and/or delivery vehicle; Water or other volatile substances (liquid or solid). Heavy grease or oil; Garbage and trash that may contain cans, bottles or other objects that can trap moisture; Salt fluxes that contain nitrates, sulfates, and oxidizing chemicals; Corroded or oxidized material; Crimped or closed end pieces of tubing, extrusions or containers that may contain water; Scrap contaminated with hazardous or toxic materials (PCB's, selenium, lead, cadmium, and radioactive materials); Miscellaneous contaminants such as batteries, butane lighters, live ammunition, medical waste and aerosol cans. If white powder is visible on the surface of magnesium, the material must be either rejected or brushed and dried.

Other requirements: For checking the load a check-list must be used. Receiving and inspection of materials must be assigned to well trained, experienced persons. These persons must be formally authorized to reject any hazardous material. Hardener batches must be used in FIFO sequence (First In, First Out). It is recommended for each plant to visualize the standards of acceptance. See more details in the AA document: "Guidelines for aluminum scrap receiving and inspection based on safety and health considerations" December 2002. Ref. [4]

Material Storage

Storage has a significant influence on major hazards, such as condensation, rain, snow and ice. Ice often is not even visible. The storage of a material determines its dryness level. The dryness level determines the permitted furnace configuration. Condensation occurs when the air meets a cold point either because of contact with a cold surface or when the temperature of the air decreases. Condensation occurs when the surface temperature is below the dew point temperature of the adjacent air. The dew point temperature is the temperature at which the air must be cooled to reach saturation.

By measuring the temperature of the air, the relative humidity (also called hygrometric degree) and the temperature of the metal, the risk of condensation can be determined using the following figure. From a starting point defined by temperature and relative humidity, there will be condensation if the temperature drops below the saturation curve (Fig 3).

One of the factors to prevent condensation is good ventilation in storage facilities. This prevents stagnant air remaining in contact with cold metal. We can consider that there is no risk of condensation if the product is stored indoors in a place where the temperature and humidity are controlled and the metal temperature remains above the corresponding dew point.

Material must be stored where direct contact with snow or rain is prevented (e.g. under a roof). Storage building structures, such as roofs must be kept rainproof. Roof, gutters and down pipes must be inspected, at least annually. Deformed tubs, which may accumulate water, must be eliminated. Tubs must be inspected, at least annually. The plastic foil over magnesium must always be removed to avoid the accumulation of condensed moisture. If material has got in contact with rain, snow or ice, strict charging procedure have to be followed, described in chapter "charging". (E.g. charging in cold furnace, prohibition of dilution etc.). Hardener storage conditions: Suppliers must be asked to pack hardeners in closed and covered buildings. Suppliers must also be asked load and transport hardeners under cover. Hardeners must be stored under a cover.

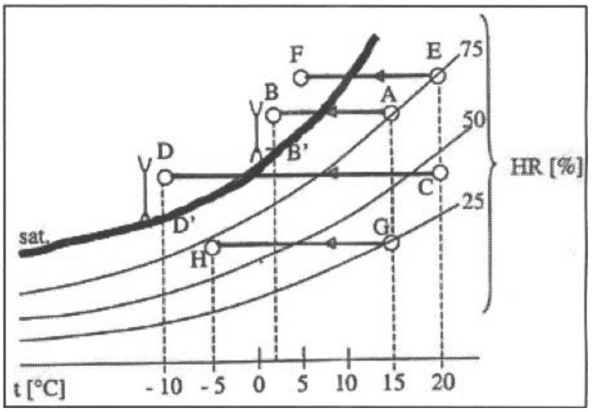

Figure 3: Risk of condensation

HR % is the relative humidity.
Case 1: Outdoor storage under a roof
Point A: Air at 15°C with 75% HR. Then over night the air temperature suddenly drops to 2°C → Point B Condensation!
Case 2: Storage inside the cast house
Point C: Air at 20°C with 40% HR. Cold metal with a temperature of −10°C is carried into the cast house → Point D – point D Frozen condensed water!
Case 3: Storage inside the cast house
Point E: Air at 20°C with 75% HR. Metal with a temperature of 5°C is moved into the cast house → Point F Condensation!
Case 4: Storage inside the cast house
Point G: Air at 15°C with 25% HR. Metal with a temperature of −5°C is moved into the cast house → point H No condensation

Best practices are: To store all materials inside under controlled conditions preventing condensation, to store alloying materials in a heated room, to unload hardeners under a cover.

Material over-drying

The site has defined for each oven temperature setting and corresponding drying time for each material ensuring trapped water gets vaporized. The definition of oven temperature and drying time has to be based on experiments with measurement of the core temperature. Here are some examples. These examples are by no means an alternative to real measurements and experiments, but give an indication of the necessary temperatures and times to vaporize trapped moisture:

Material	Core Temperature	Time
Sows	200°C	4 hours
T-Ingots	150°C	4 hours
Divided Scrap	100°C	1 hour

Material	Chamber Temperature	Time
Aluminium	400-450°C	6 hours
Magnesium	150-200°C	

For magnesium the temperature must be lower to prevent excessive oxidation and to avoid spontaneous combustion at a temperature of about 560°C. Care must be taken with regard to hot spots in ovens. It is preferable to use an oven with an even temperature. Electrical ovens are recommended. Before oven-drying the plastic strapping around ingot stacks must be removed. It does not withstand the oven temperature. For example ingot may be packed in bins. After oven-drying it can only be considered oven-dried as long as the material is continuously kept completely dry and kept under conditions that prevent condensation. It is generally not recommended and material cannot be considered oven-dried, if kept on a ledge of an operating furnace for drying.

Furnace charging

To easily understand the charging rules in this chapter, two concepts have to be introduced before: furnace configurations and dryness levels.

Furnace configurations

There are four different furnace configurations distinguishable. These configurations represent four different risk levels. They are applicable to all cast houses and structure the set of charging rules. It's obvious that any furnace can change "state" or configuration during the different stages of melting. When we look at charging we look at the furnace configuration at the moment when the material is charged into the furnace. The following configurations are defined for reverbatory furnaces, rotary furnaces, and induction furnaces.

Reverbatory furnaces
Cold furnace - empty or solidified: The furnace has been emptied and the low temperature ensures that any metal that remaining inside can only exist in a solidified state

Hot emptied furnace – dry hearth operation: The furnace has been emptied. But the furnace may still contain remaining metal which is liquid because the furnace is hot. In this furnace configuration it is possible to solidify any remaining liquid metal by adding a bed of dry divided scrap (see below, description of a bed).

Heel max. 30 cm high - heel operation: There is liquid metal in the furnace; it has not been completely emptied. The amount of liquid metal may vary between a few centimeters up to 30 cm. Depending on the surface area of the furnace; this can be equivalent to 10 or even up to 30 tons for the largest furnaces. In this furnace configuration it is no longer possible to dry the liquid metal by divided scraps. But it is still possible to prepare a "bed" to prevent that materials charged into the furnace can drop below the surface level of the molten metal in the furnace. The preparation of a "bed" will be explained later on.

High volume liquid metal: The volume of liquid metal is high. Even with a "bed" it is not possible to prevent that materials charged into the furnace "dive" into the liquid. Any liquid metal level beyond 30 cm is considered as "high volume liquid metal".

Rotary furnaces
We distinguish three furnace configurations of rotary furnaces: hot furnace emptied, hot furnace with salt or black dross, hot furnace with salt or black dross + molten metal.

Channel induction furnaces
We distinguish two furnace configurations of channel induction furnaces: Heel operation with max. 30 cm heel and charged on a bed, high volume liquid metal.

Crucible induction furnaces
We distinguish two furnace configurations of crucible induction furnaces: Hot and completely emptied furnace, high volume liquid metal.

Material dryness levels

If water is charged into a furnace, the probability of a molten metal explosion depends much on the kind of materials, the type of furnace and the furnace configuration. In some cases even a big amount of water cannot cause any explosion, in other cases a small quantity can cause a huge explosion. The following concept of dryness levels is related to the probability that water is part of the charge. These dryness levels focus on water as the most frequent cause of molten metal explosions. Other kind of contaminations must be considered equally. There are three dryness levels. These levels represent three different risk levels, are applicable to all materials and are an essential element of the charging rules.

Level 1- Sure dry:
This level represents the optimum in terms of safety. A material can only be considered sure dry, if: The material is oven-dried or equivalently heat-treated or homogenized, or if the material is inside scrap that has never been stored or moved outside of the cast house building. In both cases and for all times before charging the following requirements must be met to consider a material sure dry: The material was always been stored in a closed building and controlled conditions preventing condensation; the material was always transported under a cover (e.g. roof). The pre-charging inspection has indicated no visible wetness. Materials all can only be classified sure dry if all mentioned processes (drying, storage, transportation, pre-charging inspection, and correct classification) regularly checked by planned inspections and Leadership Safety Tours.

Level 2 – Probably dry
This level can be achieved if there is no visible wetness, but it can not absolutely be excluded that water is hiding in cavities, cracks or in areas which are difficult to be inspected. A material can only be considered probably dry, if:
Case 1: The material is stored under a roof and conditions where condensation is unlikely and the receiving inspection has not indicated any visible wetness. The inspections during storage period have never indicated any visible wetness of the material or

the ground under the stored material. The pre-charging inspection has indicated no visible wetness.
Case 2: The material has been stored outside and the following additional requirements are met: There was no rain or snowfall during the whole storage time. The temperature was always above 0°C during the last week of storage.

Level 3 – Wetness must be taken under consideration
A material has to be considered wet, if it does not meet all requirements of sure dry and probably dry. Another case is forbidden. In this case a certain combination of a material and furnace configuration is forbidden independent of the dryness level of the material.

Charging rules for the combination: material - dryness levels - furnace configurations

The following section is a key element of this directive. It defines the charging rules for the different types of furnaces as a function of the material, of the furnace type and configuration and of the dryness level. The charging charts (Fig 4) concern safety and environmental matters. However, in some cases charging might not be possible or meaningful for other reasons too, e.g. due to productivity or design.

Risk increasing ↓

	Cold furnace - empty or solidified			Hot emptied furnace – dry hearth operation: Used to dry the furnace			Hot emptied furnace – dry hearth operation: Charged on the dried furnace			Heel max. 30cm - heel operation: As a first layer (bed)			Heel max. 30cm - heel operation: Charged on a bed			High volume liquid metal		
	Sure dry	Probably dry	Wetness considered	Sure dry	Probably dry	Wetness considered	Sure dry	Probably dry	Wetness considered	Sure dry	Probably dry	Wetness considered	Sure dry	Probably dry	Wetness considered	Sure dry	Probably dry	Wetness considered
Discs or stamping skeletons	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N
Loose Chips	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N
Compacted Chips	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N
Hardeners other than Mg	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N
Sheet scrap - side trim	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y_3	Y_3	N
Clean compacted scrap	Y	Y	Y	Y_3	Y_3	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N
Extrusion butts	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y_2	Y_2	N
Extr. sections open at least at one side	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y_2	Y_2	N
Billets without cracks	Y	Y	Y	Y	Y	N	Y	Y	Y	Y_2	Y_2	N	Y	Y	N	Y_2	Y_2	N
Sheet scrap non-compacted	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y_3	N	N
Wire rod	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	Y	N	Y_2	N	N
Compacted Sawdust	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	N
Shape casting scrap	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	N
Extr. sections hollow&closed both sides	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	N	Y	Y	N	Y_2	N	N
Plate scrap	Y	Y	Y	Y	N	N	Y	Y	Y	Y_1	N	N	Y	Y	N	Y_2	N	N
Loose Coils	Y	Y	Y	Y_4	N	N	Y	Y	Y	Y	N	N	Y	Y	N	N	N	N
Tight Coils without cardboard mandrel	Y	Y	Y	Y_4	N	N	Y	Y	Y	Y_2	N	N	Y	Y	N	N	N	N
Slabs without cracks	Y	Y	Y	Y_4	Y_4	N	Y	Y	Y	Y_2	N	N	Y	N	N	N	N	N
Slabs with cracks	Y	Y	Y	Y_{1+4}	N	N	Y	Y	Y	Y_{1+2}	N	N	Y_1	N	N	Y_{1+2}	N	N
Ingots 12 - 22kg	Y	Y	Y	Y_1	N	N	Y	Y	Y	Y_1	N	N	Y_1	N	N	Y_{1+2}	N	N
T-ingots (excluding ends)	Y	Y	Y	Y_1	N	N	Y	Y	Y	Y_1	N	N	Y_1	N	N	Y_{1+2}	N	N
T-ingots ends	Y	Y	Y	Y_1	N	N	Y	Y	Y	Y_1	N	N	Y_1	N	N	Y_{1+2}	N	N
Magnesium Ingots	Y_6	Y_6	N	N	N	N	Y_{4+6}	Y_{4+6}	N	Y_{4+6}	Y_{4+6}	N	Y_{4+6}	Y_{4+6}	N	Y_{4+6}	Y_{4+6}	N
Billets with cracks	Y	Y	Y	Y_{1+4}	N	N	Y	Y	Y	Y_{1+2}	N	N	Y_1	N	N	N	N	N
Internal Sows	Y	Y	Y	Y_4	N	N	Y	Y	N	Y_{1+2+4}	N	N	Y_1	N	N	Y_{1+2}	N	N
External Sows	Y	Y	Y	Y_{1+4}	N	N	Y	Y	N	Y_{1+2+4}	N	N	Y_1	N	N	Y_{1+2}	N	N
Tight Coils with cardboard mandrel	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N	Y	Y	N	N	N	N
Magnesium sows	Y	Y	N	N	N	N	Y_5	Y_5	N	Y_1	N	N	Y_1	N	N	Y_{1+2}	N	N
Pits Cornflakes/popcorns	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lacquered material	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Material with oil, grease, plastic or paper	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Class 1 can stock scrap	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Loose Sawdust	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Figure 4: Charging chart of a reverbatory furnace.
Explanation of abbreviations:

Y = Yes = Charging recommended if all requirements are met
N = No = Do not charge!
Yi = Index i referring to additional material specific charging requirements

Footnotes – specific requirements:
1: only oven-dried
2: smooth introduction important
3: only in small blocks
4: as the only load, not as a bed
5: brushing needed, if more than 10 % surface oxidized
6: closed building, reduced condensation risk, plastic foil removed, defined site-specific minimum storage duration and temperature

Preparation of a bed

The bed is a first layer, made up of particular components of the load, with at least one of the following or often all objectives simultaneously: to protect the earth of the furnace from the shocks caused by the massive components of the load; to prevent that the loading of solid elements of the load does not cause splashes; to allow some other components to be charged on a solid material heap, to avoid (or limit) the risk of immediate contact of these components with molten metal; in case of a dry earth operation, to solidify all the remaining liquid metal.

In case of a dry earth operation a bed must ensure that all remaining liquid material is solidified. To achieve uniform coverage of the earth of the furnace the bed must consist of materials easy to spread.

The ideal components of the bed are chips and rolling edge trims. They are practically essential "to completely dry" a earth with molten metal. The compacted packages are also good constituents of a bed, but they do not bring the same guarantee of uniform cover of the residual molten metal. Other types of divided waste can also be used. Some materials, due to their shape, are completely unsuitable (e.g. large rolling coils). The loading practice should start with the more divided materials to increasingly massive materials. For example sows or T-ingots should not be put directly on a bed of chips.

The bed is not a mandatory practice. To charge more massive components directly is possible as long as they comply with the rules described in the charging tables. The bed in dry earth operation configuration offers real advantages for the safety for the materials charged afterwards. In the case of a heel a bed is much less effective. This is the reason for the more restrictive rules for the remainder of the load in this case.

Other charging rules

Sequence: The correct charging sequence starts with light materials and ends with heavy and problematic scrap: 1. Light scrap (e.g. dry or scalping chips). 2. Medium weight scrap.3.Heavy scrap. 4. Sows, coils, ingots. It is recommended to record the sequence in which a furnace has been charged.

Pre-charging inspection: The charge must be inspected before being charged: research of moisture, oxidation, foreign substance, dust. The best practice for inspection is to make it twice: a first time when preparing the load and a second time when charging the material into the furnace.

Vehicles and people:
Cabs of charging vehicles must be completely closed when operating in an area potentially exposed to a metal explosion or to splashes. During charging operations, only people directly involved in charging are permitted to stay close to the furnace.

Dilution and addition:
Dilution must be considered as charging in a furnace full of liquid metal. Addition material may be added in a trough under the

following restrictions: Material must be at a minimum "probably dry" (see definition); documented trials prove that form, quantity, and liquid flow rate do not result in splashes. Magnesium: For metallurgical reasons (melting loss, risk of spinels, etc.), the best practice is charging magnesium in a furnace that is full or has a heel.

Big-bags and other products:
Compacted products with an unknown or dubious origin, must be crushed and sorted before charging, as they may contain foreign bodies. Charging of big bags is prohibited because their content cannot be inspected properly. Pallet charging should be avoided. This can be done for example by previous removal of the pallet or by keeping the pallet on rotating forks. If the charging of a pallet or any other packaging item (cardboard, plastic film…) occurs, it does not change the charging restrictions for all materials as long as the package is dry and as long as the packaged material has been stored inside and properly inspected.

Induction furnace:
A procedure must be developed how to prevent arch formation while loading the furnace.

All the process is described in the Directive as it is done and presented for the material purchase, for its inspection, for its storage and for its loading.

Application of the Directive

Carry-out of the audits

Since the first year, all the Alcan EP casthouses were audited once a year by two auditors on the base of the guideline. Few major "Category 1 non-conformances" were found. 6 "Category 2" per plant were found in average, leading to have an action plan to control the risk (Table 2) .The following years no "Category 1 non-conformance", but the same number of "Category 2" was found. While the standards became increasingly better known by sites and auditors, the requirements were handled more and more strictly.

Table 2: Findings within the plants

	cat1	cat2	cat3	Best Pract	To be studied
tot 2009	0	84	27	46	37
average / plant 2009	0	8	3	5	4
average / plant 2008	0	7	3	5	3
average / plant 2007	0,3	6	5	5	3

An analysis of the type of findings was made (Fig 5). Many findings were related to the PPE wearing, and to the procedures and their compliance. Many investments were also made to respect the standards, especially of roofs to protect the material and of furnaces to dry it.

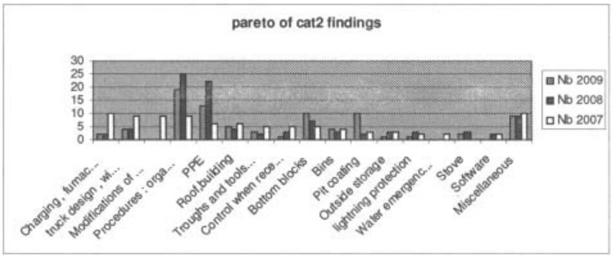

Figure 5: Pareto of Category 2 findings

Need of complementary work for progress

However, in spite of this highly involving program, several explosions - smaller than the explosion described at the beginning - occurred in 2009, leading to complementary work of the network: For example a new explosion occurred in a casthouse due to an unexpected descent of the lift at the end of a cast. Cooling water covered the sump not yet solidified, creating projection of molten metal with no injury. An addition to the procedures of the Directive was made on the design and the maintenance of the hydraulic circuits of the lifts.On another side, some recurrent small explosions occurred at the starting phase of casts in the same casthouse. It appeared that some operators did not understand the procedures and the reason why they had to be applied. A special training session was established, dedicated to this specific need. It can be adapted to the specificity of other plants. Finally, for a better understanding of the Directive, it had been translated into the three main languages of EP.

Conclusion

An accident in a plant of Alcan Engineered Products had been the trigger of a comprehensive cooperative involvement of casting experts of the company to prevent all the casting personnel from molten metal explosions. A Directive and its application was the result of this involvement. During this work a new shared culture of EHS regarding the molten metal explosion risk was born. Same vocabulary, same standards, same request were also shared. EHS results in the casthouses were in progress. To keep the system efficient, it is currently up-dated by the network.

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