

Water / molten metal explosion in a foundry

21 January 2015

Feurs (Loire)

France

Explosion
Water / molten metal
Metallurgy
Control

THE ACCIDENT AND ITS CONSEQUENCES

-  □ □ □ □ □ □ This industrial site, in operation since 1915, comprises a steel foundry.
-   □ □ □ □ □ □ The business employs a workforce of some 300 persons and is specialised in manufacturing moulded steel components intended for the rail industry, nuclear applications, armament, farm machinery and public works. The industrial zone surrounding this site features: railway line
-  □ □ □ □ □ □ running along the site boundary, industrial buildings, residential dwellings just 100 m from the site, and the water table situated at a depth of between 1 and 3 m.
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The foundry activity entails the use of two “arc” melting furnaces (furnaces 3 and 4), offering a melting capacity of 7 t each, bringing the total annual maximum production of the foundry to 50,000 t.

THE ORIGIN AND CAUSES OF THIS ACCIDENT

Origin

The source of this accident was the contact initiated between molten metal and water or humidity that had accumulated at the bottom of casting pit 4. During the process of pouring metal into the foundry ladle, some 400 kg of molten metal accidentally fell into the pit. The abnormal presence of water at the pit bottom triggered both an explosion, in the form of a dry expansion (yet without spraying any metal), and the release of a large plume of dust. The blast resulting from the explosion, funnelled by the pit walls, damaged the roof made of asbestos cement sheets, which acted like a fuse vent (many sheets landed on the floor or were displaced). No other structural damage to the building was observed.

The accident occurred around 5:20 am. First responders were called by the foundry operator at 5:28, when the 76 plant personnel present at the time were evacuated. Casualties amounted to 8 minor injuries, 3 of whom were transported to the nearby hospital while the other 5 were treated on-site.



Furnace No. 4, © Site operator

Causes

The proven or suspected causes cited were as follows:

- Defective pit drainage:
 - the bottom level of the casting pits was positioned at 3.8 m (pit 4) and 3.50 m (pit 3) below ground;
 - since the ground was permeable, the water table level when the accident struck was recorded at -1.2 m, which was significantly higher than the pit bottom levels;
 - after a fatal accident under the same set of circumstances at a neighbouring site in 2011, this operator commissioned an appraisal in 2012 to assess the pits lying beneath the melting furnaces in order to verify their impermeability and determine how best to cope with potential water infiltration;
 - that assessment did not reveal any major structural disorders yet did report a highly deteriorated concrete surface condition, together with signs of water infiltration (traces of humidity and the presence of water) on the rear faces of both pits. The infiltration was apparently due to the structures (pits) being submerged in groundwater. Subsequent to this assessment, works were engaged to drain the pit walls;
 - Expert appraisals of the furnace 4 pit, following the accident on Wednesday 21 January 2015, revealed the absence of a drainage film on at least one of the pit walls.
- Lack of controls, or even appropriate guidelines, to ensure no water accumulation in the pit bottom:
 - during the Hygiene and Safety Committee session held after the accident, it was mentioned in front of the environmental inspectors that management had on several occasions been notified of the presence of water at the pit bottom (e.g. humidity in the large pit was written in the 1 December 2014 safety log entry);
 - the Head of Maintenance indicated that preventive maintenance was being performed, along with a visual inspection of the furnace every Monday morning, to confirm the installation was not leaking water;

- no detection of humidity at the pit bottom was posted to the safety log entry on the day of the accident (Wednesday);
- the procedures and data recordings transmitted attest to the fact that a “1st level” control protocol applied prior to starting up an arc furnace had indeed been in place;
- preventive maintenance steps on idle or operating furnaces, in addition to targeted controls at different intervals (weekly, monthly, semi-annually and yearly), were being conducted;
- it should also be noted that the water levels in the various sumps were not being monitored as part of any special procedure.

ACTIONS TAKEN

26 January 2015: Prescription requiring adoption of emergency measures issued to the operator, who had been informed as of 21 January, concerning the following:

- immediate suspension of melting activities for furnaces 3 and 4;
- implementation of conservation-oriented measures (securing the facility and banning access to the site);
- request for submission of an accident report within 2 weeks;
- additional details on the conditions for resuming melting activities.

3 February 2015: Submission of the accident report presenting the origin and causes of the incident, expert appraisals and ongoing investigations, as well as solutions proposed for securing the furnace 3 pit, while awaiting the completion of works on the furnace 4 pit, which had sustained damage from the explosion.

March through May 2015: Communication of the following:

- the various scenarios involving potential deficiencies, coupled with their associated level of likelihood and seriousness scores for furnaces 3 and 4;
- technical memoranda describing each risk management measure (RMM);
- set of revised safety procedures in light of these installation modifications.

The entire array of proposed active and passive technical systems brought the final risk level to 10⁻⁸. The various RMM dedicated to works and machinery were introduced in order to prevent any recurrence of such an accident (double casing, moisture meters, level probes in the sumps, etc.).

Authorisation to resume the activity of furnaces 3 and 4 was granted on 24 March and 25 September, respectively.

Under these conditions, the operator was asked to update the site safety report by taking into account the risk of a rising water table during flood events, plus all other possible water sources (impermeable roofs, water circuits running in the vicinity, cooling water storage pits, etc.).

28 September 2015: Administrative order requesting additional prescriptions to specify the RMM for furnaces 3 and 4, including three RMM rated at a “2nd level” of confidence and three others rated with a confidence of “1”. Also requested was submitted of a set of written procedures establishing: safety instrument control frequencies, data recording protocols, and corrective actions in case of operational malfunction.

This accident gave rise to six on-site inspections, in addition to many meetings held during 2015.

LESSONS LEARNT

Despite a similar accident occurring at an adjacent site in 2011 and awareness of the presence of a water/molten metal risk, the experience feedback still pointed to a lack of appropriate resources.

The long-standing location of a foundry within a hostile environment (water table near ground level) led to a number of serious operating constraints, requiring:

- substantial financial outlays for maintaining both the building structure and industrial machinery;
- adaptation of measures and resources to better meet the site's physical and technical constraints;
- the involvement, discipline and vigilance of all members of personnel day in day out.

The measures adopted still raised some technical issues, including:

- sumps located near melting furnaces, creating a configuration that raises the water table.
- relevance of drainage systems on installations featuring in such a high risk of accident occurrence.

With the infiltration risk being known, the resources allocated on both the technical and organisational sides, along with attention paid to weak signals (e.g. alarms activated by the personnel), would serve to avoid this type of accident, for which the consequences could have been much worse.