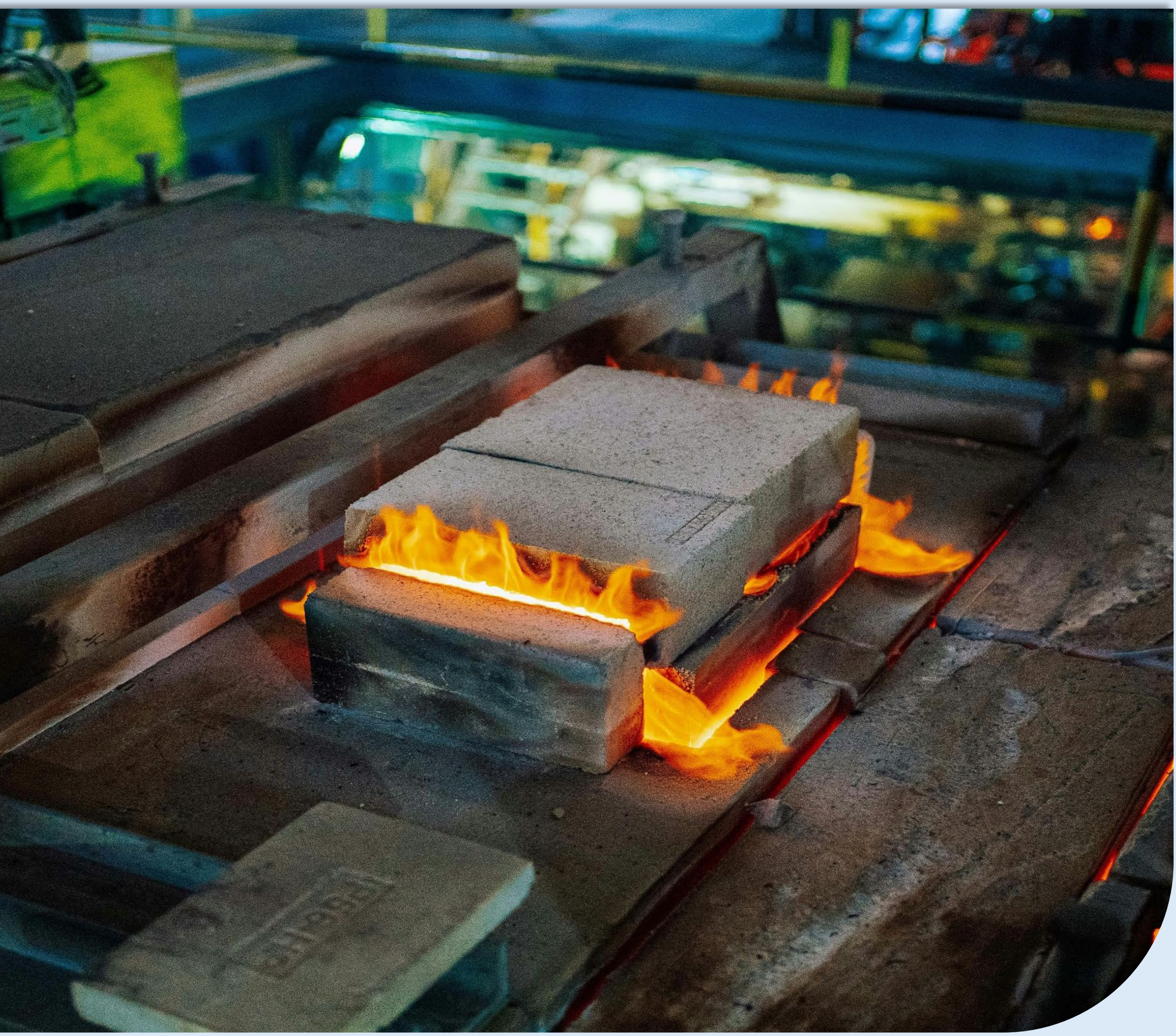

Laboratory Furnace Fire

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The following graphic depicts a high-level snapshot of a recent material loss incident at one of our members and highlights the key conditions and risk insights that shaped the outcome. The key takeaways are intended to prompt reflection and encourage further reading of the full lessons learned report, where greater examination of the contributing factors, control gaps and practical opportunities for risk improvement are discussed.

WHO: Unsupervised research students utilising relocated and uncommissioned equipment

WHAT: Fire involving a high temperature laboratory furnace

WHEN: Out of hours, during an extended unattended operating cycle

WHERE: Ground floor laboratory within an unsprinklered multi use academic building

WHY: Inadequate safeguards for a foreseeable thermal risk

HOW: Equipment malfunction, discharging contents into combustible materials

KEY TAKEAWAYS:

1. unattended high temp equipment materially increases fire severity risk
2. maintain strong housekeeping
3. value exists in risk assessments, equipment commissioning, SOPs & user training

Lessons Learned: Laboratory Furnace Fire

Purpose

This article examines a material loss event to highlight risk exposures, control gaps and practical loss prevention measures relevant to laboratory environments. The intent is to support member organisations in identifying similar vulnerabilities and strengthening controls to reduce the likelihood and severity of comparable incidents.

This article is drafted for risk and insurance managers, laboratory supervisors, technical managers, safety managers and facilities personnel.

Incident Overview

A laboratory furnace fire occurred during an extended heat treatment research activity. The incident involved a TF-Series tube furnace operating at high temperature and resulted in significant fire, smoke, and water damage across multiple rooms of the facility.

The laboratory in question contained various equipment, including a tube furnace, vacuum pump, and argon gas cylinder and other pieces of equipment, one of which is believed to be the only one of its kind in Australia. The laboratory is located on the ground floor of the building and was unattended at the time of the incident.

At approximately 1907hrs, the building fire alarm was triggered by smoke within the laboratory. No onsite first response was provided by institutional staff or students, and the building was evacuated. Initial fire brigade resources arrived on scene at 1919hrs, and confirming a real event, requested additional support. The building fire incident, which was classified post event as îaccidentalï was declared extinguished at 2333hrs.

The fire caused extensive damage to the laboratory where the fire originated. Many of the rooms on the ground floor either suffered radiant heat damage or smoke and fire water damage. Some rooms on the second floor were also affected by smoke.

According to the Fire Investigatorìs Report, the area of greatest damage was the benchtops opposite the furnace opening. An Area of Origin (AOO) was determined to be in this location opposite the furnace, with witness accounts indicating that combustible merchandise or giftware was stored in that area of the laboratory.

Asset Context

The building in which the fire occurred was constructed in 1996 of non-combustible materials being a reinforced concrete frame with concrete block and brick infill. It was connected to two other buildings and the room where the fire occurred had been recently repurposed with minor refurbishment to accommodate a laboratory housing furnace experimentation.

The building was provided with automatic fire detection and alarm systems, emergency lighting, exit signs, fire doors, fire hydrants, a fire hose reel system and portable fire extinguishers. Sprinkler protection was not provided. The tube furnace had been relocated from a sprinklered building to a building without sprinkler protection.

This building and adjacent and connected buildings did not form part of the Maximum Foreseeable Loss scenario for this campus.

Consequential Loss Impact

The fire caused extensive damage to the building. As a result, the building will not be available for use for between 8-12 months. Further, some of the analytical equipment was destroyed and must be replaced, with lead times between 6ó12 months. The consequential and business interruption losses anticipated include:

- Loss of research contracts/revenue
- Increased cost of working costs such as labour overtime or labour hire costs, relocation and fit out costs or third-party rental costs

Key Equipment and Systems

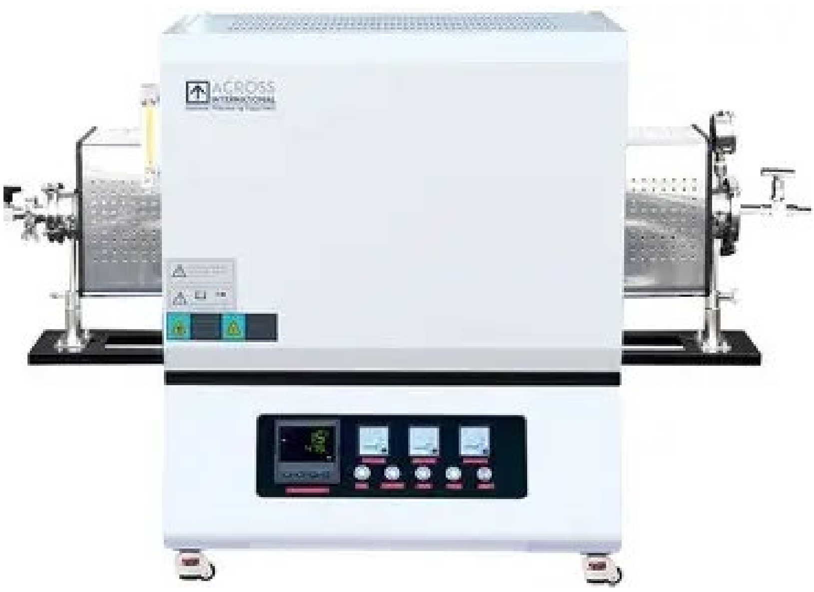
An Across International TF Series Tube Furnace, single-zone configuration with one Silicon dicarbide heating element (rated for up to 1400 ±C) and equipped with a Eurotherm 3204 controller is at the centre of this incident (pictured below). The furnace was desk mounted, noting external dimensions of approx. 610 Ÿ 490 Ÿ 660 mm, and powered via a 240V supply.

The furnace operating manual describes operation in three distinct stages:

1. Heating ó Approximately 1.5 hours
2. Holding ó Maintaining the target temperature, approximately 1 hour
3. Cooling ó Approximately 12 hours or so to fully cool down

Throughout the operating cycle, the furnace remains connected to an argon gas supply, which is used to purge the test chamber prior to heating (upon whence the flow is isolated via a manual valve). It was usual practice for the gas supply line to remain physically connected during testing.

The furnace was not connected to any monitoring equipment, was not under CCTV surveillance and was not visually monitored whilst operating. Condition and maintenance were unknown prior to the incident by the operators using the equipment.



Investigation Findings

The following key findings are summarised from the forensic investigatorìs report.

1. The furnace had been recently relocated to the laboratory in which the fire occurred, and it was the first time the furnace had been used in its new location. The incident occurred approximately one month after the move.
2. The lab is primarily used by HDR students conducting experiments.
3. The furnace was programmed to heat (and hold) materials to 900 ±C.
4. The lab was left unattended after 1815hrs during the holding stage of the furnace operation. Smoke detection provided the only source of monitoring.
5. The room contained cardboard boxes storing flammable merchandise, including gifts, cups, and backpacks, stored underneath and in front of the benchtops.
6. The area of greatest damage was the benchtops opposite the furnace. An Area of Origin (AOO) was determined to be opposite the furnace where flammable merchandise or giftware was stored.
7. The proximity of the AOO to the flammable merchandise stored near the benchtop indicates an external source of ignition. This location, combined with the fact that the furnace exterior remained cold to the touch during investigation, ruled out thermal radiation or hot-surface ignition from the casing.
8. The Police Hard Copy Report states that the fire originated near the western wall of the lab, close to the floor.

Incident Cause

The Fire Investigator proposed an ignition scenario where the flange assembly and a metal sample heated to 900 ±C was expelled from the furnace, landing among cardboard boxes and flammable material stored beneath the cabinets, igniting them as an initial fuel source.

This was confirmed by the forensic investigatorìs report whose opinion was that the probable cause of the fire was a sudden, high-energy mechanical rupture inside the furnace. The alumina tube (the internal containment vessel) fractured, releasing pressurised argon and ejecting hot components. These hot items landed in combustible materials near the western wall, which then ignited. It was noted that the expelled bimetal sample (Mn8/SS400) was operating at around 900 ±C, far above the auto-ignition temperature of cardboard and plastics (200ó450 ±C).

The following forensic investigatorìs occurrence details summary stated:

1. The alumina tube failed by brittle fracture due over pressurisation.
   a. An overpressure event occurred in a hot, constrained alumina tub, which per the OEM manual warning can cause catastrophic tube fracture. The tube remained intact in this pressure until the combined thermal and mechanical stresses caused it to shatter.
   b. Contributing factors include reliance on manual pressure control without automatic pressure relief safeguards.
2. The sudden fracture released stored pressure and energy, causing the ejection of the front flange assembly and hot samples toward the western wall.
   a. The failure of the alumina furnace tube caused pressurised argon to escape in a high velocity jet, ejecting the front flange and hot metal samples at high speed, sufficient to reach the western wall of the lab.
3. Ignition Source: The expelled bimetal sample (Mn8/SS400) was operating at around 900 ±C, far above the auto-ignition temperature of cardboard and plastics (200ó

450 ±C). When it landed among flammable merchandise stored in cardboard boxes, it provided sufficient heat energy to initiate combustion.

The forensic investigator's opinion was that a slow leak from an isolation valve allowed pressure to build unchecked in the ceramic tube. This blowout posed a severe risk of injury or fatality to anyone near the furnace front.

Recommendations from the forensic investigator included:

A. Pressure Safety: Install a low-set PRV/PSV (≤ 3 psi gauge) and add a pressure transducer with interlock to inhibit heating if pressure rises.
B. Monitoring: Continuous gauge + digital logging, with alarm and automatic isolation on overpressure.
C. Configuration: Confirm non-return/check valves, vent paths, and purge procedures; perform leak checks prior to each run.
D. Documentation: Finalise and maintain the Gas P&ID, operating SOPs, and training records.

Contributing Factors

It would be convenient to suggest that the root cause of the fire was simply a failure of the furnace, but this does not consider the interplay between the various contributing factors. A summary of likely contributing factors is outlined in the table below.

Category	Contributing factor	Impact/Consequence
Technical	Age of Equipment	No obvious impact
	Equipment condition	The furnace had no obvious condition issues
	Unsprinklered lab	Sprinkler protection could have contained the fire spread.
	Reliance on manual pressure control without automatic pressure relief safeguards.	An overpressure event in the furnace could not be controlled automatically which caused a sample to be ejected (at 900 ±C) into nearby combustible material.
Operational	Relocation of the furnace with no obvious recommissioning or evidence of testing before use by students	Potential for furnace failure during transit. Increased risk with relocation from a sprinkler protected lab to an unsprinklered lab.
	Lab was unattended at the time of ignition	Fire could have been contained with manual firefighting equipment if the lab was attended
	Combustible materials within the laboratory.	Additional fuel load increases the intensity and spread of any fire
	Commencement and duration of experiment	Commencement time of the experiment meant that the cooling phase would likely not have been continuously monitored, other than by smoke detection
Procedural	Tag out procedures	The equipment was not tagged out during the relocation or recommissioning process which by

		default indicated that the equipment was safe to use
	Standard Operating Procedures	A lack of consistently applied operating procedures can lead to inconsistent operation of equipment, damage to equipment, safety and asset exposures
		Specifically, a lack of understanding of pressure control valve operation by students led to an overpressure event in the furnace
Supervision and Training	Supervision of students by a competent person.	Incorrect and potentially dangerous operation of the furnace
	Training	A lack of training based on consistently applied operating procedures can lead to inconsistent operation of equipment, damage to equipment, safety and asset exposures
	Training records	No list of accredited or authorised furnace operators was available.

Root Cause

The root cause of the event lay not in the consequential physical overpressure event within the furnace, rather a confluence of conditions which involved a lack of:

1. Formal risk assessments,
2. Procedural documentation, and
3. Operator awareness and training.

Risk Assessments	Two separate risk assessments were either not performed or were ineffective. The first involved the risks associated with moving the equipment from one lab to another and what could go wrong during this process. The second risk assessment involved the nature of material that either was stored or may have been stored in the laboratory. This risk assessment would have clearly identified that the storage of any quantity of miscellaneous combustible material would have presented an unacceptable risk.
Procedural documentation	Had effective risk assessments been undertaken, these would have informed the development of Standard Operating Procedures for: • Recommissioning of relocated equipment • Safe operation of the furnace • General operation of the laboratory • Laboratory safety induction and furnace operation • Commencement and cessation times for furnace experiments

Operator Awareness and Training	The police investigatorìs report states that îstudents are inducted into labs for safety as opposed to the equipment. Others oversee inducting staff/students into the equipment.ï • No evidence regarding student or operator training or awareness was available within observed practice, response or documentation post review. • Nor were any standard operating procedures which would form the basis of a training program.

Lessons Learned

Every incident provides insights into and opportunities for continuous improvement.

Although no injuries occurred, the event exposed critical gaps in equipment recommissioning, laboratory controls, operator training, and housekeeping practices.

The following is a summary of the lessons learned from this furnace laboratory fire.

1. Undertake risk assessments when relocating specialised equipment and as part of broader laboratory management protocols.
2. Tag out equipment until it is fully recommissioned and is confirmed safe to use.
3. Develop clear and unambiguous Standard Operating Procedures for the operation of specialised equipment.
4. Develop and deliver training to equipment operators which are based on Standard Operating Procedures for the use of specialised equipment.
5. Maintain training / authorised personnel records for operating specialised equipment
6. Do not rely solely on manual pressure controls and human monitoring
7. Do not store combustible material in furnace labs.
8. Limit the commencement of furnace operations to mornings (AM) so that the 12 hour cool down period can be adequately supervised.
9. Do not leave furnaces unattended or unmonitored.

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