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Laboratory Furnaces SOP

Summary

- There are various types of laboratory furnaces, including Tube, Box, and Muffle.
- Because each unit is different, read the manual, complete safety training provided by your PI or trained senior colleagues. Only use a furnace that you fully understand how to operate.
- Furnaces present electrical, fire, and burn hazards, and the insulation can pose a health hazard. Furnaces can also create inhalation health hazards if they malfunction and are not stored in appropriate containment, like a fume hood.
- Regularly inspect your furnace for any loose or damaged wiring, physical defects, and water or heat damage.
- Follow the safety guidelines outlined in this document, and contact the manufacturer if you have questions regarding specific use or servicing of your furnace.

What are Laboratory Furnaces?

There are many furnace varieties used in the laboratory. They are useful for chemical synthesis, curing ceramics, and are essential in materials science, engineering, food science, and geological research. Three of the most common units are Tube, Box, and Muffle furnaces. Of note, furnaces are similar to ovens, but they can operate at much higher temperatures (typically higher than 500^{o}C).

A Tube Furnace (Figure 1) consists of cylindrical chambers surrounded by heating elements, which enable rapid heat up, recovery, and cool down. It is typically suited for smaller (and inorganic) samples and heating in an inert atmosphere. Common applications include the purification, coating, drying, hardening, or ageing of samples. A tube furnace can also be used for annealing, brazing, calcination, degassing, sintering, soldering, sublimation, synthesis, and tempering. It is generally a good idea to place tube furnaces in a fume hood, however, the need for local exhaust is process dependent and should be determined through an appropriate risk assessment. EH&S generally recommends keeping furnaces in a fume hood or to provide some other form of local exhaust in case the units malfunction, which can produce burnt wiring and other inhalation hazards.

A Box Furnace (Figure 2) features a vertical lift or swing out door allowing the various sized product(s) to be easily placed in the furnace. Box Furnaces are utilized for heat-treating, calcining, curing, annealing, stress relieving, preheating, tempering, and other high temperature thermal processes. The volatile material in a sample is burned off and escapes as a gas; therefore, these furnaces MUST be placed in a fume hood or containment must be provided by some other type of appropriate local exhaust (i.e., a canopy or snorkel hood).

Muffle furnaces (Figure 3) are a subclass of Box Furnace: they are compact countertop heating sources with insulated firebrick walls to maintain high temperatures. They allow rapid high-temperature heating,

recovery, and cooling in self-contained, energy-efficient cabinets. This is ideal for ashing samples, heat-treating applications, and materials research. Muffle furnaces use mechanical convection to direct airflow out of an exhaust muffle, and typically do not require placement in a fume hood (though it is recommended if possible in case the unit malfunctions).

Figure 1. Tube Furnace.

Figure 2. Box Furnace.

Figure 3. Muffle Furnace.

What are the Hazards?

Extreme Temperature Hazards

High voltage is needed to generate temperatures greater than 500°C. With high voltage comes inherent dangers of electrocution, fire, and severe burns. Make sure the furnace is properly grounded and no loose wires are connected to the furnace, and wear all necessary protective clothing while operating (as outlined later in this document).

The furnace program should be stopped, or the furnace shut off before opening the furnace door. Note that material will not always glow or appear hot, but will cause severe burns with improper handling.

The elements for the furnaces may be exposed and can be easily damaged if bumped or scraped. They are very expensive to replace. The furnace elements are operated at a high current and can be dangerous if touched.

Health Hazards

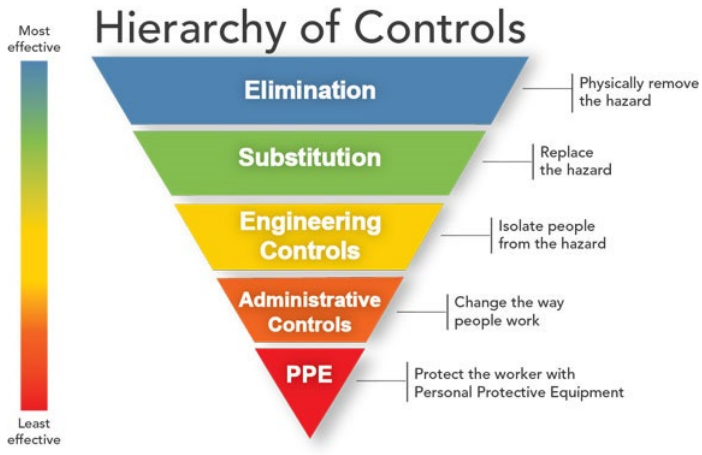
Many laboratory furnaces contain refractory ceramic insulation, which can produce respirable fibers or dust with crystalline silica when handled. Crystalline silica may cause chronic lung injury (silicosis) after prolonged exposure or a heavy exposure in a short time. Silicosis is a form of disabling pulmonary fibrosis which can be progressive and may lead to death. The International Agency for Research on Cancer (IARC) reports sufficient evidence of carcinogenicity of crystalline silica to humans. IARC classifies ceramic fiber as 2B (possible carcinogenic to humans). Older furnaces typically had insulation which contained asbestos. As such, it is also important to appropriately dispose of furnaces once they have passed their useful lifetime.


What Activities Could Pose a Risk?

- Using a box furnace that sits outside of a fume hood.
- Opening/servicing your furnace unit without specified training.
- Altering wiring, and altering or disabling the safety features, such as safety interlocks, sensors, etc.
- Using common oven mitts, cryogenic gloves, or no gloves instead of thermal-rated glove protection.
- Heating materials beyond their melting or decomposition points. Melting points (and occasionally decomposition points) can be found on a material's SDS.
- Using a malfunctioning furnace or having a furnace malfunction.
- Heating sealed vessels in a furnace may result in an explosion if the vessels are not rated for the increased pressure or temperature.
- Heating hazardous materials: Do not heat samples or glassware with chemicals that pose respiratory hazards. Evaporation in the furnace will release vapors into the atmosphere, where yourself or other lab members may breathe the toxic materials if the units are not appropriately contained in fume hood or provided with other appropriate local exhaust ventilation.

How Can Exposures be Minimized?

When working with any hazardous material or process, always conduct a thorough risk assessment and employ the hierarchy of controls to minimize risk. Specific applications of the hierarchy of controls to the unique hazards of laboratory furnaces are listed below. Apply the controls in the order of most effective to least effective (see graphic at right), and apply as many controls as possible to reduce the risk to the lowest achievable level.



Elimination/Substitution

- Avoid using a furnace for the sole purpose of cleaning glassware. Towel dry, air dry, or blow dry if possible.
- Heat materials to the lowest possible temperature to reduce the severity of potential burns and furnace failure.
- When purchasing a furnace, please consider purchasing those with safety features if possible.

Engineering Controls

- Work in a well-ventilated area. If heating hazardous materials and if the unit fits, put the furnace in a fume hood to ensure sufficient ventilation of escaping fumes. EH&S generally recommends that furnaces are operated in fume hoods or with other appropriate local exhaust ventilation in case the unit malfunctions, which can release hazardous gases into the occupied lab space.

Administrative Controls

- Before Use:
    - All furnace operators must complete safety training specific to the furnace they will work with.
    - Read the instrument's manual thoroughly, and understand the oven's capabilities, limitations, safety features and safety protocol. Always follow manufacturer protocol and recommendations.
    - Consult with the manufacturer and your PI to ensure that your planned experiments are appropriate for the unit. For instance, never overheat the materials or their containers: Borosilicate glass should not be heated above 400°C for short-term service, and Pyrex not above 300°C. Always check the manufacturer's recommended usable temperature range of containers prior to use in a furnace, and do not use containers for applications outside of the range.
    - Though lab furnaces have internal safety circuits, consider attaching an external temperature controlled power circuit that would cut the power to the unit in the event of elevated temperatures. Companies like McMaster Carr and Omega Engineering provide thermocouples and controllers that could be used to fabricate a cost-effective circuits of this kind.
- Keep the furnace's wiring tidy and away from other heat-generating sources. Damaged wiring could result in an electrical fire.
- Never disable safety features. Only service units if permitted by the manufacturer.
- Never heat a furnace to its maximum temperature.
- Do not heat samples or glassware with chemicals that pose respiratory hazards unless the units are contained in a fume hood or provided with other appropriate local exhaust. Evaporation in the furnace will release vapors into the atmosphere, where yourself or other lab members may breathe the toxic materials if these are not appropriately contained.
- Keep the area around the furnace decluttered. Items beside the furnace may get hot and melt, catch fire, boil, or explode.
- Always place and remove items from the furnace with thermal-rated tongs or forceps.
- Regularly inspect your furnace for any loose or damaged wiring, water and heat damage, or other visual defects. Contact the manufacturer or vendor directly for repairs and servicing.
- Dispose of furnace units that are beyond their usable lifetime. Follow the process for laboratory equipment disposal described on the EH&S website.

Personal Protective Equipment (PPE)

- When working with a furnace, always wear long pants, closed-toe shoes, a lab coat, and safety glasses.

- ALWAYS wear the appropriate thermal gloves, and regularly check them for rips, holes, or tears. All-cotton terrycloth gloves are sufficient protection for temperatures up to 232°C (i.e. autoclave use), but heat- or flame-resistant gloves are required when using furnaces at higher temperatures. It is recommended that a pair of such gloves is always available near a lab furnace, even when working with lower temperatures, in the case of thermal runaway. Visit the EH&S guide to glove selection for more information. If you need additional assistance in selecting appropriate gloves, please contact EH&S at askehs@umass.edu.

Service Recommendations

Regularly inspect your furnace for any loose or damaged wiring, water damage, heat damage, or other visual defects. If something appears damaged, worn, or is malfunctioning, DO NOT begin/continue using the furnace – power off immediately. Contact the manufacturer or vendor directly for repairs and servicing. Dispose of units beyond their useable lifetime.

Exposure and Spill Procedure

In the event of a furnace incident or malfunction, immediately turn off and unplug the furnace if it is safe to do so. Evacuate the room and notify EH&S (413-545-2682) for assistance.

After any emergency or near-miss circumstance, notify EH&S (413-545-2682) as soon as possible and complete the lab incident form.

For an exposure:

1. Dermal Exposure: In the event that exposed skin touches the hot oven or its contents, immediately rinse affected area with copious amounts of cool water for at least 15 minutes to reduce further tissue damage. For serious burns, call 911 (report the building name, room number, and street address) or 413- 545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. For minor burns, immediately go to UHS.

2. Inhalation: If an individual inhales fumes from a malfunctioning furnace or materials placed inside the furnace, immediately seek medical attention. If the person is unconscious or experiencing acute breathing difficulties, call 911 (report the building name, room number, and street address) or 413- 545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. Never enter a room with an unconscious person to provide assistance to avoid exposing yourself as well. For inhalation exposures without acute health effects, immediately go to UHS for evaluation. Health effects from inhalation can be delayed by hours for exposure to some materials, and can be very serious, so it is important to be evaluated by medical professionals. If it is possible to do so, provide the SDS (or whatever information is available in the absence of an SDS) for any materials involved to the medical personnel.

3. Electrical Fire: If the unit is on fire, immediately evacuate the room, close the door behind you, and activate the fire alarm. Follow your lab's evacuation route and meet in your designated location outside of the building. Call 911 or 413- 545-3111 once outside to report the incident and provide information, such as locations of the fire and materials involved.

References and Sources

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