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FURNACES

STANDARD OPERATING PROCEDURE (SOP)

Type of SOP: ☒ Process/Equipment ☐ Hazardous Chemical ☐ Hazardous Class

All personnel who are subject to these SOP requirements must review a completed SOP and sign the associated training record. Completed SOPs must be kept with the UC Davis Laboratory Safety Manual or be otherwise readily accessible to laboratory personnel. Electronic access is acceptable. SOPs must be reviewed, and revised where needed, as described in the UC Davis Laboratory Safety Manual. The unique properties of each chemical must be considered when preparing a SOP.

Date SOP Written: **4/12/23** Approval Date: **4/12/23**

SOP Prepared by: **Logan Himes**
CLSC SOP Task Force

SOP Reviewed and Approved by (name/signature): **Logan Himes**

Department: **ECE**

Principal Investigator/
Laboratory Supervisor: **Neville Luhmann Jr.** Phone: **5307545414**

Lab Manager/
Safety Coordinator: **Logan Himes** Phone: **5309570389**

Emergency Contact(s): **Lynette Lombardo** Phone: **5307549069**

Location(s) covered by SOP: Building: **2900 Spafford** Lab Phone: **~**
Room #(s): **122 Wet Lab**

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1. HAZARD OVERVIEW

This SOP for furnace operation should be read and understood by all lab personnel before using the equipment. This document provides safe operating procedures for use of furnaces in the laboratory. Use of laboratory furnaces is associated with unintended outcomes such as fire, contact and corneal burns, and potential catastrophic failure of samples/reaction vessels/crucibles due to thermal shock. Additional hazards associated with sample materials used within the furnace include thermal decomposition and chemical off-gassing during heating. Damaged refractory materials (*e.g.* interior lining, insulation) may introduce additional physical hazards, such as inhalation of fine particulates, and should not be used while operating furnaces. Samples and chemicals used should be chemically compatible with refractory and crucible materials.

2. EQUIPMENT HAZARDS

This type of equipment is capable of generating temperatures above 500°C during operation. Opening a furnace at high temperature or handling extremely hot items may pose significant risks (e.g. thermal burns from radiant or direct heat, structural failure of samples or reaction vessels due to thermal shock, corneal damage). Use caution, as hot materials may not glow or appear to be hot. Ensure that the furnace is properly grounded while in operation. See SafetyNet #512: Electrical Safety.

The 2900 Spafford Lab has various furnaces that fall into three categories, Hydrogen Brazing and Bonding furnaces, tube furnaces, general use furnaces. All furnaces at the lab have the potential to cause burns, shock, and produce dangerous byproducts. Care in use of these pieces of equipment must be taken and all applicable controls employed to prevent injury.

3. ENGINEERING/VENTILATION CONTROLS

Ventilation is always recommended. Ventilation is required for furnace work that may produce hazardous gases. If using a fume hood, ensure that it is properly functioning and has been annually certified.

Furnaces with integrated fail-safe or interlock options (including auto-shut off or alarms) are encouraged.

Contact the Chemical Hygiene Officer or chem-safety@ucdavis.edu for assistance in assessing hazards associated with furnace use and adequate engineering controls.

The Hydrogen Furnaces are placed under the large overhead exhaust hoods on the south side of the 122 wet lab. In these hoods there are hydrogen detectors, as well as other strategic places in this room. If Hydrogen is detected a two-step alarm and safety control scheme is used. At 10% hydrogen level an alarm is activated throughout the building and Hydrogen supply is cut off by means of a solenoid valve outside the building. This must be manually reactivated to get hydrogen flow to the furnaces. At 20% hydrogen level the monitoring system also calls the fire department. Hydrogen sensors and alarm are calibrated every couple of months to ensure functionality.

Tube furnaces are used in the chemical fume hoods only, where hydrogen sensors are also present in the exhaust flow. As with the Hydrogen furnaces the alarm will activate if any problem arises. These furnaces are less automated than the Hydrogen furnaces so care must be taken when operating this equipment.

The general use lab furnaces are on the tall table on the south side of the lab and share the space with the hydrogen furnaces. These furnaces are manual and limited in temperature and have controls to prevent over temperature but again care must be taken when in use to prevent burns, shock, and damage to surrounding equipment.

For all furnaces a use manual is present to log furnace use and activities.

4. ADMINISTRATIVE CONTROLS

The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory;
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer;
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS);
5. Implement good laboratory practices, including good workspace hygiene;
6. Inspect all equipment and experimental setups prior to use;

7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor;
9. Notify the PI or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving the process, hazardous chemical(s), or hazardous chemical class described in this SOP; and
10. Abide by the laboratory-specific working alone SOP, if applicable.

For work with Furnaces, the following are also required:

11. Appropriate material handling devices (*e.g.* forceps, crucible tongs) shall be used in conjunction with high temperature gloves to remove hot items from furnaces;
12. Hot samples shall be placed on specimen holders or surface made of appropriate insulators;
13. A sign, notice, or light indicating the furnace is in use shall be placed in clear view of the furnace. Some example materials are provided in Appendices A – Safe Operating Card, B – Workspace/Equipment Signage, and C – Furnace Use Notification, please contact researchsafety@ucdavis.edu if you need assistance with signage elements;
14. A logbook (or electronic equivalent) must be maintained and should include the following information:
    a. User's name and emergency contact information,
    b. Use details: date, instrument status, start and end time, material, and heating profile used;
    c. Maintenance activities; and
    d. Potential hazards associated with the process/reaction shall be indicated as well.

Any use of the furnaces at 2900 Spafford must be first checked with the safety officer Logan Himes or other responsible development engineer/SO. All use is subject to their or the PI's approval. Use without proper permissions is strictly prohibited. Various sources for SDS can be found at: https://safetyservices.ucdavis.edu/units/ehs/research/safety-data-sheets

5. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored. Leather shoes are recommended for high temperature uses wherein molten materials may be present.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for all work with hazardous chemicals and furnaces:

A. Eye Protection:
   i. Eye protection must be ANSI Z87.1-compliant.
   ii. At a minimum safety glasses are necessary.
   iii. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.
   iv. Infrared-blocking eyewear may be required depending on operational parameters (such as temperature or material emissivity). Always check for specific PPE requirements for your procedure.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   i. A flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.

ii. Face shields are recommended for procedures which may introduce a shattering hazard (e.g. quenching).
iii. Leather apron is recommended especially when shattering is possible.

C. Hand Protection: Thermal gloves rated within the appropriate temperature range of use should be used with furnace work (ISO 17493:2000 and ASTM F1060-08 level guides may provide guidance on glove selection). Gloves do not provide adequate protection for direct handling of high-temperature materials. Gloves should fit properly without significantly impeding dexterity in an unsafe manner and be maintained at a good condition for continued use. Inspect PPE before and after each use. Replace damaged PPE.

Along with appropriate PPE, The use of the hydrogen furnaces must also take into account the high temperatures these furnaces can achieve. Material, process, and capacity must be taken into account prior to a furnace run. All runs using the hydrogen furnaces must be carefully monitored to prevent damage to the furnace and maintain the safety of lab members working in close proximity.

6. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual, campus Emergency Response Guide (ERG), and UCD Health System ERG. The applicable ERG must be posted in the laboratory. All other locations must describe detailed emergency procedure instructions below.

Furnace work may result in spills of molten materials and fires. An appropriate fire extinguisher shall be maintained in the laboratory, and emergency procedures shall be outlined below.

7. WASTE MANAGEMENT AND DECONTAMINATION

Hazardous waste must be managed according to Safety Net #8 using the appropriate WASTe label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the accumulation time for waste disposal to ensure compliance. Hazardous waste pick up requests must be completed using WASTe.

Refractory materials and dedicated crucibles should be inspected for potential contamination or damage before and after use and should be disposed appropriately through EH&S if necessary.

Upon completion of work with hazardous chemicals and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated hazardous work area remove all PPE worn and wash hands and forearms as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

8. DESIGNATED AREA

Furnaces must be placed in a designated area that is well-labeled and free of flammable chemicals, combustible materials, or other fire hazards. This designated area should extend 2 meters in all directions during furnace operation. Do not place furnace directly under a sprinkler head (it could activate it).

9. DETAILED PROTOCOL

Include the following topics as applicable below or as an attached document:

A. Equipment and safety check (*e.g.* condition of insulation, refractory materials, grounding, etc.), including protocols to follow if equipment is found to be not in working order;
B. Use of furnace tools (*e.g.* tongs/forceps, crucibles, insulators, etc.), include protocols to follow if tools are found to be not in working order;
C. Analysis of potential thermal events which may occur during furnace use (*e.g.* phase transition, thermal degradation, volatile gas release, vessel over-pressurization, etc.);
D. Analysis of associated hazards/risks (*e.g.* description of hazardous chemicals or procedures, toxicity, risk of ignition, melting point, boiling point, reactivity under influence of atmosphere and temperature); and
E. Descriptions of heating patterns or ramping rates and holding times, as recommended by manufacturer.

10. APPARATUS OVERVIEW

For each furnace used in the laboratory, the following information should be provided in the Lab-Specific Safety Plan, in a user manual or data sheet appended to this SOP:

A. Furnace model
B. Physical description of equipment (schematic diagram recommended) and the location
C. Description of frequent uses for the furnace within the scope of the laboratory's research
D. Electrical power and outlet requirements
E. Equipment start up and shut down procedures
F. Operational temperature range
G. Operational heating rate range
H. Instructions necessary for use of any temperature controllers.
I. Fail-safe or interlock systems (auto-shut off or alarms for overheating)
J. Emergency shut off procedures
K. Lock Out, Tag Out (LOTO)
L. Safety Net #512: Electrical Safety

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TEMPLATE REVISION HISTORY

Version	Date Approved	Author	Revision Notes:
1.0	**12/6/2017**	**CLSC SOP Task Force**	**New template**

LAB-SPECIFIC REVISION HISTORY

Version	Date Approved	Author	Revision Notes:
1.1	4-12-23	**Logan Himes**	Added SDS link per UC Safety Services update.

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Documentation of Standard Operating Procedure Training

(Signature of all users is required)

- ✓ Prior to using **Furnaces**, laboratory personnel must be trained on the hazards involved in working with this SOP, how to protect themselves from the hazards, and emergency procedures.
- ✓ Ready access to this SOP and to a Safety Data Sheet for each hazardous material described in the SOP must be made available.
- ✓ The Principal Investigator (PI), or the Laboratory Supervisor if the activity does not involve a PI, must ensure that their laboratory personnel have attended appropriate laboratory safety training or refresher training within the last three years.
- ✓ Training must be repeated following **any** revision to the content of this SOP. Training must be documented. This training sheet is provided as one option; other forms of training documentation (including electronic) are acceptable but records must be accessible and immediately available upon request.

Designated Trainer: *(signature is required)* Logan Himes

I have read and acknowledge the contents, requirements, and responsibilities outlined in this SOP:

Name	Signature	Trainer Initials	Date

Safe Operating Card
Furnaces – At a Glance

DO NOT use this equipment unless you have received authorization from the Lab Manager


Safety glasses must be worn at all times.


Long and loose hair must be contained.


Close fitting/protective clothing must be worn.


Thermal gloves must be worn when using this equipment.

POTENTIAL HAZARDS AND INJURIES

- ⓘ Fire & electrical
- ⓘ Contact & corneal burns
- ⓘ Generation of hazardous gases and undesired reactions
- ⓘ Materials shatter/cuts

PRE-OPERATIONAL SAFETY CHECKS

- ✓ Check the temperature and inspect integrity of the equipment before each use
- ✓ Consider potential risks before use of equipment
- ✓ Ensure you are familiar with all equipment operations and controls
- ✓ Know emergency procedures
- ✓ Ensure workstation is clear of all flammable and combustible material
- ✓ Fill out Furnace Log Sheet
- ✓ Inspect PPE before each use

SAFE OPERATING PRACTICES

- ✓ Use appropriate tools (i.e.: forceps/tongs) to manipulate items in furnace
- ✓ Immediately report broken or faulty equipment to PI/ lab manager
- ✓ Place hot samples on appropriately insulated specimen holders.
- ✓ If power fails, turn equipment off
- ✓ Use ventilation controls for exhausting chemical off-gassing.

ENDING OPERATIONS AND CLEANING UP

- ✓ Switch off the equipment and wait until furnace cools down
- ✓ Clean sample residue at the end of each use
- ✓ Leave the furnace in a safe, clean and tidy state

DON'T

- ✘ Do not use faulty equipment. Immediately report suspect equipment.
- ✘ Do not leave items on top of the equipment.

DO

- ✓ De-energize and lock-out equipment before attempting any maintenance

Furnace Operating Parameters		
Furnace Model	Max Operating Temperatures	Max Operating Ramp Rate
Camco B16	1700 deg C	~
Camco M2000	2000 deg C	~
Camco G2000	2000 deg C	~
Thermo Fisher Lingberg Blue M	1100 deg C	~
Thermolyne	1000 deg C	~
Grieve Lab Oven	200 deg C	~

Example of workspace/equipment hazard signage. Contact researchsafety@ucdavis.edu for stickers if needed.

FURNACE USE NOTIFICATION

Name: _____ Date In: _____

Contact Phone #: _____ Time In: _____

Contact Email: _____ Date Out: _____

Alternate Contact: _____ Time Out: _____

Material: _____ Highest Temp: _____

_____

Indicate Hazards: _____

_____

_____

_____

Notes/Emergency Procedures: _____

_____

_____

_____

PLEASE PLACE THIS NEAR THE OVEN WHEN IN USE

FILE WHEN YOU HAVE FINISHED