

Title: Beamline Vacuum Systems Bakeout		
Section where used: <i>(List all sections/groups that will use this procedure)</i> Mechanical Technicians (MT), Beamline Staff		
Type of Procedure: <i>(Administrative / Technical)</i> Technical	Review Period: 3 years	
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1.0 PURPOSE

To provide guidelines for applying heat to various beamline components and experimental apparatus in safe manner.

2.0 SCOPE

To achieve ultra high vacuum it is common to 'bake' components by wrapping the components with electrical heater tape and heating the vacuum envelope. This presents both electrical and thermal hazards which must be monitored and controlled. This procedure applies to the ALS experimental floor and all supporting lab and assembly areas.

3.0 REFERENCES

- [1] ALS 09-01, LOTO Supplemental Procedure for the ALS
- [2] LBL PUB 3000, Chapter 8

4.0 REQUIRED MATERIALS, EQUIPMENT, SUPPLIES, TOOLS, AND MANPOWER

- [1] Undamaged heater tape/cord
- [2] GFCI distribution outlets
- [3] Variable transformer (Variac) and/or Process controller
- [4] Turbo pump cart or equivalent
- [5] Aluminum foil
- [6] Aluminized tape
- [7] Recommended PPE: safety glasses, wear gloves, long sleeved shirts
- [8] Bakeout Registration Form (online): <https://goo.gl/forms/d1JP77cKVgn4Gvz53>
- [9] Warning sign – Bakeout (Appendix 1)

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5.0 PROCEDURE

5.1 Bakeout Procedure

NOTE: *ALS electricians will provide the power distribution panel with GFCI outlets.*

WARNING: *Extreme caution must be exercised at all times during bakeout due to high temperature of the vacuum chamber ($\geq 100^{\circ}\text{C}$).*

Personal injury could result if one touches the hot surfaces.

[1] Notifications

[a] Complete the Bakeout registration form. The form will be sent to the Control Room and the Electronics Maintenance group emails.

[i] The Control Room will note the bakeout information on the status board. This information will be used for reference during the on-shift tours by the Operators and EM groups.

[ii] If temperature monitors and controllers are used to actively regulate the temperature during a bakeout, contact the Control Room or EM Shop for a setup inspection (see [7][d] for guidance) and to show where to find temperature readouts.

[b] Post Warning signage (Appendix 1) around bakeout area to indicate that a bakeout is in process and equipment is hot.

[2] Remove all connectorized cables, rubber hoses, and other equipment from the chamber that are not designed to be baked.

LOTO - If hardwired equipment that supplies voltages and currents exceeding hazard thresholds is to be disconnected, contact EMs to LOTO equipment out and to admin lock the LOTO. Contact the EMs for any questions concerning what equipment needs to have a LOTO lock.

[3] Exercise good housekeeping by ensuring there are no flammable materials or pressurized canisters near the bakeout system. Route power cables, power taps, and other cables to ensure they are not heat stressed by the bakeout.

WARNING: *Personnel injury could occur if water-cooled equipment are not drained and blown down before bakeout.*

[4] Drain and blow down any water-cooled equipment in the bakeout area. If this is not done, there is possibility of creating steam and high pressures in the water system.

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[5] Install heater tapes/cords

NOTES: *Install heater tapes/cords following guidelines in Electrical Safety Requirements for the use of Heater Tapes and Cords (Appendix 2).*

For use of small heater tapes with DC voltage, see Section 5.2.

The following are recommended PPE:

- 1) Safety glasses for working in a technical area.
- 2) Gloves
- 3) Long-sleeved shirt when handling tapes because the fiber glass insulation of some heating tapes can irritate the skin.

[b] Engineered bakeout setups using heating tents, boxes, permanently installed heaters, etc., may require steps that deviate from this procedure. Refer to instructions by the manufacturer of the equipment.

[c] Do not use tapes/cords with signs of wear. Inspect all heater tapes/cords for fraying insulation or exposed wire. Dispose of them by unplugging, cutting in half and disposing in salvage.

NOTE: *The following steps are provided for guidance purposes. The “art” of how to distribute tape and foil is gained through experience, for example more tape is needed at the bottom of a chamber than at the top and the core of the chamber needs less tape than extrusions. It is recommended to monitor temperatures during the first bakeouts and then add Al foil or adjust tapes until temperatures are even.*

[d] Apply heater tape, aluminum foil and tape

[i] Ensure that all plastic covers sometimes used on viewport covers are removed. Tightly wrap items to be baked out with aluminum foil.

[ii] Wrap heater tape ensuring that there is good contact between heater tapes and vacuum system to distribute heat evenly. Note that larger mass equipment such as con-flat flanges will take more heat to bring up to temperature, and smaller part items have the potential of overheating and damage.

[iii] Use aluminized tape to secure the heater tape to the vacuum system.

WARNINGS: *Any air gap between heater tapes and vacuum system will create a hot spot that will overheat the heater tape, resulting in burning out the heating element and creating a short.*

Personal injury or electrical shock could result.

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- [iv]** Wrap sensitive parts of the setup with aluminum foil, e.g., thin walled bellows, electrical or mechanical equipment that can't be removed.
- [v]** Evenly distribute and wrap heater tapes around the setup. **Do not overlap tapes.** Make sure that tapes don't slip or bunch up, secure heater tapes with aluminized sticky tape, if necessary. Keep track of number of heater tapes used.
- [vi]** Wrap setup and heater tapes with more aluminum foil to facilitate heating insulation and distribution.
- [vii]** If desired, cover the bake area with a heatproof insulating blanket; this helps use less energy to keep bakeout at an even and constant temperature.

[6] Heater Tape/Cord Connections

NOTE: *Connect heater tapes/cords following guidelines in Electrical Safety Requirements for the use of Heater Tapes and Cords (Appendix 2).*

CAUTION: ***Do not overload electrical circuits.***

Check the following connection requirements.

- [a]** Ensure the vacuum system to be baked out is grounded. Have the EMs or Electricians verify the ground before energizing heater tapes.
- [b]** Plug heater tapes into a variable transformer (variac) to control how much voltage is applied to the heater tape. Confirm that all heater tapes installed are plugged in. Alternatively, if using a temperature monitor and controller, verify all the heater tapes are plugged into the controller.
- [c]** Do not exceed 80% of the rated current for the variac.
- [d]** When grouping two or more heater tapes on the output of a variac, verify that they are the same wattage.
- [e]** Ensure all variacs are UL approved and plugged into a GFCI circuit. The GFCI must be tested before plugging in the Variac.

NOTE: *Refer to the LBNL Electrical Safety Manual for information concerning the use of GFCI.*

For any problems with circuit breaker or GFCI trips and/or variable transformer issues during the bakeout, see section 5.2 Unusual Conditions.

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[7] Bakeout

- [a]** Ensure there are no flammable material near the bakeout system.

CAUTION: *Do not leave a bakeouts unattended for long periods of time. Bakeouts require regular monitoring by personnel.*

- [b]** It is recommended and good practice to keep a log of pressures, temperatures, variac settings, and pump status before, during and after the bakeout. This will allow you to recognize unusual conditions and give you guidance when to stop the bakeout to reach the desired base pressure. It will also allow you to determine a protocol to follow during future bakeouts.

- [c]** If this is the first bakeout of a setup, raise variac power slowly and monitor temperature/pressure frequently to avoid overheating and pressure spikes, otherwise follow established protocols when setting variac power. Make sure the temperature is stable before you walk away.

[d] Temperature Monitors

- [i]** Use temperature monitoring devices to ensure that sensitive parts of the setup don't overheat. If the setup is new or complex, monitor temperatures frequently and at as many places as necessary, to ensure that temperatures do not exceed the maximum bakeout temperatures of components.
- [ii]** If temperature monitors are used as feedback devices for temperature controllers, make sure that the temperature monitor (thermocouple, RTD, thermistor, etc.) is:
- 1) Mechanically fastened (i.e. **not** taped).
 - 2) Includes strain relief to the hardware being baked and will not separate from the bake due to incidental stress (i.e. tugs).
 - 3) Verify the feedback system is functional and calibrated.
- [iii]** The placement of the temperature monitor, and the temperature ramp rate, will be such that no part of the bake gets excessively hot.

CAUTION: *It is possible in a thermal run away condition that experiment equipment will damage or contaminate the UHV apparatus. Pay particular attention to rubber sealed valves since these valves have a maximum temperature they can tolerate before potentially contaminating the system.*

- [e]** After the system has been at temperature for ample time to allow it to reach UHV pressures after the bakeout, turn off variacs. Wait until the system is cool before removing heating tapes and Al foil.

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- [f] Start degassing equipment, e.g. ion gauges, evaporators, electron guns, etc., when the temperatures are low enough to safely reconnect cables. Follow the manufacturer's instructions.

[8] Close-out

Upon completion of bakeout:

- [a] Remove bakeout signage.
- [b] Contact the Control Room to inform them that the bakeout work is complete, so they can update the status board.

5.2 Unusual Conditions

- [a] **Heater tapes** - Small heater tapes may also be powered up with a DC voltage source under 100VDC. This would render the operation safe from hazardous shocks.
- [b] **Circuit breaker trip** - If a breaker trips during a heating operation, this usually occurs because the circuit is overloaded. Disconnect an appropriate number of the heater tapes and reset the breaker. If the breaker trips again, call an LBNL qualified electrical worker for help.
- [c] **GFCI trip** - If a GFCI trips during the heating operation, it is permissible to reset the GFCI one time. Personnel must remain clear of equipment when the GFCI is reset. If the GFCI trips again, all of the heating tapes must be disconnected and thoroughly inspected for damage to find the AC current path to ground. If the problem persists, call an LBNL qualified electrical worker for help.
- [d] **Variable Transformer Issues** - If the fuse blows in the device, replace the blown fuse only with a fuse rated for the device. Using a higher current fuse than rated for the device will allow overheating and may cause a fire. Variable transformers and other control devices for heater tape control should be periodically checked by a qualified electrical worker for receptacle tension and proper fusing.

6.0 APPENDICES

- 1 Bakeout Sign
- 2 Electrical Safety Requirements for the use of Heater Tapes and Cords

Revision Log

	Date	Pgs. Affected	Type of Change	Brief Description of Revision
0	2/23/17	--	--	Original Revision 0 issued.
0.1	12/18/17	2, 4-5	Negligible	Revisions made to provide additional guidance for application and electrical safety.