

Please report all accidents and near misses. Things happen and it is important to learn from others. Environmental Health and Safety (EHS) and your colleagues appreciate hearing about incidents, reviewing their causes, and learning from them.

AUTOCLAVE SAFETY

Autoclaves are an important part of biology research. They are essential for sterilizing instruments, supplies, and solutions. Autoclaves achieve sterilization by applying steam at a temperature of 121 °C/250 °F and pressure of 15 psi inside the autoclave chamber, for a set period of time, in order to kill microorganisms. However, the high temperature and pressure can pose significant safety hazards for laboratory researchers. The heat, steam, and hot items associated with autoclaves can cause burns to researchers who are not aware of the hazards and are not wearing the appropriate personal protective equipment (PPE). **Aqueous fluids become superheated in an autoclave and may boil over suddenly and violently shortly after removal from the autoclave.**

Additionally, some plastic items must not be autoclaved because they are made of materials which cannot withstand the high temperature and pressure. Finally, hazardous chemicals must never be placed in an autoclave.



What Happened?

Three similar incidents occurred between May 2021 and December 2022, where containers boiled over after being removed from the autoclave resulting in two injuries and a near miss.

1. In the first incident, a graduate student placed a 750 mL media/salt solution in a 1.0 Liter screw-capped Pyrex container sealed with a cap assembly into an autoclave tray and then placed the tray in the autoclave. The student was using heat-resistant cotton terry cloth autoclave gloves, but was not wearing safety glasses, face protection, or a lab coat. After the autoclave cycle finished, the student removed the tray with the container and brought it back to the lab area on a cart. The container was jostled, the cap assembly popped off, and approximately 350 ml of the interior contents erupted from the container hitting the ceiling, adjacent lab benches, and the student. The student was splashed in the face but was not injured and did not seek medical attention. Lab members immediately called the EHS emergency line for assistance.
2. In the second incident, a researcher attempted to remove a biological indicator (BI) from inside a screw-capped Pyrex container using a pair of tongs when water from the recently autoclaved bottle erupted and burned their hand. The researcher had just removed their autoclave gloves. As the tongs touched the water surface, the liquid erupted from the container.
3. In the third incident, a researcher removed several 1.0 Liter and 2.0 Liter screw-capped Pyrex containers from the autoclave after the cycle had completed and placed the containers on a nearby cart. All containers were more than 80% full of hot water, and they belonged to an unknown lab group who shared the facility. The researcher was not wearing safety glasses, face protection, or a lab coat and was using a glove which was not adequately heat-resistant. The researcher rearranged the hot containers on the cart in order to make more space. As they grasped one container by its top, the cap popped off and approximately 20-30 % of the hot liquid erupted from the container on to their hand and arm causing first and second degree burns on fingers, hand, and forearm. The researcher received treatment at a nearby burn unit.

It is believed superheated water was a contributing factor in all three incidents. **In each case, the autoclaved containers had been removed from the autoclave and were not given a chance to cool.** An initiating event occurred; a movement or jostling of the container, or a set of tongs being placed in the water. In all three incidents, adequate personal protective equipment was not worn.

What Went Right?

Each incident was promptly reported to EHS by researchers and supervisors.

What Should Have Been Done Differently?

- Allow time for the containers and their contents to cool before handling.
- Containers should not be filled above 50% of their volume when placed in an autoclave.
- Ensure personal protective equipment is worn and is adequate to protect the user
- Many autoclaves are in shared facilities. Make sure all containers are marked as to the contents and the lab which owns them.
- For autoclaves with a manually operated door, open the autoclave door only slightly (about one inch) and allow the steam to escape for a period of five minutes prior to completely opening the autoclave door to allow sufficient time for cooling or expansion. This does not eliminate the need for personal protective equipment.



What Corrective Actions Have Been Taken?

- All incidents were reviewed by EHS with the individuals who were involved. Standard Operating Procedures were reviewed and changes were made to increase personal safety.
- Additional PPE was recommended in each case.
- In two out of three cases, autoclave safety training was conducted with the injured person and other researchers.

How Can Incidents Like This Be Prevented?

- Wear a lab coat, face shield, heat-resistant apron, and heat-resistant gloves whenever you work near the autoclave. Cover all exposed skin.
- Do not exceed 50% of the container volume.
- Allow time for items to cool before handling.
- When opening the autoclave door, stand to one side. Do not stand in front of the door.
- Request autoclave safety training from EHS for personal operating autoclaves.

More Information

- **George Washington University EHS, Lab Safety, Autoclave Safety-**<http://bit.ly/40sWDFq>
- **Stanford University EHS, Autoclave Safety-**<https://bit.ly/3HwMHC7>
- **University of Nevada, Las Vegas, Risk Management and Safety, Autoclave Safety-** <http://bit.ly/3HxBlxz>
- **OSHA Quick Facts, Laboratory Safety Autoclaves/Sterilizers-** <https://bit.ly/3HzTr1M>
- **Autoclave Safety Poster, Yale EHS-** <https://bit.ly/3JDudlS> (Contact EHS at ehs@yale.edu or 203-785-3550 or contact your Safety Advisor for a laminated copy)

Suggestions for Researchers who Use Autoclaves

- Wear PPE to protect yourself from injury. Adequate PPE includes a face shield, lab coat, heat-resistant gloves or mitts that cover the forearm, and clothing that covers all exposed skin on the feet, ankles, and arms. A heat-resistant apron is optional, but strongly recommended.
- Do not put any of the following in an autoclave:
 - radioactive isotopes
 - flammable, corrosive, or toxic chemicals
 - oxidizers
 - bleach or bleached items
 - plastics which are not compatible with the heat and pressure of autoclaving
 - formalin or formaldehyde-containing materials, paraffin-embedded samples
 - any human waste designated as anatomical or pathological waste
- Read the autoclave operator's manual and learn to operate your autoclave model.
- Inspect containers for cracks, chips, dents, damaged caps or other problems which might compromise the container. Damaged containers can rupture catastrophically inside the autoclave or immediately after removal from the autoclave.
- When opening the autoclave door, stand to one side. Do not stand in front of the door.
- Allow time for items to cool before handling and ensure others in the workplace are informed of hot items. Consider using timers and signage.
- Do not exceed 50% of the container volume. Before placing a container in the autoclave, loosen the cap on the container at least a full turn.
- The following plastics should not be autoclaved: Polyethylene (PE), High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Polyethylene Terephthalate (PET), Polyethylene Terephthalate Glycol (PETG), Polystyrene (PS), Polyvinyl Chloride (PVC).
- Know where the autoclave drain plug is located and check it periodically for blockage.
- Understand the difference between the autoclave "liquid"/Slow Exhaust and "Gravity" cycles.
- Post a sign, with your name and date, when the autoclave is discovered to be inoperative. Know who to contact for maintenance and repairs. Contact Yale Police or Yale EHS if there is an emergency.