Fatal Hyperbaric Chamber Fire in Troy, Michigan

An appeal to all users of hyperbaric chambers to heed the lessons learned.

This document has been prepared by two independent and authoritative hyperbaric specialists who were asked to assist in determining the cause of this fatal event.

The following account is based upon firsthand information obtained from CCTV footage and an examination of the site by the authors and police investigators. This account serves as an enduring reminder of the real risk of fire, the importance of patient grounding, and why it is essential to consider the risk versus intended benefit of anyone receiving hyperbaric oxygen therapy.

The timeline of the event reinforces the importance of avoiding energy sources inside pressurized, oxygen-enriched environments.

Initial Observations

- The oxygen-filled monoplace hyperbaric chamber was at 2.0 atmospheres absolute (14.7 psig). The fire occurred 42 minutes from the beginning of pressurization.
- Ignition appeared to be caused by an intense discharge of static electricity from an ungrounded occupant to a grounded chamber mattress.
- Factors contributing to the accumulation of static in the chamber include excessive movement by the occupant and the fact that 100% oxygen, a very dry gas, had been flowing for 42 minutes over all surfaces of the chamber, including the occupant.
- Most of the linen and clothing materials present inside were reportedly 100% cotton. However, this did not appear to reduce the accumulation of static charge on the occupant.
- The pillows used in the hyperbaric chambers at this facility were filled with 100% polyester. The outer covering of these pillows was identified to be 100% cotton. The pillowcases were made of 100% cotton.
- The occupant's movements dislodged the sheet covering the chamber mattress. As the bare skin of the occupant's knee contacted the uncovered mattress, an intense spark was observed.
- Instantly after the spark, a significant flame shot up the occupant's leg, enveloped him in flames, and filled the entire chamber with what appeared to be an intense fireball. As a result of the intense heat, the pressure in the chamber increased

rapidly, and the door seal ruptured to relieve the pressure. The elapsed time between ignition and door seal rupture was less than 3 seconds.

- When the chamber door was eventually opened (52 seconds after ignition), the fire erupted again.
- The rescuers then attempted to suppress the fire and eventually extinguished the visible flames using a dry chemical, ABC fire extinguisher. This delayed the rescuers from being able to extract the occupant.
- It took a total of **2 minutes and 17 seconds** from the moment of ignition to the eventual extinguishing of the fire and cessation of rescue efforts.

Further observations from this event:

- Static electricity clearly provides sufficient energy to ignite cotton fabric. Cotton is a relative insulator of electricity. 100% cotton requires a temperature of around 653°F (345°C) to ignite in 100% oxygen at 2 atmospheres absolute (14.7 psig). [Source: NFPA 53]. While it was not possible to determine the exact temperature of the spark during this event, it clearly ignited the cotton material.
- The hyperbaric chamber used was a code-compliant, FDA-cleared medical device.
- From the chamber manufacturer's manual:

  "CAUTION: Before using the Chamber, ensure that the Patient Grounding Assembly is in proper working condition. Verify the continuity between the wrist strap and the Chamber ground lug located on the back end of the Chamber." and

  "Check the chamber ground and patient ground by utilizing the methods described in Section 4 – Safety Features and Procedures." [Source: Sechrist P/N 100383 Rev. 3]"

- During the site visit, all chambers in the facility were evaluated, and found to be appropriately grounded. Grounding of the stretcher in the affected chamber to the building ground was also confirmed. There was no evidence of patient grounding straps being used on any of the chambers.
- During the site visit, bedding was found to be 100% cotton, and in good condition. There was no evidence of detergent containing perfumes or dyes.
- During the site visit, a cotton pillowcase was removed from a 100% polyester-filled pillow on an adjacent gurney. Audible and visual static electricity was generated.

- During this fire, the temperature inside the chamber was high enough to melt stainless steel mesh, cause almost complete combustion of all materials inside, and generate a maximum pressure likely several times over the chamber's rated design pressure. Despite the intense heat and pressure, the chamber maintained structural integrity.

Rules and guidance:

- The Hyperbaric Facilities chapter of the NFPA 99 Health Care Facilities code requires grounding of occupants in any hyperbaric environment containing more than 23.5% oxygen by volume. Based on the design and function of the chamber involved in this fire, after 42 minutes of treatment, the chamber environment would have been very close to 100% oxygen.
- The NFPA 101 Life Safety Code recognizes these risks and requires all hyperbaric chambers to comply with the requirements of the Hyperbaric Facilities chapter of NFPA 99, regardless of where the chamber is physically located.
- These safety publications are revised every few years based on public input and real-world experience.
- Non-compliance or ignorance of these publications have led to most of the hyperbaric mishaps, injuries, and fatalities over the past 50 years.

Essential lessons learned:

- **Had the safety protocols contained in both the manufacturer's manual and NFPA 99 been observed, this catastrophic event would likely not have occurred.**
- All potential candidates (parents/legal guardians in the case of minors or someone unable to provide informed consent) for hyperbaric oxygen therapy should be made aware of the potential risks of the hyperbaric environment, including fire.
- Facilities should be aware that excessive movement by the occupant will increase the risk of static discharge if they are not properly grounded.
- If an occupant refuses to be grounded, cannot be grounded, or if ground integrity cannot be confirmed, the hyperbaric session should not proceed.
- If ground continuity is broken during a treatment (such as a detached occupant grounding cord) and cannot be restored immediately, the session should be aborted.
- The time between ignition and the explosive release of gas is very short, in this case less than 3 seconds. Therefore, it is imperative that an oxygen-filled chamber be

decompressed immediately as the fastest possible rate in the event of fire. This procedure must be practiced in emergency drills. For most monoplace chamber, turning off the oxygen at the wall or at the zone valve, will likely slow down the decompression.

- The industry must ensure that all hyperbaric chamber users - regardless of chamber type, intended use, building occupancy code, or staff qualifications - are educated about the fire risks associated with static electricity in chambers filled with more than 23.5% oxygen, and the proper techniques to ensure that both the chamber and the patient are grounded.