

Hyperbaric Chamber Fires: Lessons Learnt

Dick Clarke, CHT

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Lessons Learnt

Primary Training in Hyperbaric Medicine
Columbia, South Carolina

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Factors Precipitating Chamber Fires

- Absence of design/manufacturing codes; code non-compliance
- Lack of a formal fire safety plan
- Inadequate fire safety plan
- Apparently adequate fire safety plan not adhered to
- Unanticipated factors

Absence of design/manufacturing codes: code non-compliance



Steel monoplace at 2.4 ATA
air compressed; mask O₂; inboard dump
no analyzer so unknown O₂ concentration

Flash fire
structural integrity maintained
hot gases melted door seal, cut through concrete floor, blew out building windows

Cause of ignition: non-intrinsically safe communication system



Intrinsically safe

- keeping level of electrical energy too low to cause ignition
thereby preventing sparks & keeping temperatures low
- device designs that exclude oxygen
plus, purging device with inert gas
- device strong enough to contain explosion
- moving device outside hazardous (chamber) area

No chamber design/construction codes & standards in Peru
some such countries adopt authoritative standards

Lack of adequate operational safety procedures

- no overboard O2 dump*
- unknown chamber O2 concentration*
- no pt. grounding*
- oil lubricated air compressor ? filtration*

**Monoplace Chamber Fire
 Lima, Peru, 2006**

Incident Report

Glenn J. Butler,
 President & CEO |

R.W. "Bill" Hamilton, Ph.D
 Hamilton Research

Michael W. Allen,
 Senior Vice President - Operations & Safety |

Life Support Technologies group
 www.lifegas.com

Absence of design/manufacturing codes: code non-compliance

Absence of design/manufacturing codes: code non-compliance

Lack of a formal fire safety plan

Lauderdale-by-the-Sea, Florida, May 2009

fire engulfed chamber & 2 occupants at 1.75 ATA O2
 ~ 4 yo CP pt., 62 yo grandmother
 ~ his tx started 7 months earlier!

operator (trainee) didn't know procedure for emergent decompression
 ~ tried several times to open door while pressurized

both occupants succumbed

Vickers "clam shell" manufactured in 1967

Burn pattern again suggested internal speaker as source

Legal proceedings:

Adult "reached to adjust cushion, static discharge from her clothing jumped to earphone jack"

Adult "banged on chamber for five minutes to attract attention"

"Nobody was monitoring them and when fire started victims were required to scream and bang on glass (sic) dome to get the attention of a bystander who in turn notified staff of the fire, which caused a delay in decompressing the chamber and freeing the victims before the flash fire occurred. When police deputies arrived, the victims were still in the chamber and on fire"

Numerous pages of safety violations

Most damning, set up fictitious inspection company
 "Certified Hyperbarics" for federal facility certification application

Medical Director & CHT "exhibited gross lack of competency, gross inattention, criminal indifference to pt. safety"

Both guilty of "aggravated manslaughter of a child & manslaughter by reckless disregard of human life & safety of persons exposed to dangerous effects"

Lack of a formal fire safety plan



Steel oxygen-filled monoplace chamber
single pt. fatality
attempted to smoke cigarette



Hospital admitted responsibility...

"We did not warn pt. that smoking or taking a lighter into the chamber could be dangerous"

Inadequate fire safety plan



Multiplace chamber Milan, Italy
personal clothes; synthetics/pockets
no pt. or IA checks...pockets
hood exhaust system disconnected
"improperly modified hood latex neck seals allowed O2 to escape into pt. clothes making patients flammable cylinders"
chamber O2 concentration commonly exceeded permissible limit
"O2 monitor alarm manipulated"



Fire occurred during compression
"red flame explodes on screen, video goes black"
Water deluge system activated...no water emitted
10 pts 1 nurse quickly succumbed

10 patients and nurse die within seconds in hospital fire

Several international newspaper accounts
Fire lasted ~ 30 seconds
led some to believe it was extinguished vs burning itself out
Fire dept official; "fire unstoppable in high O2 content"
inconsistent with previous water deluge experience

Initial official report

"Patients going into the chamber were checked by two doctors for flammable objects, but something must have slipped through"

Court proceedings

"A lady enters the hyperbaric chamber where she is to undergo treatment and brings with her an alcohol-based hand warmer, those with flame. From that hand warmer starts the fire that kills, after a slow agony, all the people who were inside."


Initial official report

"Automatic in-chamber fire-fighting system went into immediate action and the fire was put out within less than one minute"

Court proceedings

"The fire extinguishing system was not functioning as the tank that was supposed to contain the water was empty, the propellant compressed air cylinder had the tap closed and the water supply hose valve was closed. The hand shower inside the hyperbaric chamber, foreseen in the design phase, had not been installed."

Inadequate fire safety plan



Chamber operator opened 3-way valve to select BIBS O2 source

selected >2,000 psig option

reported hearing 'sizzling bacon' sound

Fire immediately erupted from chamber control panel

flame shot out 3 feet/1 meter, spraying molten stainless steel

penetrated steel filing cabinet igniting contents

chamber tech burned on face, arms, back, as she moved pt.

fire extinguished when O2 supply secured

Facility sprinkler system & fire alarm activated

News Briefs

Oxygen Fire at Shands Teaching Hospital in Gainesville, FL

*By David A. Desautels, MHA, MSF
Medical & Safety, PE
Steven J. Butler*

The incident occurred when a chamber technician selected the wrong oxygen source, resulting in a fire that caused significant damage to the facility and injured a chamber technician. The fire was caused by a high-pressure oxygen source being selected, which resulted in a fire that caused significant damage to the facility and injured a chamber technician.

Hyperbaric Medicine Center Dedicated to Dr. Jefferson C. Davis

The Jefferson Davis Center of the University of Florida is dedicated to the memory of Dr. Jefferson C. Davis, a pioneer in hyperbaric medicine. The center is named in his honor and will continue his legacy of research and clinical care.

2nd International Meeting on High Pressure Biology

The second international meeting on high pressure biology was held in Gainesville, Florida, in 1990. The meeting was organized by the University of Florida and the University of Alabama. It was a significant event in the field of high pressure biology.

Chamber Fire Analyzed

*By David A. Desautels, MHA, MSF
Medical & Safety, PE
Steven J. Butler*

The fire at the Shands Teaching Hospital in Gainesville, Florida, was analyzed to determine the cause and prevent future incidents. The analysis revealed that the fire was caused by a high-pressure oxygen source being selected, which resulted in a fire that caused significant damage to the facility and injured a chamber technician.

Misc. Courses

Various courses and seminars are available for hyperbaric medicine professionals. These courses cover topics such as hyperbaric oxygen therapy, chamber safety, and clinical applications. They are designed to provide ongoing education and training for healthcare providers in the field.

Desautels DA, et al. PRESSURE Nov/Dec 1990 **Desautels DA, et al. PRESSURE Jan/Feb 1991**

"Likely cause...high-velocity particle impacts"


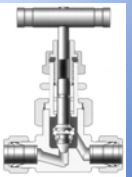
- ignited valve's Teflon seating & seal material*
- several fittings significant for "sand blasting" appearance*
- likely source of particles...HP O2 cylinder valves & piping*

Auto-ignition temperature of valve seating 400-700 F/200-370 C


particle friction heating in HP O2 exceeds 1,600 F / 870 C

Lessons learned-safety standard failures

- protect otherwise disconnected oxygen piping*
- oxygen piping "cleaned for oxygen service"*
- HP oxygen reduced at source*
- quarter turn valves contraindicated*
- filtration at source/prior to reducing regulator*
- larger diameter piping reduces oxygen velocity/related heating*

Apparently adequate fire safety plan not adhered to



Istanbul University Medical Center

Multiplace chamber fire July 1998

3 fatalities: 2 divers, 1 physician

- Ongoing contamination O2 piping & valving; inadequate filtration
- Latter stages extended USN TT 6
- Chamber O2 atmosphere not monitored nor routinely flushed
 - one diver/pt. using mask with overboard exhaust, second using hood with inboard exhaust*
- Two "lightsaber-like" oxygen flames seen emitting (via viewport)
 - spontaneous ignition within regulators*
- Chamber operator did not/could not activate water deluge
 - internal fire extinguisher not activated*
 - Flames only died out when oxygen system exhausted*
- Relief valves lifted (10 ATA)

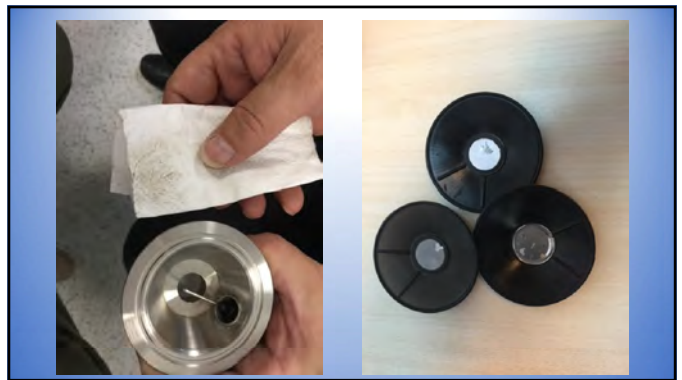
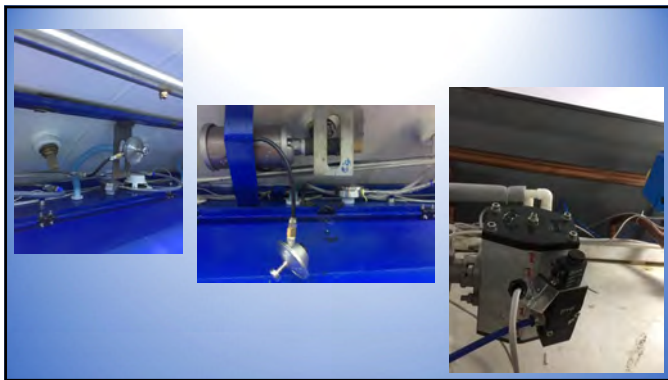
Inadequate system maintenance; particularly O2 delivery system cleanliness

Operational practices inconsistent with recognized standard of care

Physician entered chamber with cigarette lighter

"In all incidents I have encountered in my 30-year hyperbaric practice, the people who accidentally put a lighter or mobile phone inside are inside attendants and doctors, because patients are checked before each entrance"

Inadequate/non-existent emergency drills




Apparently adequate fire safety plan not adhered to



Steel oxygen-filled multiplace chamber

animal pt. fatality

chamber operator fatality



Patient treatment #5 underway

horse unsettled; kicking out

dislodged protective padding overlying steel hull

'massive spark' & flames per CCTV

urgent decompression initiated

Marion County Sheriff's Office Incident Report

REPORT BY: SGT ANDREW JONES SUPERVISOR: WALTER GIBSON

ON 10/25/2023 AT APPROXIMATELY 06:30 HOURS, I RESPONDED TO THE INCIDENT LOCATION AND ARRIVED AT APPROXIMATELY 07:00 HOURS. UPON ARRIVAL, I MADE CONTACT WITH FACILITY MANAGER TERRY BUCHHEIT. BUCHHEIT STATED THAT HE HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT.

I THEN MADE CONTACT WITH THE MANAGER OF THE FACILITY, REPORTING INCIDENTS AND PROVIDING HIM WITH MY BUSINESS CARD. THE MANAGER OF THE FACILITY STATED THAT HE HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT. I STATED THAT I WOULD BE AT THE FACILITY AND HE POINTED ME TO THE AREA OF THE INCIDENT. I THEN MADE CONTACT WITH THE MANAGER OF THE FACILITY AND HE STATED THAT HE HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT.

I THEN CONTACTED DEPARTMENT 02000000 AND WAS ON SCENE. THE DISTRICT COMMANDER, WALTER GIBSON, ARRIVED AT APPROXIMATELY 07:30 HOURS AND I STATED THAT I HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT. I STATED THAT I HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT.

I INVESTIGATED A SHORT SCENE LOG AT 08:00 HOURS. I THEN TOOK ALL PERSONS INFORMATION AND I ADDED THAT I HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT. I THEN TOOK ALL PERSONS INFORMATION AND I ADDED THAT I HAD BEEN ADVISED BY THE INCIDENT AND ABOUT THE INCIDENT.

OTHER PERSONNEL ON SCENE: THE MEDICAL EXAMINER'S OFFICE ARRIVED ON SCENE TO CONDUCT THE INVESTIGATION.

A REPRESENTATIVE FROM THE COUNTY ARRIVED ON SCENE TO CONDUCT THE INVESTIGATION.

THE INVESTIGATION WAS CONDUCTED THROUGH THE JOINT OPERATION OF THE MARION COUNTY SHERIFF'S OFFICE AND THE MEDICAL EXAMINER'S OFFICE. AT THE CONCLUSION OF THE INVESTIGATION, THE BODY OF THE DECEASED WAS REMOVED FROM THE SCENE.

Assistant ran to alert fire service; heard two explosions
first smaller, followed in ~1 second by massive one, as chamber exploded
 sound reported to have been heard several miles away
piece of chamber went through apartment window > 2 miles away



Operator (29 yo) died immediately; blunt force trauma/thermal injuries
 remains found buried under chamber debris

Assistant/trainee suffered multi-trauma, including severe head injuries
 evacuated to regional trauma center; survived



Horse remained shod (steel)

Not sedated

His coat contained oil-based lotion
not washed with approved soap per FSP

No formal hyperbaric safety training

Authoritative codes re animal chamber construction
guided but not certified per human standards?

Formal training in hyperbaric technology/safety

Water deluge system?

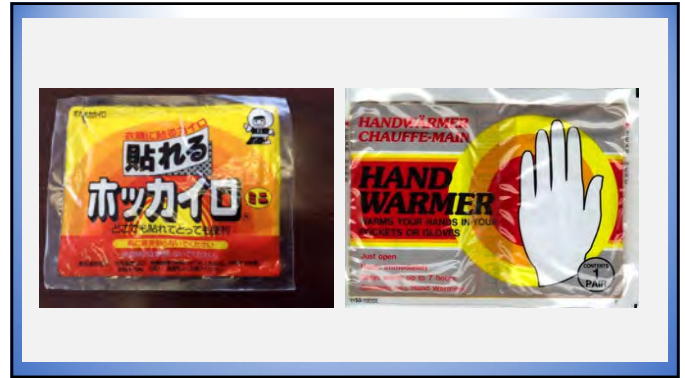
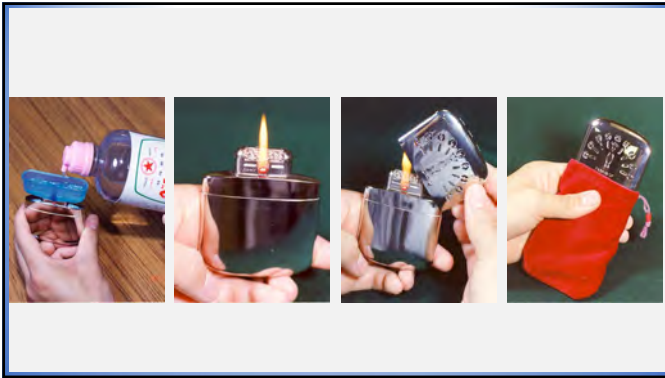
Methane gas detector-chamber flushing issue?
becomes explosive 5-17% range in air...? HBO
loudest explosions > 10% in air... HBO

Apparently adequate fire safety plan not adhered to

Initial statement released by hospital was that all recommended safety procedures were carried out

Oxer H. SPUMS Journal 1996;26(4)





Monthly Safety Notice

Importance of Optimizing Chamber Gas Flow

Background

The hyperbaric chamber regulates oxygen flow rate to maintain a constant partial pressure of oxygen within the chamber. The oxygen flow rate is controlled by the oxygen flow control system. The oxygen flow rate is controlled by the oxygen flow control system. The oxygen flow rate is controlled by the oxygen flow control system. The oxygen flow rate is controlled by the oxygen flow control system.

Key Operational Issues

1. Oxygen flow rate is controlled by the oxygen flow control system.
2. The oxygen flow rate is controlled by the oxygen flow control system.
3. The oxygen flow rate is controlled by the oxygen flow control system.
4. The oxygen flow rate is controlled by the oxygen flow control system.

Conclusion

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Inadequate fire safety plan

One of several chambers Naval Hospital Central Jakarta, Indonesia

Fire & "explosion" > 4 deaths
3 pts. 1 physician
room filled with smoke > several occupants hospitalized (2 remained so at 7 days)

Operator...

- "tried using water deluge system but too late"
- "failed to activate deluge system"
- "deluge system inoperable"
- "deluge system activated but inadequate to extinguish flames"

Hospital declared...

"It had complied with strict operating procedures"

Fire kills 4 inside hyperbaric chamber

The hyperbaric chamber at the Naval Hospital Central Jakarta, Indonesia, was destroyed by a fire on Tuesday, October 10, 2018. The fire started in the chamber and spread to the surrounding area. The fire caused the death of four people and the hospital was declared a disaster area.

Police: Negligence may have caused fire at Navy hospital

The police are investigating the cause of the fire. The police believe that the fire was caused by negligence on the part of the hospital staff. The police are looking for the people responsible for the fire.

Unanticipated factors



Youn B, et al. J Hyperbaric Med 1989;4(2)

Multiplace chamber at 2.0 ATA
 2 inside attendants
 4 patients; 3 adults, 1 4-wk-old
 SOP microwave warming of blankets
 some pediatric, all neonates

Cotton blanket warmed for 2.5 mins. high setting

Scorched (ironed shirt) smell upon removal

Examined by unfolding several times
 nothing untoward/not unduly hot

Compressed in medical lock

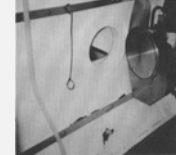
Upon receipt into chamber IA noticed 2 brown spots
 blanket immediately developed open flame

IA attempted to reinsert into lock

Chamber deluge activated...twice

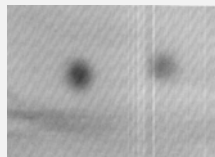


Burned 100% cotton blanket



Carbon deposits below medical lock

Pts switched to air breathing
 Poor visibility resulted in second deluge
 All occupants uneventfully decompressed
 Pts counseled & monitored; 3 inpts.
 All eventually completed their HBO courses
 Tested microwave warming 2.5-4.0 mins.
 Scorching not obvious unless blanket fully opened



Scorched areas between creases at 2.5 mins.



Scorched areas between creases at 4.0 mins.

