



# A Fire Incident Whilst Handling an Oxygen Cylinder: Preventive Measures and Recommendations

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## ABSTRACT

Healthcare fires have always been one of the major internal hazards and an oxygen-rich environment further aggravates these threats. The present case study reports such a fire incident in an Advanced Trauma Centre of a tertiary care hospital in North India wherein a tiny spark generated while handling an oxygen cylinder a health care worker got caught in a fire blaze. Fortunately, the flare was controlled within no time due to prompt action by a fellow HCW, and a major unexpected incident was averted. A formal investigation conducted by a team of experts ascertained that oxygen enrichment from leaking equipment, improper handling, and repeated striking of cylinder regulator by the spanner which attained the required threshold temperature was the probable cause for the onset of a flare. Henceforth, to mitigate such incidents users shall follow manufacturer recommendations, and ensure only safe and suitable components are used as part of a compressed oxygen system. Maintenance of cylinders, valves, and regulators should be done periodically to mitigate the risks of such incidents. All hospitals shall carry out risk-assessment exercises and provide oxygen safety training to all healthcare staff.

## INTRODUCTION

Health care facilities have always been places of haven and protection for managing external incidents, but situations turn grim and challenging when such facilities itself are affected by internal hazards<sup>1</sup>. Healthcare setting fires are always one of the major hazards and an oxygen-rich environment further aggravates these risks. Oxygen gas, also called a medical gas, is virtually used in every healthcare setting for resuscitation and inhalation therapy for patients. It is used either through compressed oxygen cylinders or through manifold oxygen supply lines. Primarily, the benefits of using oxygen cylinders are that it does not require a power source, have no warm-up time, require least maintenance, and is comparatively cheaper for the fulfilment of temporary and short-term oxygen requirements. On the contrary, these cylinders provide support for a limited duration, are difficult to transport due to their heavy weight and have to be handled with utmost

care to avoid an accident. Although usage of these oxygen cylinders has significantly enhanced the performance of several processes, unless adequately designed and handled, they also carry the risk of fire<sup>2</sup>.

The present case study reports such a fire incident of an Advanced Trauma Centre (ATC) of a tertiary care hospital of North India wherein a tiny spark generated while handling an oxygen cylinder a health care worker got caught in fire blaze.

## CASE REPORT

On January 16, 2022, at 1545 hours, when a HCW was operating upon regulator of a compressed oxygen cylinder to turn on the oxygen supply, suddenly the gas rushed out in a gush from the nozzle resulting in a spark leading to onset of bright white fire flame. This sudden eruption necessitated a prompt action, and, as expected, there was an immediate re-

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sponse by healthcare staff posted there. The actions required immediate dousing and containment of fire as well as evacuation of nearby patients to safer place. Although the fire was contained within no time due to prompt action by a fellow HCW, and a major unexpected incident was averted, yet, HCW suffered burn injuries on both hands and apparel around the abdomen. And, it required no shifting of patients.

A formal investigation was conducted by the team of concerned institute officials to ascertain the cause of the fire. And, after thorough examination and simulating the incident scenario, it was reported that opening of cylinder regulator might not have been smooth, as the same might have got tight fitted or got stuck on assembly. And, to open it HCW used force and repeatedly struck it with spanner. This repeated striking might have generated the frictional movement inside and outside the regulator causing spark leading to onset of flare. And, cylinder components such as O-rings, nylon seats and even metal components (which will burn if heated to a high enough temperature) might have worked as fuels. Henceforth, the probable cause of this fire onset might have been due to oxygen enrichment from leaking equipment, improper handling of oxygen cylinder with regulator heats up due to repeated striking by the spanner.

## DISCUSSION

In healthcare settings, oxygen cylinders form part of an oxygen system attached to valves, piping, manifolds, oxygen masks intended for patient usage. Oxygen usually behaves differently from air, compressed air, and other inert gases and is very reactive and efficient oxidizer. And, pure oxygen at high pressure (e.g. compressed gas cylinders) reacts violently with common inflammable materials viz. oil and grease, textiles, rubber and even metals burn vigorously in oxygen enriched areas. In common scenarios oxygen enrichment usually results from leaks due to poorly maintained or damaged pipes and valves, poor connections, either accidental or deliberate opening of valves and fire incidents are the primary hazard in such oxygen-enriched atmosphere<sup>3</sup>.

It is a known fact that fire occurrence requires three elements viz. fuel, a source of ignition (flame, spark or rising temperature) and oxygen (to support the ignition)<sup>4</sup>. In the present case scenario, it was noted that the HCW might have repeatedly used force and struck repeatedly with a spanner to open the regulator. And, due to repeated striking gas rushed out in a gush and frictional movement might have generated the heat leading to spark inside and outside the regulator leading to onset of flare. This was similar to the findings in the study by Kukfisz et al where it was concluded that hazards caused by combustion of a substance in an oxygen rich environment not only burns with higher intensity, but substances which in normal conditions would not be easy to ignite (plastics as well as metals), become more flammable<sup>4</sup>. In a

similar ICU fire incident by Kelly et al where it was reported that fire appeared to have initiated within cylinder valve due to a particle impinging in the cylinder valve, and temperature elevated due to frictional force might have led to onset of flare. Even witnesses had supported that a spark was seen coming from the valve outlet<sup>5</sup>. So, it is very much crucial to comprehend the prerequisites while handling compressed oxygen cylinders as very often substances become easily flammable in an oxygen rich atmosphere leading to higher intensity and more damaging hazards.

Various causative factors for ignition in oxygen regulators and attachments have been explained in the literature for such incidents. The '*Particle Impact*' involves smaller particles generated during assembly over time that can flake off from inside the cylinder and accelerate with high velocity due to flowing oxygen. When these particles hit the internal surfaces of the valve or the regulator, heat is generated and can burn in oxygen, igniting a fire. '*Adiabatic Compression*' happens when one opens the valve and pressurizes the regulator leading to an oxygen rush into the high-pressure side of the regulator. As the gas rapidly compresses, heat is generated, igniting any non-metallic part and contaminant inside the regulator. Another causative factor is '*contamination*', which involves exposing parts of a regulator or a cylinder to a contaminant like a grease or oil-based lubricant leading to ignite either by particle impact or adiabatic compression. '*Friction*' is heat and interaction of the two rubbing parts, destruction of protective oxide surfaces or coatings and the rapid opening of oxygen cylinder valves resulting in high oxygen velocities generating frictional heat and creating a potential ignition source. And, one of the causes of fire incident reported in the present case scenario is that a pressure regulator connected to an oxygen cylinder might have generated heat due to compression of the oxygen<sup>6</sup>.

Henceforth, to mitigate such incidents user end shall make its best efforts to abide by the given manufacturer recommendations and ensure that safe and suitable components are used as part of a compressed oxygen system. All materials used must be designed and approved as per laid down applicable standards and the same shall be kept clean to prevent contamination with flammable or non-oxygen compatible substances<sup>6</sup>. Approved lubricants should be used in the most negligible possible amount. Maintenance of cylinders, valves, and regulators should be done periodically to mitigate the risks of such incidents.

## CONCLUSION

The awareness about the possible dangers of fire hazards while handling the oxygen cylinders shall be imparted to all concerned stakeholders to prevent any untoward incident. All hospitals shall carry out

risk-assessment exercises and provide oxygen safety training to all healthcare staff.

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