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Automotive V-Belt as Autoclave Door Gasket Improvise in a Financially Constrained Healthcare Facility

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Abstract

This study seeks to document our experience with the use of an automotive V-belt as an autoclave door seal improvise in a financially constrained healthcare facility with respect to the experiment and outcome. The investigation was conducted using a 150-liter vertical steam autoclave in the Central Sterilization and Supply unit of a healthcare facility in Ebonyi state Nigeria. The standard lid seal was replaced with a locally sourced multi-ply automotive/industrial V-belt of the same circumference. The improvised seal was used over a number of sterilization cycles under standard conditions (121^{o}C, ~15psi steam). The result indicated initial effective sterilization. However, after repeated cycles, the improvised seal exhibited material fatigue, loss of elasticity, and diminished compression. This outcome suggests that while a V- belt may serve as a temporary stop-gap in emergencies, it is not a substitute to standard autoclave gasket.

Keywords: Automotive, V-belt, Autoclave, Healthcare, Gasket

1. Introduction

Effective management of healthcare technologies in developing countries like Nigeria face a lot of challenges such as lack of adequate resources, low-level technology transfer, and poor access to spare parts. The challenges often drive frugal innovative strategies that helps to maintain effective service delivery in such constrained facilities. There are various sterilization methods in the healthcare industry but, the use of autoclave machine is considered the most reliable, efficient and cost-effective for medical devices and equipment (WHO, 2022). The door gasket is a very important part of the autoclave machine that helps maintain; a seal between the contents within the enclosed chamber and the outside world. It also helps in regulation of correct temperature, prevention of dust and biological materials that would contaminate the chamber's load. Sterilization by autoclave depends on saturated steam under pressure – typically at 121^{o}C for 15 – 20 mins in order to achieve microbial inactivation (Rob Dyer Surgical, 2025). One of the critical determinants of sterilization success is the integrity of the door seal; a properly fitted, steam –tight gasket ensures that the steam penetrates uniformly and that pressure is maintained, preventing leakage and guaranteeing full exposure of load contents to sterilizing conditions (Jehbco, 2025).

Standard autoclave gaskets are typically made of high temperature, steam-resistant elastomeric materials such as medical-grade silicone because, silicone have a wide range of tolerance, as they can withstand temperatures up to 232°C. It is also more malleable, able to endure more pressure and compression, and more chemically inert and stable than other rubber compounds (Robert Wolfe, 2021). Equally, Ethylene Propylene Diene Monomer (EPDM) rubber with a temperature range of ~ 50 – 150°C can be used for an autoclave gasket (Seal Eastern, 2025). However, even these materials are subject to thermal fatigue, compression set, and chemical or mechanical degradation over many cycles. In many resource-constrained healthcare facilities, procurement delays due to lack of funds may mean that worn-out gaskets are not replaced on time, risking autoclave downtime and disruption of service delivery (Medical Design Briefs, 2022). Under such constraints, health workers and technicians might consider improvised solutions. This work describes a small-scale pragmatic trial of this approach in a hospital setting where a standard V- belt (commonly used in automotive or mechanical drive systems) is used as a makeshift seal, given its shape, relative thickness, and potential to deform under compression. The research was carried out to evaluate the mechanical properties of car drive belt as an alternative to standard Autoclave machine door seal in the sterilization departments of resource constrained healthcare facility.

2.0 Materials and methods

A vertical 150 – liter steam autoclave whose door seal/gasket had failed and for which a replacement gasket was not available was selected for the trial. A standard V13 Raw-Edge Plain belt (REP) made of rubber, synthetic fabric material and tension member was selected and used (ARAI, 2005). The selected V-belt has a ride out of 2.2 ± 0.8mm and of the same circumference with the Autoclave door. It was fit into the channel around the chamber door. The V-belt section was placed so that on the door closure, it would be compressed between the door and frame (Jehbco, 2025).

Sterilization cycles were conducted under standard hospital conditions: saturated steam at 121°C and ~ 15psi, for 20 minutes. After each cycle, the chamber was allowed to cool; pressure was carefully released before opening the door. To assess sterilization success, the following were used: Steam indicator tape on instrument packages (to confirm exposure to steam and temperature) (UMBC Environmental Safety and Health, 2025), biological indicator tests (spore vials of a standard spore-forming bacterium) placed at the hardest – to- sterilize location (bottom shelf near drain), following recommended validation protocols (Risk Management, 2019). Visual inspection of the V- belt-seal was carried out before and after each cycle, to check for steam leaks (condensation outside the chamber, hissing, loss of door compression) or visible degradation (hardening, cracking, loss of elasticity) (Eureka Patsnap, 2025).

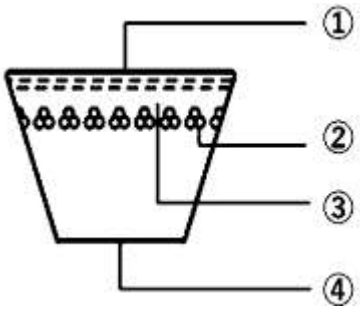

Fig. 1. Sectional view of V-belt

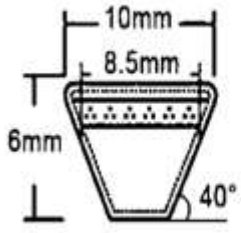

Fig. 2 Dimensions of V-belt

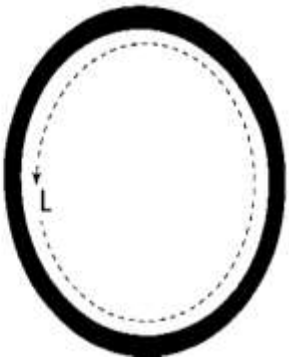

Fig. 3 V-belt measurement

1 - top fabric
2 - buffer layer,
3 - tensile member,
4 - bottom rubber.

To measure a belt length, we use: $L = 2C + K$ 1.

$$C = \frac{C_{max} + C_{min}}{2} \quad 2.$$

Where, L: V belt length (mm)

C = Center distance (mm)

K = 300

C_{max} = Maximum center distance (mm)

C_{min} = Minimum center distance (mm)

Fig. 4. 150 ltrs Vertical Autoclave

Fig. 5. Autoclave lid with improvise V-belt gasket

3.0 Result and Discussion

Upon initial installation, closing the door with the V-belt in place produced reasonable compression, and the autoclave reached target steam temperature and pressure. No obvious steam escape was noticed (Rob Dyer Surgical, 2025). Steam indicator tape on the packages turned appropriately, indicating exposure to saturated steam at sterilizing temperature (UMBC, Environmental Safety and Health, 2025, Anyafulu, et al. 2024). Biological indicator (spore vials) placed in the load was tested for sporulation after incubation using Malachite green as a primary stain and Safarin as the counter stain. The result tested negative for growth, indicating effective sterilization (Risk Management, 2019). Over successive cycles (after 8 uses), the V-belt began to show signs of material fatigue: decreased elasticity, minor surface cracking at stress points, and reduced tightness of the seal upon closure, resulting in steam leakage and extended time of sterilization (Eureka Patsnap, 2025, Nwambu et al. 2017). These outcomes suggest that in the short term, the V-belt seal was able to function sufficiently to permit sterilization of instruments in the 150-liter chamber, but performance degraded under repeated steam temperature cycles, raising concern over long-term reliability. The result indicated that a V-belt, though not designed for very high temperature sealing, could temporarily serve as a crude autoclave gasket in a resource-limited setting. This improvisation allowed continued sterilization when a standard gasket was unavailable, potentially preventing service disruption and enabling patient-care continuity (Medical Design Briefs, 2022). Nonetheless, the approach presents the following limitations and risks. Material unsuitability and durability; Autoclave gaskets are designed to tolerate repeated cycles of steam, high temperature,

pressure and moisture while maintaining elasticity and sealing force (Jehbco, 2025, Ekwedigwe et al. 2023). A V-belt by contrast is engineered for mechanical belt drives, not steam sealing. Loss of elasticity and surface cracking after few cycles is consistent with known failure modes of elastomers exposed to repeated thermal cycles and steam exposure (Eureka Patsnap, 2025). Seal reliability and uniformity: Standard autoclave gaskets are molded to fit precisely into gasket channels, ensuring uniform deformation and consistent sealing under pressure (International conference on civil engineering for sustainable development, 2016).

An improvised V-belt may not seal evenly, leading to micro-gaps that compromise steam tightness or uniform penetration in the sterilization chamber (Rob Dyer Surgical, 2025). Standard compliance and safety concerns: Sterilization standards recommend use of validated, purpose - designed gaskets, and requires regular inspection, maintenance and replacement as part of quality assurance programs (Risk Management, 2019, Onyia et al. 2023). Use of non- specified sealing materials undermine these standards and may result in abrupt failure, posing safety hazards. Thus, while the V-belt improvisation provided a temporary, emergency workaround, it is not a safe or sustainable long-term solution.

4.0. Conclusion

In the context of a financially constrained healthcare facility lacking replacement autoclave gasket, using a standard V-belt as improvise, would allow short term continuation of sterilization services. However, the observed V-belt material degradation and reduced sealing performance after a few cycles demonstrate that this is an inherently unreliable and unsafe approach for long term use. Therefore, the use of V-belt as autoclave seal should be restricted strictly to emergency, short term situations accompanied by rigorous quality monitoring, and replaced with a proper certified autoclave gasket as soon as resource permits. Hospitals operating under financial constraints should consider prioritizing procurement of indispensable replacement parts – even if through pooled funds, donor support, or bulk ordering to ensure service reliability, personnel safety and compliance with accepted standards.

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