



Original communication

Acoustic levels of heavy truck tire ruptures

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ABSTRACT

Transportation vehicles, whether they are passenger vehicles or heavy trucks and transport vehicles, rely upon rubber tires to negotiate the roadways and surfaces on which they are driven. These tires have the potential of sudden rupture resulting from various causes including but not limited to over-pressurization, sidewall failures, or punctures from roadway debris. These rupture events can and do occur while the vehicles are stationary (e.g., during servicing) or are being driven, and often occur without notice. While the phenomenon of sudden tire failure has been documented for several decades, the potential bodily injury which can occur when an individual is in close proximity to such a sudden rupture has only more recently been documented. Aside from anecdotal mention in case studies, there has been little quantitative information available on the acoustic levels during these failures. Our study provides measured acoustic levels as a function of distance for such catastrophic tire failures.

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1. Introduction

Heavy trucks and transport vehicles comprise roughly 45 percent of all vehicles on the roadway (FHWA, 2009).⁶ These vehicles may be tractor–trailer combinations, delivery vehicles, service vehicles, or farm vehicles, all with Gross Axle Weight Ratings (GAWRs) much higher than those of passenger vehicles. The higher load bearing capacity of these vehicles necessitates that the tires support higher loads as well. Recommended tire inflation pressures in passenger vehicles are in the 32–36 psi range (Continental Tire, 2009–2010).⁵ In comparison, inflation pressures of heavy truck tires are typically between 70 and 120 psi (Sumitomo Tires, 2008).¹³

The higher inflation pressures of heavy truck tires represent an increased potential for injury during tire rupture simply from the presence of higher levels of stored energy contained within the tire and wheel assembly. Tires may fail for several reasons, but tire blowouts are the most common comprising 40 percent of tire

failures on heavy vehicles (Bareket, Blower, & MacAdam, 2000).³ One way for blowouts to occur is continued vehicle operation while tires are below the recommended inflation pressure or vehicles are over their recommended load (Rohlwing, 2000).¹² When tire pressures are allowed to fall below the recommended pressures, tire sidewall heights decrease creating cyclical loading of the steel body cords of the structure of the tire. This circumstance can lead to what is known as a “zipper rupture” (Rohlwing, 2000)¹² in which a section of the steel cords of the tire suddenly fails. This may happen when additional air is added to the tire while the vehicle is being serviced, or while the vehicle is in operation (e.g., if the vehicle drives over roadway debris (Clarke, 1972)).⁴

The fact that sudden tire failures occur is known to drivers of heavy vehicles and those within the tire- and tire-servicing industries. The potentially dangerous nature of these events and the chance of catastrophic injury in these non-collision accidents has been recognized for decades as evidenced by the presence of tire inflation cages and guards as early as 1946 (see Fig. 1).

The literature in this area has been largely focused on contact injuries sustained from projectiles created in these events. Consequently, these occurrences are sometimes likened to blasts or explosion events. There is some mention of primary blast injuries involving the human ear (Murty, 2009),⁹ but no documentation of the acoustic levels which can occur during a sudden tire rupture. The primary safety practices in the literature for tire inflation and

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installation for heavy vehicle tires recommend wearing protective eyewear, clothing, and/or standing to the side of the center of the wheel and tire assembly (OSHA, 2003).¹⁰ Of the service literature reviewed only one listed hearing protection as recommended safety material to be worn by the operator only (ARI Hetra).² To understand the phenomenon better, in the current paper, catastrophic tire ruptures were induced in heavy truck tires and the acoustic levels of the resulting failures were measured.

2. Method

A test setup was created in order to simulate a puncture failure caused by roadway debris. A test structure was built by affixing a $4' \times 8' \times 1/2''$ piece of plywood to a single $8' \times 12' \times 6''$ solid wood beam (Fig. 2). A 1" hole was drilled at a 45° angle through the beam in order to allow for a striking object to pass through. The striking object used was a concrete chisel tool intended for use as a pneumatic drill tip attachment. The chisel tip was filed to a sharp edge to facilitate the ease of puncturing the tire sidewall. The end of the chisel was then placed into the open end of a 10-foot section of $3/4''$ black iron pipe used in common plumbing applications. This pipe was routed through the drilled hole in the wooden beam and connected to two additional ten-foot sections of pipe. This provided a safe distance for the experimenter to be away from the tire while it was being struck by the chisel tip. Two Rion NL-31 Sound Level Meters were placed 4 feet and 8 feet from the tip of the chisel edge (Fig. 2). The meters were placed at different distances to quantify the acoustic drop-off in the readings as a function of distance. The

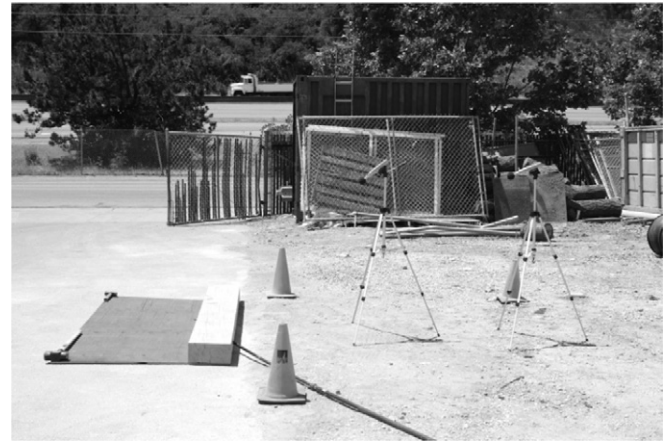


Fig. 2. Overall test setup with roadway mockup, striking object, and sound level meters.

sound level meters were set to record at a rate of 10 Hz and the frequency weighting during recording was A-weighting. Both sound level meters were fitted with a windscreens to reduce any other external sounds at the microphone.

The exemplar vehicle used in these tests was a refuse vehicle with an unladen weight of 55,000 lbs, and was fitted with tires compliant with the recommended vehicle specifications (Diesel Truck Index, 1985).¹⁴ The tires used in the testing were 315/80 R22.5 tubeless steel radials inflated to 100 psi for the tests. The vehicle was positioned so that the axle of the tire to be punctured was directly in line with the striking chisel tip. Two separate tests were conducted: the right-side outboard tire of axle 2 was punctured during the first test and the right-side outboard tire of axle 3 was punctured during the second test. A video camera was positioned parallel to the right side of the vehicle to record the tests.

3. Results

The peak acoustic values measured in the first test were 130.1 dB at the distance of 4 feet from the tire and 124.8 dB at 8 feet from the tire. A plot of the measured data from Test #1 is presented in Fig. 3.

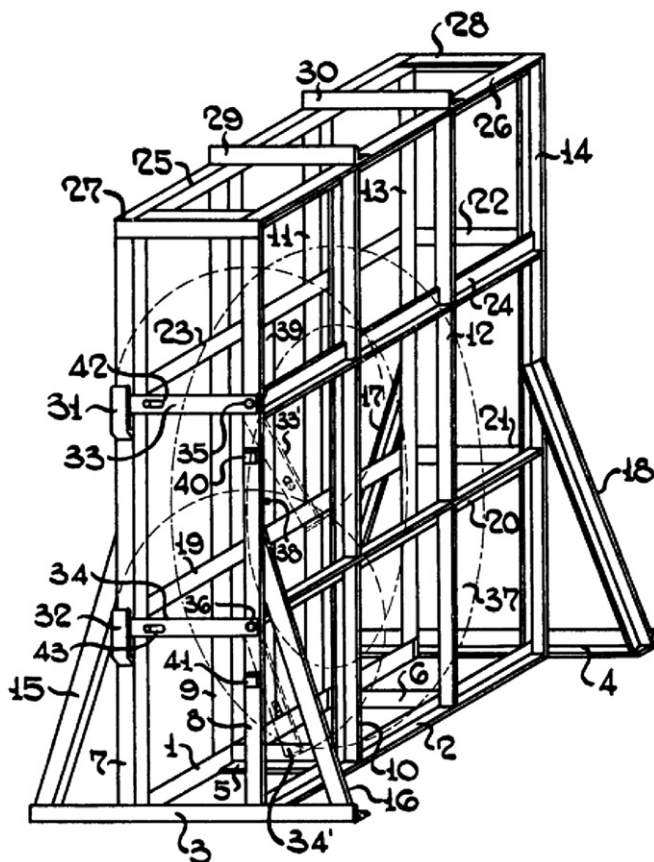


Fig. 1. Tire inflation guard — U.S. Patent 2407049.

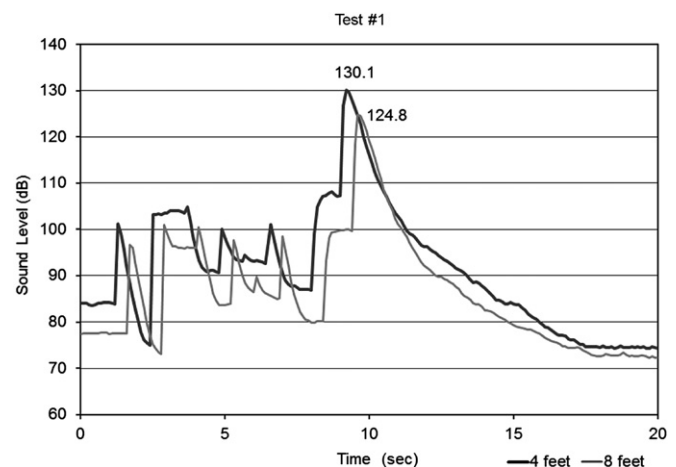


Fig. 3. Sound level plots for Test #1 at measured distances of 4 feet and 8 feet.

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