POLYURETHANE-FILLED PNEUMATIC TIRES vs. SOLID TIRES: A COMPARATIVE PERFORMANCE OVERVIEW

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Presented by Accella Tire Fill Systems
Manufacturer and Marketer of TyrFil®

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Introduction

It's all about tire choice. Tire purchase and maintenance are among the most significant expenses that operators in the construction, waste management, mining, agri-business, industrial and military fields must consider. The benefits and varied value propositions of the two primary flatproofed tire options—1) polyurethane-filled pneumatic tires (commonly referred to as "tire fill" or "foam-filled" tires) and 2) solid or aperture tires—have been debated many times over the past few years by original equipment manufacturers (OEMs), aftermarket tire dealers, rental companies and end users. It is important to understand that there is a healthy market opportunity for both products, but it is difficult to directly compare the two because they are entirely different – in terms of constitution and performance. As with any product category, both leading tire flatproofing solutions have strengths and weaknesses.

Two ways to drive the industry

Determining the best option for your particular business and operational needs is entirely dependent upon the desired application. Both polyurethane-filled and solid tires will function effectively as long as they are installed correctly and used according to the manufacturer's instructions. The greatest advantage of polyurethane-filled pneumatic tires over solid apertures is the smoother ride as a result of a substantially lower g-force transmission. Higher g-force transmission can cause operator injury and premature wear and tear on equipment components.

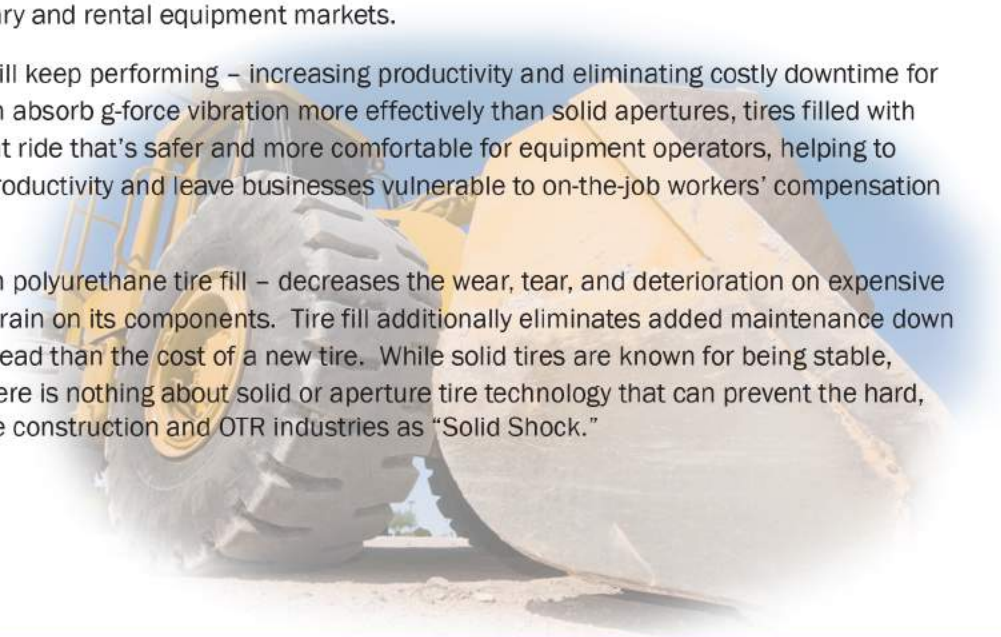
Also, the range of choice tire fill offers in tire sizes, tread patterns, polyurethane fill durometers and psi pressures for the equipment operator to choose from and customize according to each application, makes it difficult for solid tires to even compete on the same playing field. By coupling this broad adaptability with the eco-benefits and greater sustainability of polyurethane-fill, the advantages to considering tire fill are clear. Additionally, the savings that Off-the-Road (OTR) equipment operators have the opportunity to capture by choosing polyurethane fill—due to reduced wear and tear placed on both the operator and the equipment—make it a highly reliable, cost-effective solution.

Polyurethane fill: When there's more riding on the purchase decision

When performance, cost considerations and worker safety are paramount, especially in hazardous environments, tire fill delivers on a myriad of levels. For one, a filled tire will never go flat – it allows equipment to operate over broken glass, nails, sharp metals, rocks, rebar, and other damaging objects. The durability of polyurethane fill has been proven to perform in this capacity time and time again – in literally thousands of demanding applications for the construction, waste management, mining, municipality, military and rental equipment markets.

Despite cuts and punctures, filled tires will keep performing – increasing productivity and eliminating costly downtime for field operators. Plus, because tire fill can absorb g-force vibration more effectively than solid apertures, tires filled with polyurethane deliver a smooth, consistent ride that's safer and more comfortable for equipment operators, helping to prevent potential injuries that can stall productivity and leave businesses vulnerable to on-the-job workers' compensation claims.

The reduced jarring – made possible with polyurethane tire fill – decreases the wear, tear, and deterioration on expensive operational equipment and also eases strain on its components. Tire fill additionally eliminates added maintenance down time that would equate to far more overhead than the cost of a new tire. While solid tires are known for being stable, puncture free and reliable in the field, there is nothing about solid or aperture tire technology that can prevent the hard, rugged impact of what's referred to in the construction and OTR industries as "Solid Shock."



History: The evolution of tires

Solid rubber tires were first used with heavy equipment in 1868 by Robert Thomson.[1] Polyurethane tires were introduced during World War II, when German scientist Otto Bayer created polyurethane as a replacement for expensive rubber.[2] It was not until 1971, when the company that is now Accella Tire Fill Systems, formerly ArncoPathway, invented tire fill (under the brand name TyrFil®) that polyurethane became widely used as the premier flatproofing solution. This polyurethane tire fill material has seen many further developments and improvements in ride quality and endurance since then, and the continuous improvement of fill solutions and the tire fill process has allowed polyurethane filling to maintain its position as the preferred value proposition for flatproofing tires. This value – and the performance track record that marks the advantages of using tire fill with OTR, waste management and military vehicles – is the reason that most tire customers continue choosing polyurethane-filled pneumatic tires for their flatproofing needs.

Getting grounded on Tire Basics

Essentials of Tire Fill

Tire fill is a polyurethane liquid that is pumped into pneumatic tires to replace air with a resilient, synthetic rubber core that eliminates dangerous and costly tire flats in commercial and industrial heavy equipment vehicles. Tire fill is typically delivered through a valve stem and cures within 24 to 36 hours to offer excellent flat free protection. The material can be used in any tire with a sound casing and is able to sustain tire pressure and footprint shape – even in adverse weather conditions, including temperatures as low as 70 degrees below zero, or in sweltering heat.

A cost-effective solution for OEMs, aftermarket tire dealers and global distributors, the use of polyurethane fill guarantees that tires will remain "flat free" – defraying frequent vehicle repair expenses for industrial and heavy equipment operators. The ability to effectively recycle tire fill using appropriate equipment and methods also helps to drastically ease environmental strain by helping to keep used fill material out of domestic and international landfills, which contributes to ensuring a healthier, safer planet. Filled tires can be retreaded, in many cases multiple times, extending the life of costly tire casings.

1 *http://www.itec-tireshow.com/history/The%20first%20pneumatic%20tire.pdf*
2 *http://www.polyurethanes.org/index.php?page=history*

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Comparative Overview

Adaptability and Choice

A key differentiator between tire fill and solid tires lies in the fact that polyurethane-filled pneumatics allow the choice of a greater variety of tread patterns, construction and design (for example, smooth vs. lugged, radial vs. bias, and low profile vs. standard section height.) The fill chemicals that are available offer unlimited polymer combinations so the products can exhibit remarkable physical properties including high tensile strength, tear strength, elongation, deflection, compression, hardness, and rebound. Under testing in the field or lab, these properties allow the tire to endure at high speeds, loads, and temperatures.

Wear, Tear and Durability

The life of a tire depends on many factors, including the application in which the tire is used, the quality of the tire, and whether the tire is used according to the manufacturer's specifications. However, the larger variety of tread patterns, sidewall constructions, and rubber formulations available when using polyurethane-filled pneumatic tires compared to solid tires allows the customer to customize the tire and fill for specific applications and soil conditions. This customization maximizes traction, comfort and tread life, resulting in increased value. Moreover, the use of polyurethane tire fill ensures less vehicle damage due to prematurely worn out components as a result of lessened g-force transmission.

While solid tires have traditionally been associated as being better suited for use in some extreme applications such as demolition, a large mining customer located in South Africa tested both solid and polyurethane-filled pneumatic tires and found that using heavy-ply, deep tread (L5 or L6) pneumatic tires filled with polyurethane in these applications provides a better value.[3]

Solid tires tend to retain more heat than polyurethane-filled tires. Heat is retained in the center of the solid tire, which can lead to catastrophic tire failure. It has been reported that some makes of solid rubber tires have even caught on fire due to excessive heat retention.

Traction

Another difference between solid and polyurethane-filled tires is found in the traction of the tire, which refers to the maximum frictional force that can be produced between the tire and the surface without slipping.[4] Due to the wide range of tread patterns, rubber compounds and polyurethane hardness, polyurethane-filled tires have better traction over a wider variety of surfaces and terrains. Filled pneumatic tires tend to have additional ground contact area when compared to solid tires, giving increased traction, braking, and tire footprint.

3 Corrie DeVilliers, with Cool Ideas, prefers using a heavy-ply pneumatic tire with foam fill in loaders at Power Metal Recyclers (PTY) LTD in their metal recycling facility near Johannesburg, South Africa

4 http://dictionary.reference.com/browse/traction?s=t

Cushioning, stability and "shock resistance"

A significant measure used to evaluate the cushioning ability of any solid or polyurethane-filled tire lies in the "durometer" of the tire. For solid tires this would indicate the hardness of the rubber compound and other components used in construction of the tire, and in the case of filled pneumatic tires, in the polyurethane material that fills the tire cavity. A solid or polyurethane-filled tire with high durometer components is harder and absorbs less impact. A tire with low durometer components is softer and absorbs more impact.

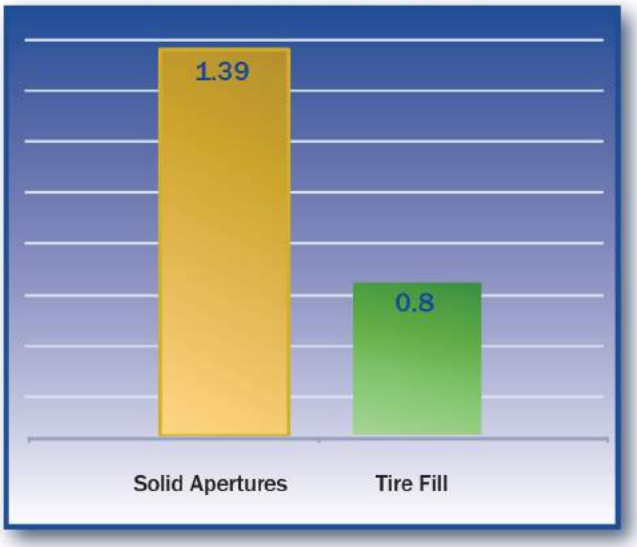
Most solid rubber tires are manufactured with a two or three stage construction. They typically have a tread durometer of 65 and higher, with inner layers at higher durometer levels. Many solid tires have added aperture holes in an effort to try and reduce the negative impact of a harsh ride performance, but these holes do not go through the entire tire and can easily crack.

Polyurethane-filled pneumatic tires, on the other hand, offer a wider range of core durometers from 8 to 55, allowing the customer to tailor the deflection of the tire for the application. Additionally, the pressure the polyurethane fill is installed at can be specified to match the application requirements. Thus, polyurethane-filled pneumatic tires provide the operator many options to modify the tire's deflection capabilities, either decreased for a more comfortable ride where desired or increased where greater stability is required. Solid tires, in contrast, offer a very limited choice in deflection.

Polyurethane-filled tires absorb more g-force vibration, reducing both operator fatigue and equipment stress. Heavy duty equipment operators seek as smooth a ride as possible. These operators often prefer polyurethane-filled tires, as the comfort and handling characteristics of polyurethane-filled tires are more comparable to those of air-filled tires. Because tire fill is available in a variety of durometers, it provides each piece of equipment with the operating characteristics appropriate for each application.

Another stability factor to be considered is the density of a tire. Filling a pneumatic tire with a polyurethane adds weight and stability to equipment. Lowering the CoG will provide increased vehicle stability, lessen the risk of roll over in extreme situations, and in most cases increase lateral grip. Rubber, on the other hand, is more dense than polyurethane, resulting in even more added weight. A customer must consider that extra weight may be tougher on equipment. The added stability from additional weight may put stress on hubs and wheel bearings, so additional maintenance may be required. Also, it is important to note that solid tires can exceed the ROPS (Roll Over Protective Structures) weight capacity limits on some equipment creating a substantial safety concern.

Front End Loader Testing Results – Recorded G-forces



TyrFil Processed Tires – 41% less g-force transmission to cab/operator than solid aperture tires. Data was collected on a front end loader tested on a track replicating real jobsite conditions.

Performance Quality and Driver Safety

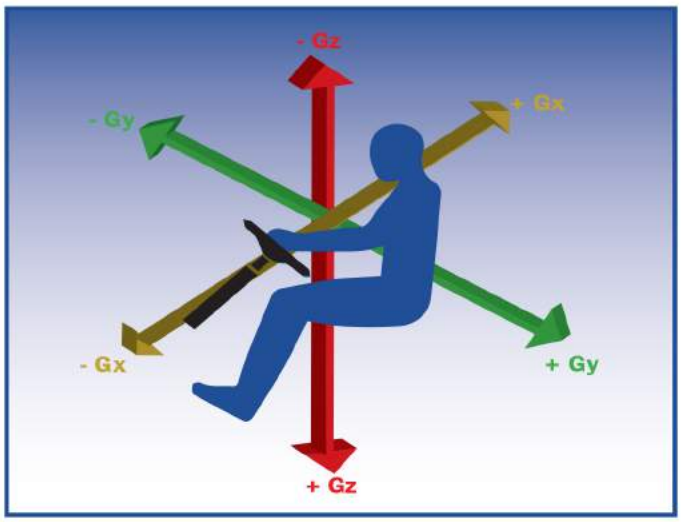
One major area of differentiation between polyurethane fill and solid aperture tires is in the ruggedness of the ride for OTR equipment operators. In addition to providing better traction and overall stability, tire fill aids in allowing heavy equipment operators to experience less body jarring effects, especially when they are scaling rough and uneven terrain. This is also especially true for waste management wheel loaders, which often experience rough and uneven driving circumstances.

The physical impact of a jarring ride in a heavy equipment or OTR vehicle is a phenomenon known in the occupational field as Whole Body Vibration (WBV). This is a real medical condition suspected to cause adverse health effects such as fatigue, lower back pain, vision problems, interference with or irritation to the lungs, abdomen, or bladder, and negative effects to the digestive and urinary systems. Other issues include back injuries (resulting from constant impact on the equipment operator for up to 8 hours per day), which can be a significant symptomatic effect of the WBV phenomenon – and one that may contribute to lessened on-the-job productivity and worker focus.

WBV can also be a major source of lost time in occupational environments, especially for operators of commercial, industrial and heavy equipment/OTR vehicles. About 8 million U.S. workers have occupational vibration exposure. Of these, an estimated 6.8 million are exposed to WBV. Mandatory standards for the regulation and monitoring of worker exposure to WBV exist in Europe; but in the U.S., there are reference standards, but no specific regulations.

Tire fill, when used in conjunction with the proper tire application, versus solid apertures, may help to significantly reduce the effects of WBV impact. The smoother ride offered by polyurethane-filled tires is a result of the increased deflection that tire-filled pneumatics provide that enables it to decrease g-force impact. Lower back pain and whole body vibration are often a result of excessive g-force transmissions from solid aperture tires. This phenomena of increased operator injury and equipment damage is known in the industry as "Solid Shock."

Tire fill offers a better, ergonomic alternative to the heavy equipment industry – creating a smoother, "softer" ride that is more similar to air-filled tires, while offering the tire all the flatproofing advantages of a solid tire. Polyurethane-filled pneumatics can allow 30% - 46% less adverse g-force effects compared to solid aperture tires resulting in less equipment and operator fatigue.



This graphic helps depict the three axis that make up Whole Body Vibration (WBV) that are directed to a vehicle operator:

- Gy - side-to-side motions
- Gx - back and forth motions
- Gz - up and down movements

Collectively, the tri-axial values of vibration are cumulative and will be amplified to the driver. WBV is now being explored using these measurements to provide meaning to driver fatigue, discomfort, and injury. All three are happening simultaneously and can be observed, both in the positive and negative modes.

Recycling and Retreading

The polyurethane in filled tires can be reclaimed much easier than the rubber in solid tires, creating a second product lifecycle that extends end-user investment and reduces resource consumption. When the tread is worn on a polyurethane-filled tire, but the tire casing is still functional, the tire can be retreaded. Tests on Accella Tire Fill Systems TyrFil® product with re-treaders demonstrated that there is no degradation in the polyurethane fill even after up to four retreading cycles. If the tire is damaged beyond repair, an Accella dealer can recover the polyurethane fill and effectively recycle it. This process saves both operator costs and resources, making it a qualitative and quantitative win for the industry.

Sustainability

An estimated 1 billion tires reach the end of their useful life each and every year.[5] Annually, the U.S. alone generates more than 290 million tires. Tire manufacturers, distributors and the retail channel are continually searching for answers to identify an environmentally sound way of disposing of scrap tire pieces and creating a sustainable use of natural resources in tire production.

Tires are widely considered to be one of the most toxic and problematic sources of waste, primarily due to the alarming levels of fossil fuels and other raw materials used in tire production. Regrettably, solid tires pose a particularly stubborn obstacle on the path to create a more eco-friendly industry solution.

For one, they take up extensive space to store when discarded – and in a landfill environment, whole tires can float to the top of the landfill (breaking through closures and landfill caps) to create leaking and necessitate costly repairs. Secondly, the need for additional landfill square footage to accommodate tire waste can promote mosquito infestation, which in turn breeds vector-borne disease. Lastly, solid tire waste is flammable and at risk of "tire fire" danger, which can take days, weeks, months or even years to extinguish.

Polyurethane tire fill, by contrast, offers many sustainable advantages over solid or aperture tires. For sustainable-minded businesses looking to culture a Triple Bottom Line ethos (nurturing People, Planet, and Profits) when it comes to their equipment operations, investment in a tire fill flatproofing solution greatly reduces their carbon footprint and eliminates whole tire and tire scrap waste from clogging our already over-cluttered global landfills.

In general, polyurethane fill technology is better for the environment and reduces toxic emissions on various levels. Unlike solid tires, tire fill material is recyclable. The fact that polyurethane-fill product can be repurposed is a significant measurement of eco-compatibility. Again, because a filled tire can be retreaded for longer life and usability – and because it can be reclaimed much easier than the rubber in solid tires – it saves both the dealer and the customer tangible expenses that can directly impact bottom-line savings.

5 Source: World Business Council for Sustainable Development

Tire Performance Comparison by Application Type

Based on Customer Survey

= BEST IN CLASS = AVERAGE = WORST IN CLASS

Solid Tires

	Mining	Agriculture	Construction	Forestry	Material Handling	Scrap Metal	Ground Support
Cushioning, Floatation & Shock Resistance							
Stability							
Wear, Abrasion & Durability							
Traction							

Polyurethane-Filled Pneumatic Tires

	Mining	Agriculture	Construction	Forestry	Material Handling	Scrap Metal	Ground Support
Cushioning, Floatation & Shock Resistance							
Stability							
Wear, Abrasion & Durability							
Traction							

Cost

Tires are one of the most expensive maintenance and repair costs on an industrial vehicle. From a pricing standpoint, it is difficult to precisely compare the two types of tires, as there are many variables to be considered. The initial price paid for tires is generally higher for solids than for polyurethane-filled tires.

Additionally, solid aperture tires can come with hidden costs. Excessive g-force transmission and "Solid Shock" can produce premature damage to the equipment and injury to the operator. Solid Shock can generate expensive damage to the axle, hubs, engine mounts, and transfer case, just to name a few. To the operator, Solid Shock can create headaches, lower back pain, joint pain, and fatigue. Prolonged exposure to Solid Shock can induce Whole Body Vibration, a measurable muscular-skeletal and neurological injury which results in spinal, nerve, and internal organ damage. These real occupational hazards can cost hundreds of thousands of dollars.

Furthermore, some rental customers state that polyurethane-filled tires provide the lowest cost per hour compared to solids. The rental fees that companies charge for similar machines are the same, regardless of whether the tires on the machine are solid or polyurethane-filled. Since polyurethane-filled tires are less expensive to buy and maintain, rental companies realize higher profits from rental equipment with polyurethane-filled tires.

Lastly, disposal costs must also be considered. Polyurethane-filled tires can be retreaded for extra life. The polyurethane-fill inside a used filled-pneumatic tire can be recycled by a local tire dealer through the utilization of a tire fill recycling system, whereas solid apertures almost always end up in landfill.

Summary

OEMs, aftermarket tire dealers, and global OTR tire distributors all have a serious decision to make when it comes to tire selection. Presumably, most operators will seek the most comfortable ride and superior product performance. Purchasers likely also know that tire fill offerings are among that spectrum of available options, but until recent years, they may not have truly recognized the flatproofing advantages that tire fill offers the industry.

While solid tires offer a stable option that can be long lasting and reliable, they also incur non-direct operator costs. These include greater wear and tear on the vehicle, the potential negative effects of Whole Body Vibration on equipment operators, and fewer eco-benefits to protect the environment.

Tire fill offers a cost-effective, pro-environment tire flatproofing solution for improved safety and productivity that delivers the reliability required for rigorous military, agriculture, waste management, mining, and OTR applications. Additionally, the use of polyurethane-filled tires reduces vehicle damage and deterioration and may prevent worker injury and liability claims. Accella Tire Fill Systems stands alone in the industry as the one global tire fill provider that seamlessly integrates the highest product integrity with an international customer service and supply network that is second to none.

Please visit www.accellatirefill.com for additional information, including an instant Profit Analysis Calculator to see the total cost savings of using TyrFil® for your business.

NO MORE SOLID SHOCK

ACCELLA TIRE FILL SYSTEMS

2003 Curtain Pole Road, Chattanooga, TN 37406
(800) 821-4147
www.accellatirefill.com

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