TIRE

AMMICO

ARZESH AFARIN
MINING & MINERAL INDUSTRIES CO.

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OTR Tires

OTR (Off-The-Road) tires are specifically designed for use under special conditions. These tires are primarily utilized in construction, agricultural, and mining machinery. Generally, tires with a rim size larger than 25 inches fall into this category. These tires are manufactured using reinforced compounds to withstand harsh conditions. Additionally, the compounds used in the tread and sidewalls of these tires offer greater resistance to cuts, punctures, and abrasion compared to other tires.

They feature deep, large lugs that facilitate their operation in specific environments. Designed to carry heavy loads, they are commonly used in mining operations. The structure of these tires comprises various layers of wire and compounds with different compositions, arranged to enhance tire strength, retain air, and ensure optimal performance. The inner structure of the tire is illustrated in the following diagram.

Importance and Necessity of Tire Retreading

Tire retreading involves reusing a worn-out tire by removing the remaining tread and replacing it with a new tread, which can be done through various methods. The necessity of using retreaded tires has several aspects, including cost reduction, environmental preservation, and reduction in material consumption.

Cost Reduction

New OTR (Off-The-Road) tires are quite expensive due to their large size and high material consumption, with costs ranging from $20,000 to $40,000 depending on the size and brand. Retreading a tire costs about 30% to 50% of the price of a new tire. If the retreaded tire maintains a quality comparable to a new one, it becomes a cost-effective option. Generally, retreaded tires have a lifespan equivalent to 75% to 100% of new tires.

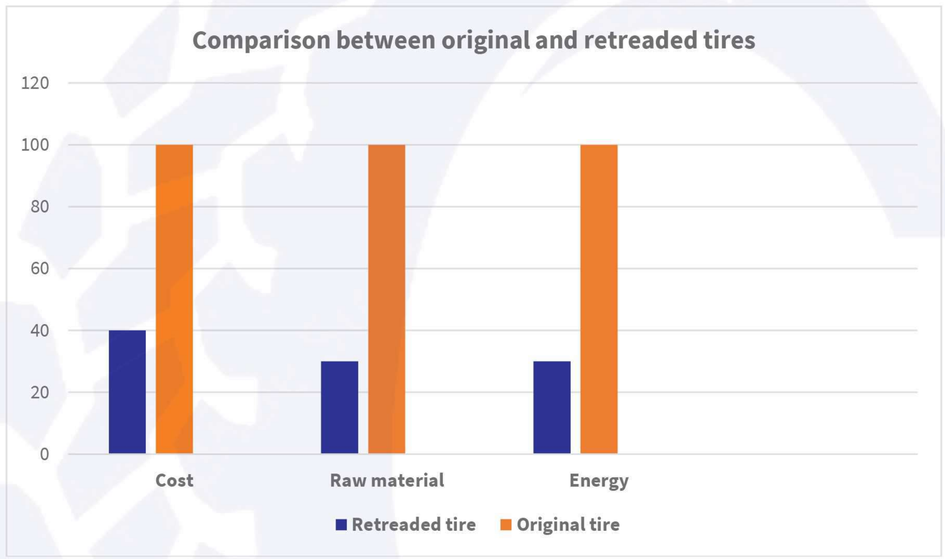
Reduction in Raw Material Consumption

The production of these tires requires a substantial amount of raw materials, including compounds and steel wires. Retreading tires allows approximately 70% of the raw materials in the tire to be reused, significantly conserving petroleum products and natural resources. The rubber used in tires primarily comes from petroleum derivatives or Hevea trees that produce natural latex. In recent years, using retreading technology for used tires has saved 500 million gallons of oil in North America. Producing one mining OTR tire uses 22 gallons of oil, which can be reduced to 7 gallons through retreading.

Environmental Preservation

In addition to reducing the consumption of petroleum-based and natural raw materials, which significantly contributes to environmental conservation and a circular economy, the energy required for retreading OTR tires is only 30% of the energy needed to produce a new tire. If used tires are not retreaded, a large volume of tire waste is generated, which requires significant costs and energy to recycle, and it also leads to environmental pollution.

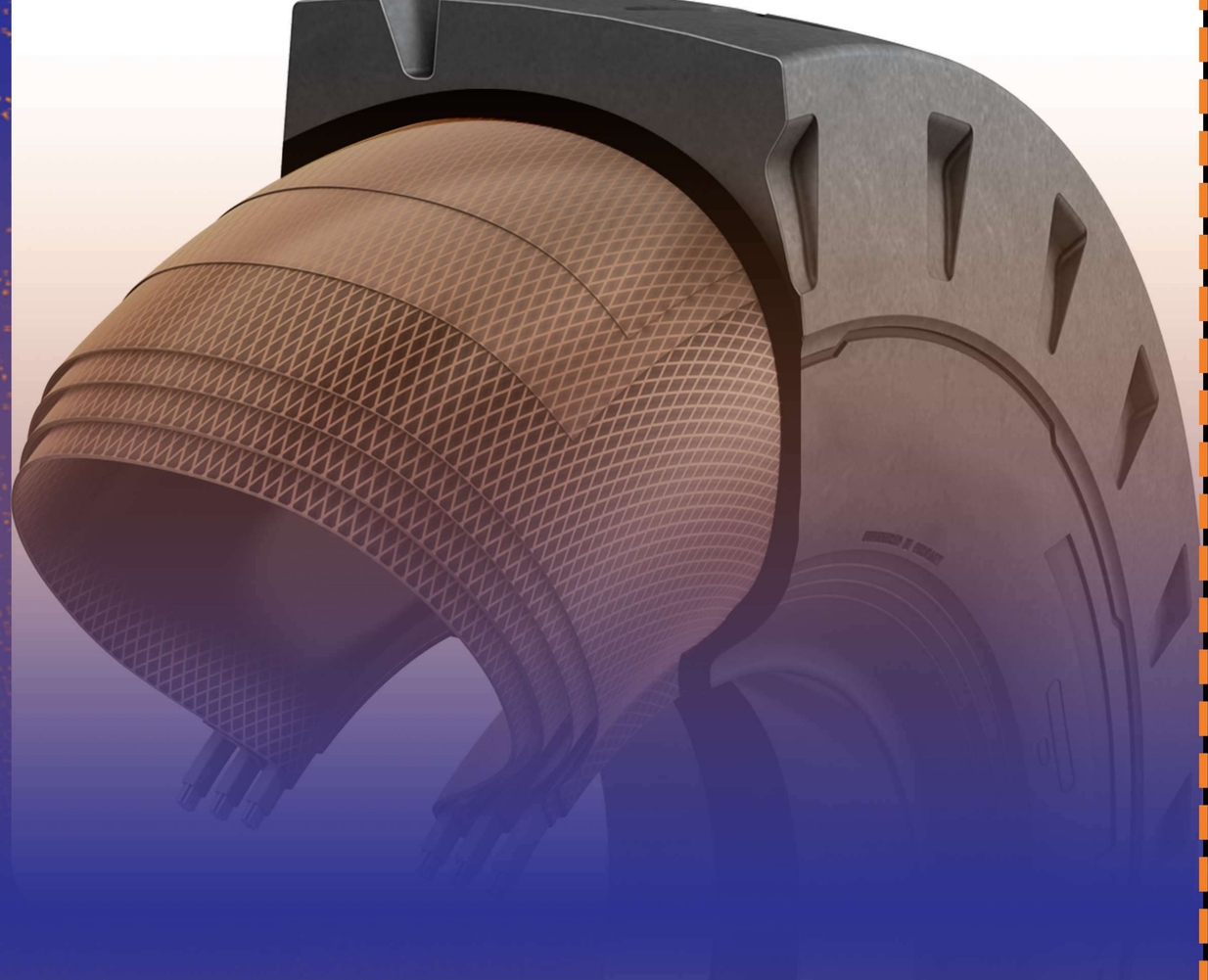
Considering these factors, tire manufacturing standards have evolved to require manufacturers to design tires capable of being retreaded. OTR tires can be retreaded up to two times, depending on the quality of the tire carcass.



Tire Retreading and Repair Processes at Arzesh Afarin Mining and Industries Company

To increase the lifespan of tires, enhance mining operations, reduce foreign exchange outflows, decrease tire waste in mines, and protect the environment, an OTR tire retreading factory has been established. Tires that have worn out treads after use in mines undergo the retreading process, while tires damaged during operations are repaired.

Arzesh Afarin Mining and Minerals Industries Company (AMMICO) uses an up to date method with international standards for retreading mining tires. This company provides retreading and repair services for these types of tires to ensure they meet the highest quality standards.



Retreading Mining Tires

Once 90% to 92% of the tread on mining tires is consumed, these tires are ready for retreading. The steps for retreading these tires are as follows:

Casing Acceptance

The acceptance of the casing occurs in several stages as outlined below:

- Initial Acceptance: This takes place at the mining site while the tire is still in use.
- **Inspection after Removal:** The tire is inspected after being removed from the truck.
- **Inspection at the Factory:** After washing, the tire is inspected at the factory.

The selection and acceptance of casings for retreading are conducted according to the Rema TIP TOP standards, using specialized tools and equipment to identify tire defects. The optimal time for retreading is when 8% to 10% of the tire tread remains.

During the tire inspection process at the mining site, tires in operation are also examined to determine the optimal time for retreading, ensuring the maximum possible performance from new tires. Some tire defects may only become visible after complete washing and inspection at the factory, making the final inspection at the factory crucial.

Peeling and Buffing

For the retreading of tires, it is necessary to remove the tread that has been damaged by rock cuts and wear, which is done in two stages. In the first stage, known as peeling, the remaining tire tread is removed using a fully automatic machine. In the next stage, called buffing, areas with deep rock cuts or separations are buffed by a technician to reach the undamaged layers of the tire. Depending on the depth of the damage, the buffed areas may reach the wire layers, which would then require tire repairs in subsequent stages. These processes prepare the tire surface for the next stages of retreading.

Several important parameters must be considered during these stages:

- **Adjusting Peeling Machine Variables:** The machine settings need to be adjusted based on the tire size, requiring a thorough understanding of tire geometry and precise dimensional specifications. Extensive cross-sectional analysis of the tire is conducted for this purpose.
- **Peeling Depth (Undertread):** The peeling depth must be adjusted so that a specified amount of compound remains on the casing to ensure maximum adhesion and performance of the retreaded tire.

Repairs

Areas where buffing has reached deeper layers of the tire need to be filled with a compound to level the casing surface. If the buffed area reaches the underlying wire layers, in addition to the compound, a patch is required. This patch is applied to the inner layer of the tire to enhance the strength of the casing in the deeply buffed area.

Cementing

Before applying the compound to the casing, a cementing step is carried out on the tire to ensure a strong bond between the compound and the casing. The adhesive used, which is rubber-based, is known as cement. The parameters influencing the adhesion performance between the cement and the casing include:

- **Thickness of the Applied Cement:** Ensuring an appropriate thickness of cement on the tire.
- **Optimal Drying Time of the Cement:** Allowing the cement to dry for the optimal duration after application.
- **Formulation of the Cement:** Enhancing adhesion between the various components.

Applying the Compound to the Casing

Once the cement has sufficiently dried, the compound is applied to the casing. During this stage, the belt compound enters the extruder and is heated to 80 degrees Celsius. The compound extruded is then layered onto the casing to achieve the required thickness.

Compound Curing

After applying the compound to the casing, the curing process is carried out to form cross-links in the compound and bond it to the casing. Tire curing is performed in an autoclave with controlled temperature, pressure, and curing time. The following factors are crucial in this stage:

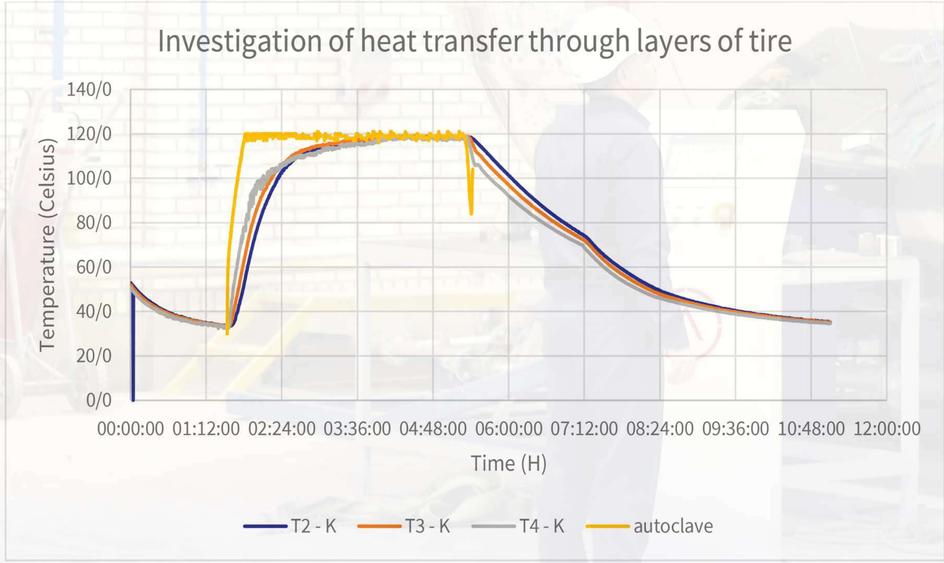
- **Determining the Appropriate Curing Temperature:** This depends on the type of compound, compound thickness, casing conditions, and whether the tire is fabric or steel-belted.
- **Heat Transfer Management:** Ensuring proper heat distribution through the tire's thickness and across its various layers.
- **Optimal Pressure and Curing Time:** These are determined by rubber vulcanization equations and ensuring they meet the necessary specifications.

Applying tread

After the tire has been cured and cooled, the desired tread pattern is applied. This process is conducted using specialized cutters guided by machinery. Various tread designs can be applied to the tire. At this stage, the new tire tread or any other customer-specified tread pattern can be created.

Final Inspection

Upon completing the tire production stages, a final inspection is conducted to ensure the tire's integrity. The tire's quality is then graded based on its condition and adherence to standards.



Repairing Mining Tires

In many cases, mining tires may sustain damage during operation. If this damage is not addressed, the tire could become unusable and result in waste. In such situations, localized repairs are carried out on the tire, allowing it to continue functioning. It is worth noting that these tires can also be retreaded once the tread is worn out. The repairable areas include:

- **Tread Repairs:** In case of stone impacts or tread separation.
- **Sidewall Repairs:** Due to stone impacts.
- **Bead Repairs.**

Sizes and Tread Patterns for Retreading

Retreadable Sizes

AMMICO offers retreading services for mining tires ranging from size 12R24 to 33R51. All tires with rim sizes from 24 to 51 inches are eligible for retreading within this range. Generally, retreadable sizes can be classified into two categories: mining tires and construction tires

Category	Size	Category	Size
Mining Tires	18R33	Construction Tires, Agricultural Tires	12R24
	35/65R33		14R24
	24R35		16R25
	27R49		17.5R25
	30R51		20.5R25
	33R51		23.5R25

Tread Patterns for Retreading

Tire tread patterns are designed based on operational conditions and their applications. According to the standards of the Global Tire and Rim Association, the specific designations for each tire are introduced in the table below. Operational conditions determine the type of compound used in the tire, the tread pattern, and its depth. Mining tire manufacturers adjust the compound based on the required operational needs, modifying factors such as wear resistance, cut resistance, heat generation rate, and rolling resistance in accordance with the operating environment.

Operation	Application	Machinery	Properties	TRA Classification
Mining	Transportation	Dump trucks	Heat resistance, Cut resistance, Operational stresses resistance	**E**
Grading	Flatting	Graders	Steering, maneuverability, stability	**G**
Loader	Loading & Transportation	Loaders	Cut resistance, Abrasion resistance	**L**
Rolling	Compressing	Rollers	Chemical resistance, Abrasion resistance, Cut resistance	**C**

Mining tire manufacturers generally adhere to four main categories of tread patterns:

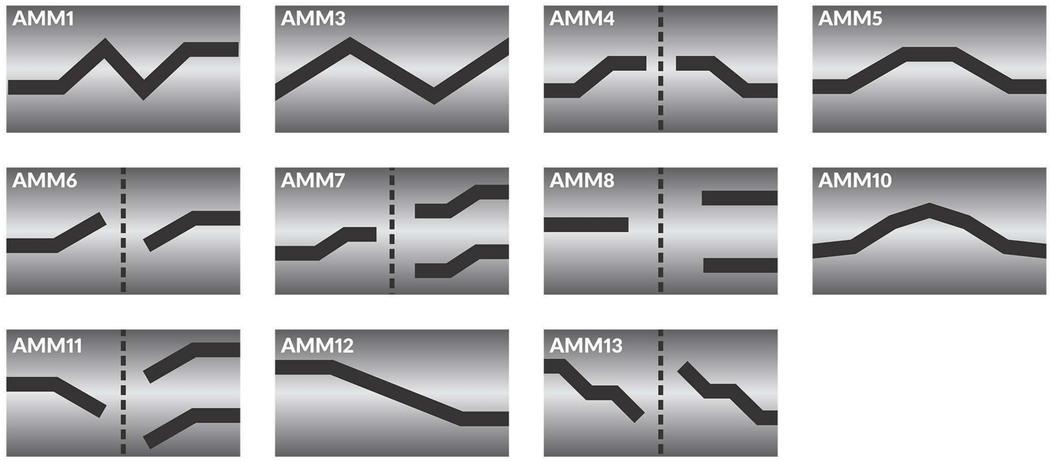
1. **Rocky Tread Pattern**
2. **Block Tread Pattern**
3. **Grooved Tread Pattern**
4. **Soft Tread Pattern**

Tread pattern	Application	Properties	Machinery	Pattern figure
Rock pattern	Harsh mining conditions	Cut resistance, Heat resistance	Dump truck, Grader, Loader	
Block pattern	Hard rocks	Steering, Cut resistance	Dump truck, Loader	
Grooved	Road	Steering, Low rolling resistance	Truck, Automobile	
Smooth	Hard rocks	Cut resistance	Roller, Loader	

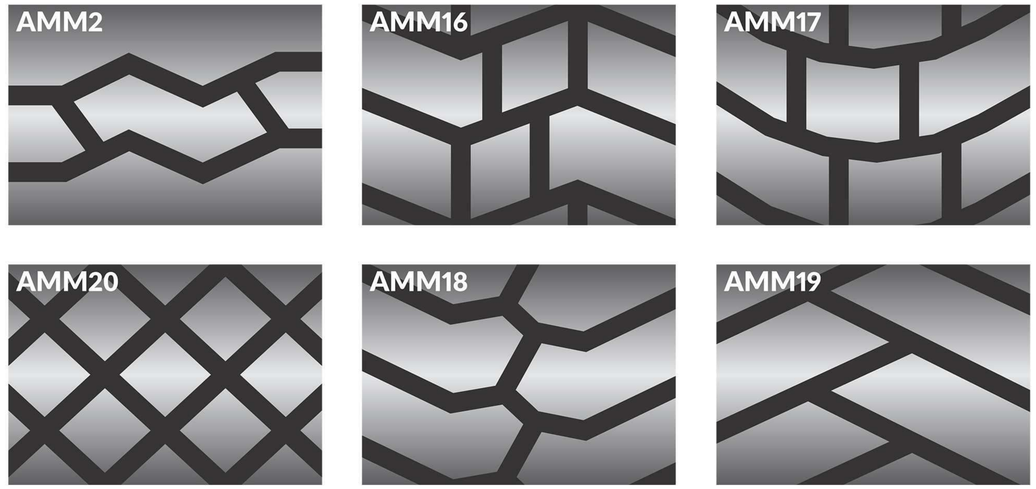
Primary Tread Patterns

The primary tread patterns used by AMMICO are the Rocky and Block patterns. However, other patterns can also be applied according to customer requirements. The common tread patterns used for retreading mining tires are illustrated in the following figures:

- **Rocky Tread Pattern**
- **Block Tread Pattern**



Rocky Tread Pattern



Block Tread Pattern

Quality Control and Laboratory

All stages of production are overseen by the factory's Quality Control unit. Inspection of the production process is conducted according to TIP TOP standards. Quality control tests are regularly performed on raw materials, outputs of each production stage, and the final product to ensure complete confidence in the quality of the produced tire.

The factory's tire laboratory, as a key component of quality control and production, utilizes state-of-the-art laboratory equipment to test various compounds and other raw materials. The data obtained from these tests are used to enhance the quality of the produced product. The laboratory is equipped with the following instruments for testing mining tire compounds:

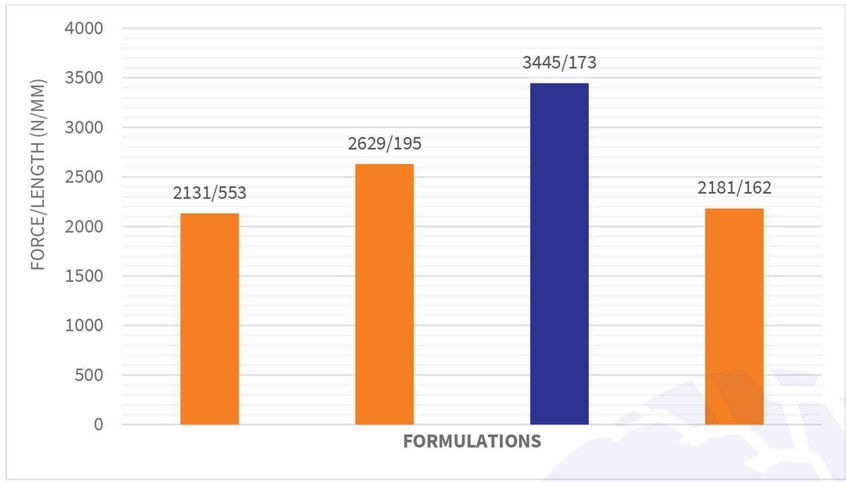
- **Rheometer**
- **Tensile Testing Machine**
- **Abrasion Testing Machine**
- **Sh-A Hardness**
- **Resilience Testing Machine**
- **Other necessary equipment for various compound tests**

Research and Development

The Research and Development unit of AMMICO is actively working to enhance production processes, optimize raw materials, improve retread tire quality, and reduce overall production costs. Various projects have been undertaken in this regard.

Improving the cement formulation

One of the critical interfaces in retreaded tires, which significantly impacts the product's lifespan and prevents compound delamination from the casing, is the interface between the metal wire and the compound. The key to achieving proper adhesion between the wire and the compound is the cement. By optimizing the formulation of the cement used in the production process of retreaded tires, adhesion has increased by 60%. This enhancement brings the strength and structural integrity of the retreaded tire very close to that of a new tire



Design of Compounds for Various Operational Conditions

Tires require different compounds to achieve optimal performance based on the mining site, size, load, distance traveled, speed, and TKPH (Ton-Kilometer per Hour). Depending on the operational conditions, different properties are prioritized:

• In some conditions, resistance to stone impact and effective heat dissipation are of utmost importance. These are typically seen in dump truck and loader tires.

• In other conditions, abrasion resistance and traction are more critical, which is often the case for truck tires.

To enhance tire quality and lifespan and to better match the tire compound with its operational conditions, AMMICO has developed two types of compounds tailored for these operational conditions. Their properties are described as follows:

• Compound for Dump Truck and Loader Tires

Test	Standard	Unit	Result
T90(Rheometer)	ASTM D2084	Min	5:06
T sc2		Min	2:57
Torque.Max		dN.m	6.68
Torque.Min		dN.m	0.41
Hardness	ASTM D2240	Sh.A	68
Stress	ASTM D412	MPa	21.8
Elongation	ASTM D412	%	459
Tear	ASTM D624	Kgf/cm	67.5

• Compound for Truck Tires

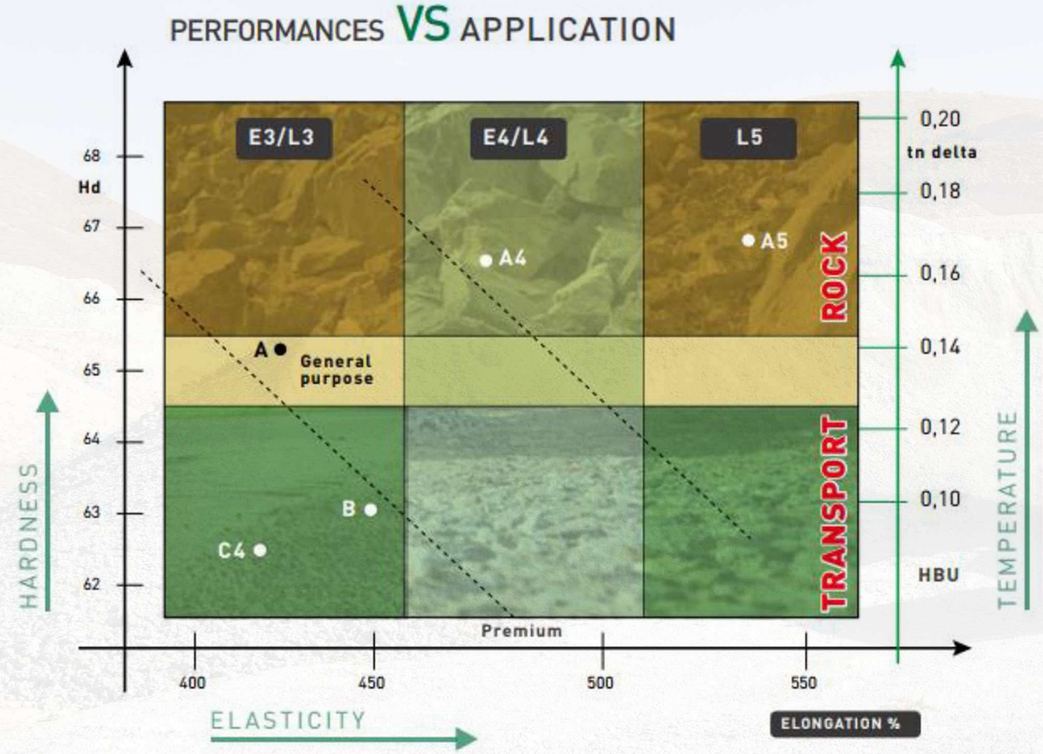
Test	Standard	Unit	Result
T90(Rheometer)	ASTM D2084	Min	5:06
T sc2		Min	2:57
Torque.Max		dN.m	6.68
Torque.Min		dN.m	0.41
Hardness	ASTM D2240	Sh.A	68
Stress	ASTM D412	MPa	21.8
Elongation	ASTM D412	%	459
Tear	ASTM D624	Kgf/cm	67.5

Determination of TKPH for Compounds

One of the most crucial parameters for a compound that indicates its suitability for mining conditions is the TKPH factor. The formula to determine this factor is as follows:

$$TKPH = \frac{Q_{Loaded} - Q_{Empty}}{2} * \frac{N * L}{H}$$

Using the above factor, it is possible to determine whether the compound has properties of resistance to cutting, heat resistance, or intermediate characteristics. Each of these properties is suited to specific mining conditions.



Additional Services

In addition to providing retreading and repair services for mining tires, AMMICO also offers the following services:

- **Tire Consumption Management and Performance Enhancement in Mines**
- **Continuous Monitoring of Tires at Workshop Sites**
- **Optimization of Operational Parameters to Extend Tire Lifespan** (e.g., air pressure, load, speed, etc.)
- **Optimization of Mining Ramps**
- **Consulting Services for Tire Selection**
- **Tire Engineering Training for the operators**
- **Management of Active Tires for Retreading Planning**
- **Consulting and Providing Operational Solutions for Tire Wear Management for Retreading**
- **Planning Tire Replacement Timing for Retreading based on usage hours and wear rate of the tires in the mine**

Customers of the Tire Retreading Factory

Some of the clients of the mining tire retreading factory are as follows:

- **Karaavaran Sanat KhavarMiyaneh Co.**
- **Jahad Nasr Sirjan Co.**
- **Jahad Nasr Kerman Co.**
- **Khatam Headquarters, Sarallah**
- **Khatam Headquarters, Sepasad**
- **Mana Saz Co.**
- **Samin Gohar Co.**
- **Kani Kavan Co.**
- **Yutab Yazd Co.**
- **Semnagan Tarabar Iranian Co.**
- **Kani Kushan Co.**
- **Kaveh Foolad Arya Co.**
- **Arman Gohar Sirjan Co.**
- **Mess Derakhshan Takht Gombad Co.**
- **Opal Kani Pars Co.**
- **Foolad Esfarayen Co.**

Ongoing Projects

Precured Retreading

To increase the retreading rate of 12R24 truck tires and reduce the overall cost of retreading these tires, AMMICO is establishing a precured retreading line. In this method, precured tread is applied to the tire after buffing and then cured in an autoclave. This method uses less compound compared to the current process for truck tires. The capacity of this line is 20 tires per shift.

Compound Production Line

To complete the supply chain for the tire retreading factory and reduce production costs, AMMICO is also establishing a compound production unit. With the commissioning of this production line, it will be possible to produce various compound grades for different tires with diverse operational conditions. The production capacity of this line is 1 ton per shift.

Industrial Automation System for the Tire Retreading Factory

Tires are among the most complex products in the polymer industry, involving numerous parameters in their production and monitoring. This complexity also applies to retreaded OTR tires. From inspection to production processes, quality control, and field monitoring, the multitude of stages, involved parameters, and personnel complicate the process. Therefore, it is essential to design a mechanism that accelerates processes, prevents task overlap, and enhances production efficiency and coordination among various departments. In this regard, AMMICO tire retreading factory is in the process of implementing an industrial automation system. This system aims to accelerate the production process, optimize data recording, manage resources, and increase production efficiency. It will ensure that all data related to each tire is recorded and its schedule and performance are clearly defined.

Warranty

AMMICO, with its experienced and trained personnel, is committed to significantly reducing operational costs for contracting companies by providing the best retreading for construction and mining equipment tires. The company aims to minimize human errors and enhance the quality of retreading materials to substantially reduce tire costs. Depending on the accepted casing condition and operational circumstances, up to 3,000 hours of warranty is provided for retreaded tires.

Continuous field consulting to monitor tires and establish optimal operational conditions specific to each mine is a fundamental aspect of the company's activities.

Any damage to retreaded tires caused by external or internal factors is not covered under this company's warranty. However, any failures due to poor quality of retreading materials or defects in the retreading process are covered by the warranty.

Exclusions from Warranty

The following conditions will result in the product being excluded from warranty coverage:

- **Overheating of the Tire**
- **Separation of Inner Layers**
- **Tire Damage Due to Hot Surface Contact**
- **Tire Damage from Contact with High-Voltage Electrical Cables**
- **Tire Damage Due to High-Voltage Electrical Discharge**
- **Operating in Underinflated or Overinflated Conditions**
- **Wear Due to Cuts or Stone Impacts on the Sidewall**
- **Burning of the Tire's Outer Surface**
- **Tire Operation Under Overload**
- **Tire Operation at Excessive Speed**
- **Delamination or Separation from Below the Tread Surface**
- **Uneven and Unbalanced Wear**
- **Failure to Use Uniform Tread Thickness in Dual Rear Axle Tires**
- **Thickness Variations Exceeding 10% in Tires on the Same Axle**
- **Use of Damaged Rims with Tires**
- **Incompatibility Between Rim and Tire**
- **Storage of Tires Near Welding Areas**
- **Exceeding the Maximum TKPH Rating**
- **Damage from External Environmental Factors or Mechanical Faults in Equipment**
- **Premature Failure Due to Improper Installation or Removal Equipment for Rims and Tires**

STD-02

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