CABOT®

Engineered
Elastomer
Composites

INNOVATIVE SOLUTIONS
FOR OFF-THE-ROAD AND EARTHMOVER TIRE APPLICATIONS

eApplication Guide

Cabot Engineered Elastomer Composites

Cabot Engineered Elastomer Composite (E2C™) Solutions enable tire manufacturers to:

- Differentiate products through step-change performance innovation.
- Simplify operations and unlock manufacturing capacity to meet growing demand.
- Enable the smart expansion of business models through next-generation solutions and services.
- Achieve sustainability goals by extending product lifetimes, improving energy efficiency and reducing raw material consumption.

OTR AND EARTHMOVER APPLICATIONS
PERFORMANCE
ECONOMICS
SOLUTIONS
SUSTAINABILITY
HOMEPAGE

Achieve Step-Change Innovation

- E2C™ Solutions are well suited for use in Off-the-Road (OTR)/Earthmover applications where conditions demand extreme tire performance.
- E2C™ Solutions break trade-offs in tire compound design and enable new levels of tire performance.
- Improvements in cut, chip, chunk resistance, tread life and load capacity (i.e. TKPH*) are possible when using E2C™ Solutions.
- Mining customers can realize increased vehicle uptime and higher mine productivity when their tires contain E2C™ Solutions.

OTR AND EARTHMOVER APPLICATIONS

OTR TIRE SEGMENTATION

MINING INDUSTRY CUSTOMERS

PERFORMANCE

ECONOMICS

SOLUTIONS

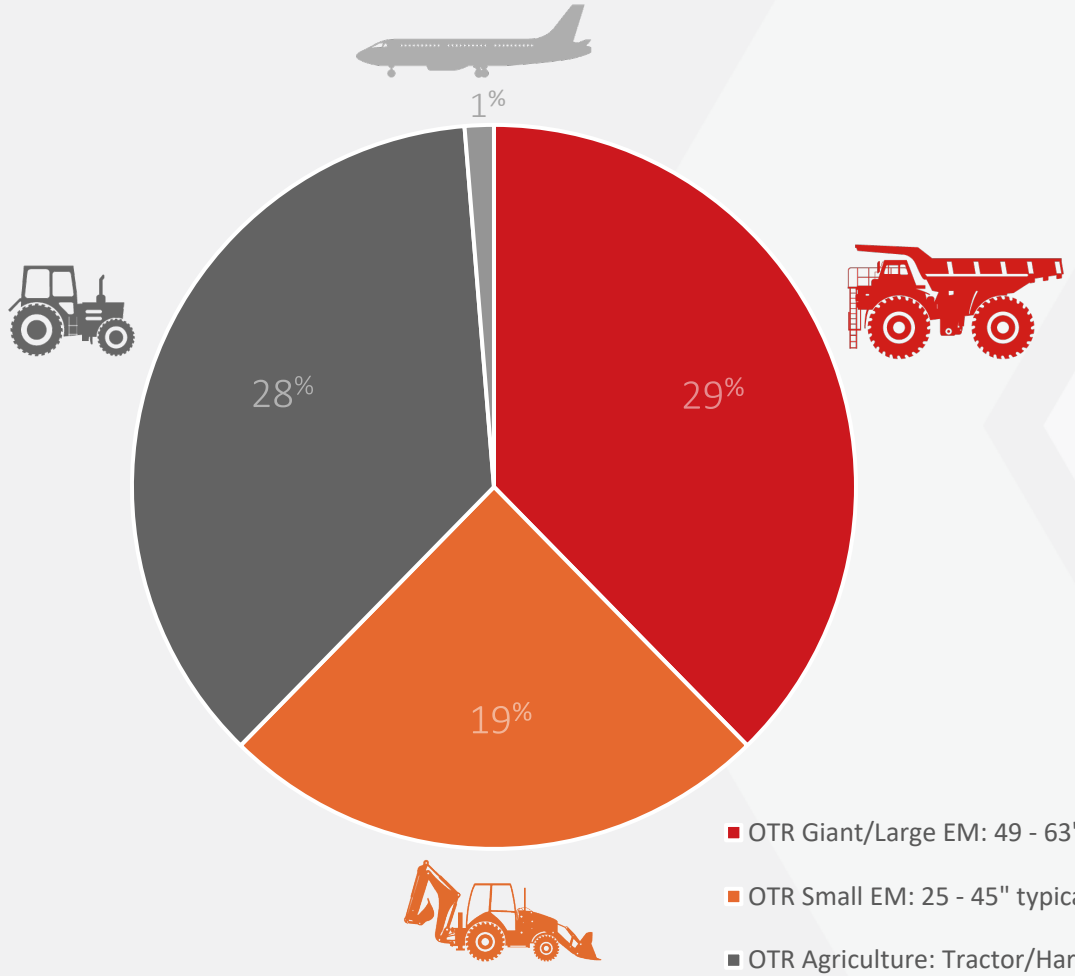
SUSTAINABILITY

HOMEPAGE

* Tonne-kilometres per hour

OTR Tire Segmentation

- E2C™ Solutions can improve performance in a variety of tire types, with requirements varying substantially by application.
- For Large and Giant Earthmover applications, tires are typically sized from **49 to 63 inches**, used on **100 to 400 ton** rigid haul trucks.



Mining Industry Customers

Each year, the mining industry extracts and transports over

12 BILLION
tons of material

- The world's largest and most sophisticated mines focus relentlessly on productivity to maximize profitability.

NEXT →

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Mining Industry Customers

One enabler is ultra-class haul trucks, capable of carrying up to **400 TONS** of material in a single load.

A fully loaded truck might weigh 675 tons!

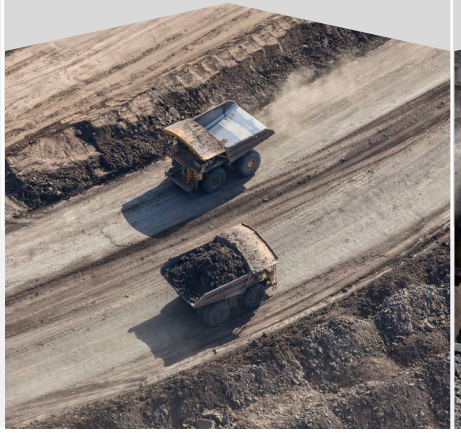
- Autonomous haul trucks use sophisticated self-driving hardware to maximize efficiency, minimize downtime and optimize driving paths at transport speeds of up to 70 km/h.
- In some mines, peak summer temperatures can be above 46°C.
- These peak loads, high speeds, continuous uptimes and high temperatures create a challenging environment for the largest tires in the world.
- E2C™ Solutions are designed to overcome these challenges.

Unlock Superior Performance

- E2C™ Solutions offer superior performance enabled by proprietary process technology, market-leading reinforcement agents and leading formulations know-how.
- E2C™ Solutions break performance trade-offs in Off-the-Road (OTR)/Earthmover tire design.
- E2C™ Solutions are formulated for specific applications to deliver maximum performance benefits.
- Cabot will help you to select the right E2C™Solution and to compound it properly.

Environment

OTR/Earthmover tires must perform in a wide range of severe operating environments:

Oil Sands – Canada	Iron Mines – Australia	Copper/Diamond/Gold Mines – South America, Africa, North America	Coal Mines – United States, Australia
◆ Extreme temperatures ◆ Soft roads ◆ High speeds ◆ Long, flat haul distances	◆ Extreme temperatures ◆ High vehicle utilization enabled by autonomous trucks	◆ Deep pit haulage ◆ Hard, abrasive surfaces ◆ Rough roads	◆ Soft roads with potentially hard waste material ◆ Long, flat haul distances
			

Key Performance Requirements - Tire

Each mine environment requires a different set of tire performance requirements:

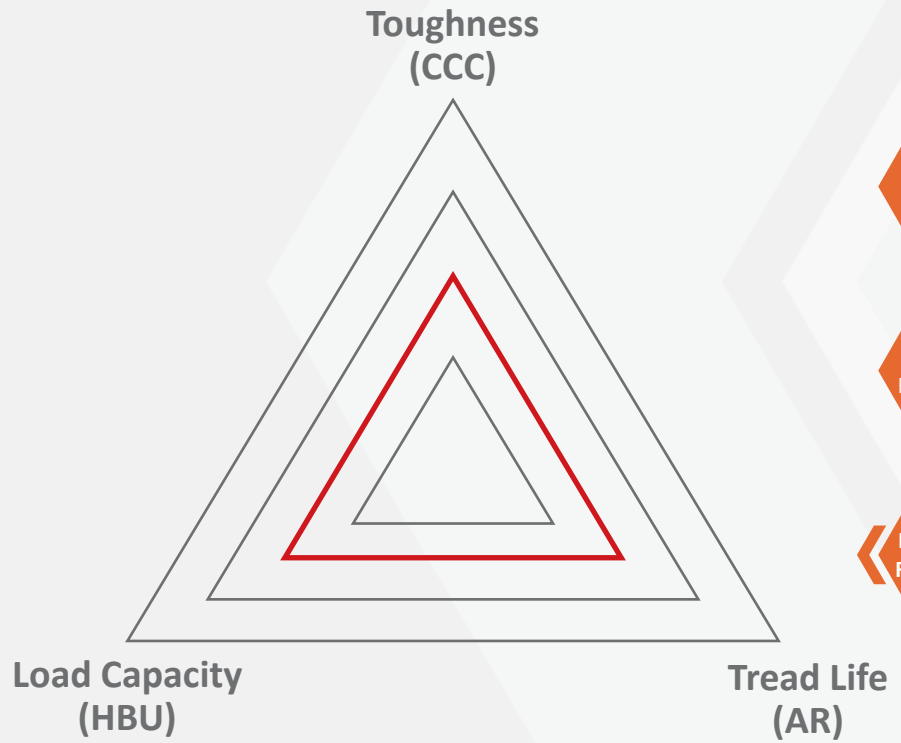
Oil Sands – Canada	Iron Mines – Australia	Copper/Diamond/Gold Mines – South America, Africa, North America	Coal Mines – United States, Australia
◆ Extreme temperatures ◆ Soft roads ◆ High speeds ◆ Long, flat haul distances	◆ Extreme temperatures ◆ High vehicle utilization enabled by autonomous trucks	◆ Deep pit haulage ◆ Hard, abrasive surfaces ◆ Rough roads	◆ Soft roads with potentially hard waste material ◆ Long, flat haul distances
↓	↓	↓	↓
◆ **High TKPH*** to enable longer haul distances ◆ **High carcass durability** to survive high speed operation on soft roads	◆ **High TKPH** to realize full benefits of autonomous trucks ◆ Durability at extremely high temperatures	◆ **Resistance to cut and chip damage** from hard rocks	◆ **High tread durability** to enable long tire service life

* Tonne-kilometres per hour

Key Performance Requirements - Tread

Effective Tread Compound Design requires optimization of performance across three primary dimensions:

- **Lower Heat Build-up (HBU)**
  - Compound Design Target: Lower hysteresis
  - Tire Performance Benefit: Higher TKPH*, reduced carcass and tread compound degradation
- **Increased Cut, Chip, Chunk (CCC) Resistance**
  - Compound Design Target: Higher stiffness, improved tear and fatigue strength
  - Tire Performance Benefit: Resistance to damage from hard, abrasive road surfaces
- **Improved Abrasion Resistance (AR)**
  - Compound Design Target: Higher modulus
  - Tire Performance Benefit: Longer tread life



* Tonne-kilometres per hour

Improve Product/Brand Economics

- The priority for major mine operators is to increase productivity and decrease operating costs.
  - Use of autonomous trucks is expanding
  - Increased focus on optimization of mining asset uptime
- Major mining tire manufacturers continue to push the design envelop to protect or grow market share in response.
  - Higher durability (cut, chip, chunk and abrasion resistance)
  - Higher productivity (improved TKPH* through better heat resistance)
- E2C™ Solutions can unlock step-change value to both the tire manufacturer and end user.

* Tonne-kilometres per hour

Mine Company Economics

- Giant Earthmover tires represent a small percentage of the vehicle cost but can have an enormous impact on value to mine operations.
  - Haulage is typically largest cost center in the mining operation
  - Tires are the largest incurred cost in haulage next to fuel (1/3)
  - Tires are the main limiting factor in the design of larger mining vehicles and maximum haulage
- Improvements due to advanced tire technology can expand Earthmover vehicle productivity.
  - $100M to $150M of additional haul value can be achieved through productivity improvements in Earthmover tires*
    - Lower unplanned downtime through higher durability
    - Reduction in truck stand down time through better heat resistance
    - Improved TKPH through higher load capacity and faster speeds

* Based on third party analysis and/or testing

Break Performance Tradeoffs

- E2C™ Solutions are patented and proprietary pre-mixed composite solutions.
- E2C™ Solutions break traditional trade-offs in compound and tire design.
- E2C™ Solutions enable product differentiation without complexity of new filler selection and development of complex mixing processes.
- E2C™ Solutions provide improvements in cut, chip, chunk resistance, tread life and load capacity (i.e. TKPH*).

* Tonne-kilometres per hour

E²C™ Solutions

Novel composites of rubber and filler achieve high levels of dispersion quality › *…delivering step-change improvement in key material properties* › *… and enabling transformational tire performance.*

CABOT LIGHT TOUCH™ mixing process

Tear Strength

Abrasion Resistance

Modulus Ratio

Heat Build-Up

Fatigue Life

Tensile Modulus

Better Durability

Higher TKPH

Lower Heat Buildup

Pre-mixed product form enables product differentiation without production complexity

- No need to source or inventory specialty fillers
- No need for multiple non-productive mixing steps to ensure specialty filler dispersion

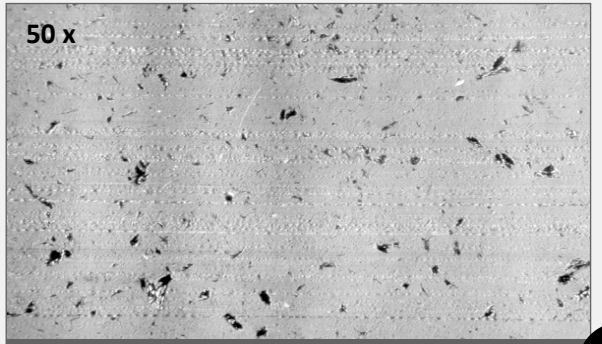
Product Series & Benefits

A series of solutions that offer balanced performance and extend tire durability and efficiency.

- **E2C™ Foundation Series**
  - For formulation flexibility for a variety of tire types that need multidimensional performance improvement.
- **E2C™ Durability Series**
  - For high-durability tires to eliminate in-field failures and maximize operational uptime.
- **E2C™ Efficiency Series**
  - For fuel-efficient, high TKPH, cooler-running tires that deliver higher per truck productivity, without other performance compromises.

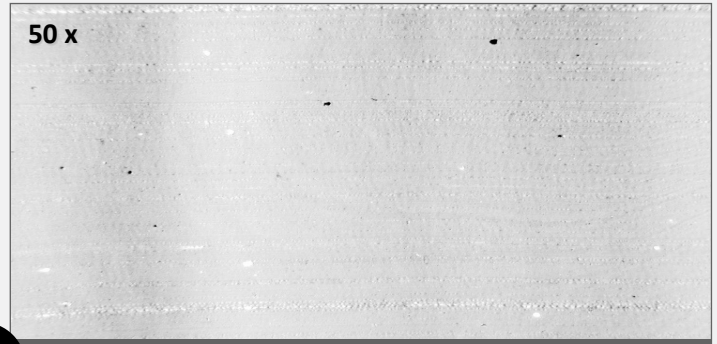
Processing – Light Touch™ Mixing

- E2C™ Solutions are produced in a proprietary and patented mixing process that enables a superior level of carbon black dispersion.
- When properly compounded using Cabot's Light Touch™ mixing guidelines, E2C™ Solutions transform performance through dramatic improvements in rubber properties. VIEW →
- In fact, our elastomer composites have been proven in field trials to both lower the operating temperatures and extend the life of off-the-road tires by more than 15 percent.



Conventional 2-Stage Mixing

vs



Cabot's Light Touch™ Mixing with E2C™ Solutions

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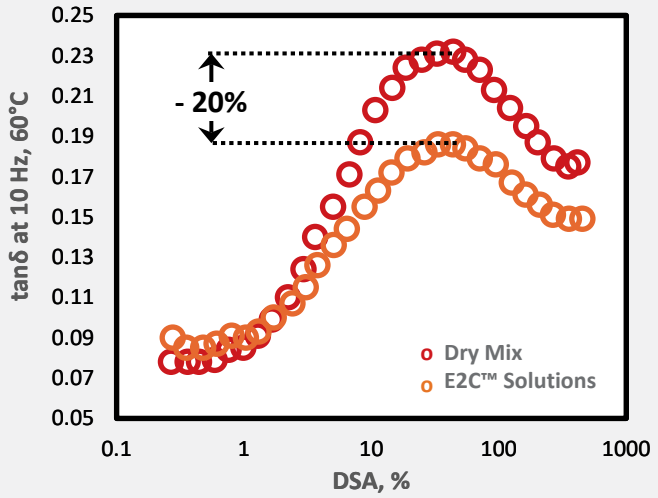
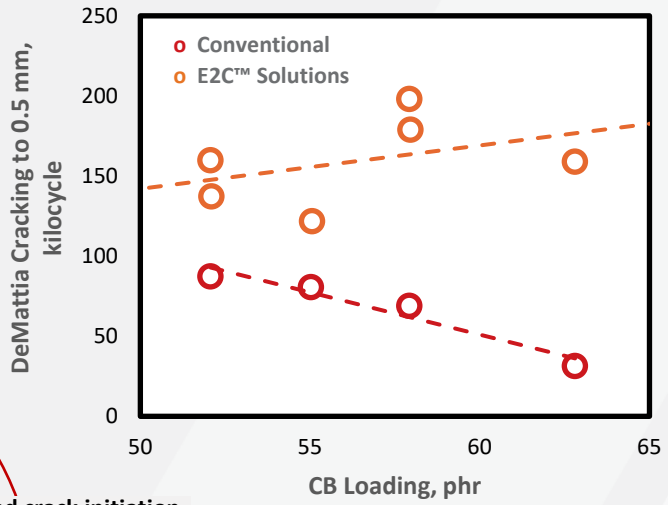
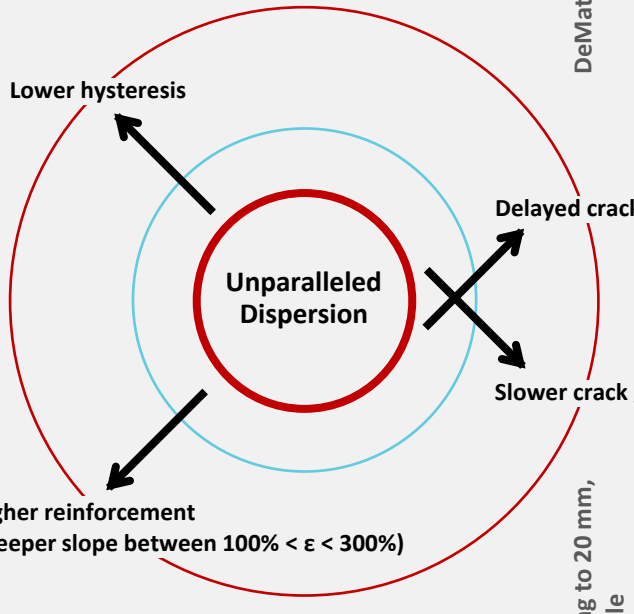
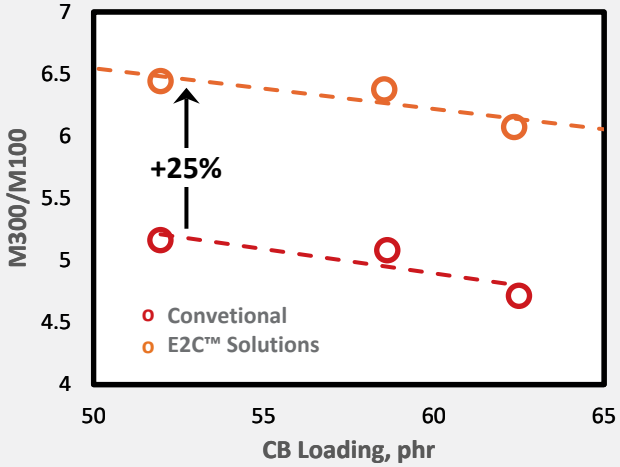
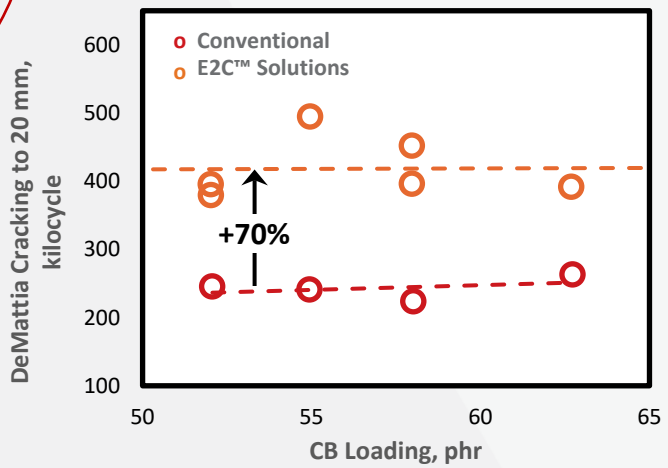










Field Trial

Mixing: Tangential mixers, 190 L or 370 L

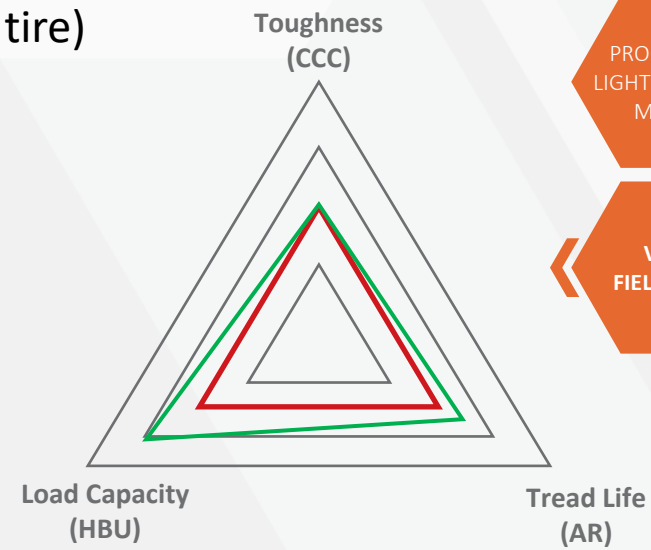
Tire Size: 18.00 – 25.00

Application: 50 ton trucks, open mine, rough roads

Testing: 22 total tires, segmented (two tread per tire)

Compound type	Service life, day	Initial tread depth, mm	Average tread remaining, mm	Tan Delta	Load Capacity (HBU) Index†	Tread Life (AR) Index†	Durability (CCC) Index†
Dry Mix	122.7	38	5.68	0.238	100	100	100
E2C™ Solutions			10.10	0.188	126	116	100

†Higher value is better performance; index normalized



Meet Sustainability Challenges

- E2C™ Solutions can extend the life of tires and other rubber products by 15 to 30 percent, reducing waste and the quantity of end-of life tires and parts*.
- E2C™ Solutions can improve the energy efficiency of tires and other rubber products.
- E2C™ Solutions can enable parts to be smaller, supporting manufacturers efforts to produce lighter weight rubber components.
- E2C™ Solutions can reduce the energy consumed in manufacturing tires and other rubber products by reducing mixing time by up to 50 percent, lowering the environmental footprint.

* Based on third party analysis and/or testing

Mining Industry

- The mining industry generates significant quantities of waste tires.
  - In 2019, large earthmover tire production totaled 690,000 units.
- Due to their size, recycling options for end-of-life treatment of these tires are limited.
- New legislation requires increased recycling or reuse of waste tires from mining and requires mining companies to pay recyclers for handling these tires in some cases.
  - In Chile, the Extended Product Liability and Recycling Promotion (REP) will require that 100 percent of all waste tires 57 inches or larger be reused by 2026, while 98 percent of waste tires below 57 inches be collected and recycled by 2028.
  - Currently, only 17 percent of waste tires, including those from the mining industry, are recycled in Chile.