

ITEC – GREEN TIRE

NorthStar Elastomers

- I TIRECYCLE™ TECHNOLOGY**
- II TIRECYCLE™ BENEFITS SUMMARY**
- III BENEFITS & DRAWBACKS of USING TIRECYCLE™**
- IV TIRECYCLE™ PROCESS**
- V COST COMPARISON**
- VI FIELD TRIAL SUMMARY**
- VII TIRECYCLE™ – BEYOND “GREEN”**

NorthStar Elastomers

Tirecycle™ Technology

Tirecycle™ products are produced by a process of surface treating ground particulate vulcanized rubber with an adhesive polymer, which enables the ground rubber to actively cross-link with other rubber. This enables the user to incorporate high concentrations of ground particulate in rubber and plastic without significantly affecting the physical properties of those compounds, while achieving significant cost reduction, quality control and enhanced performance of the ultimate end products.

The Tirecycle™ process converts used tires from an overwhelming environmental nuisance and pollutant from a negative value, into a raw material that has significant commercial value to the rubber and plastics industry, without any environmental side effects, as no effluent is produced during the process and only electrical energy is used.

NorthStar Elastomers, LLC, manufactures and markets various Tirecycle™ products for different usage, which can be adjusted for your specific master batch manufacturing and performance needs. It blends readily with NR/SBR/BR.

Tirecycle™ products have proven to be a commercially viable and effective raw material in the manufacture of tire tread, molded mechanical items, floor tiles, roofing, plumbing parts, shoe outsoles, hoses, railroad crossings, automotive equipment, other injection molded and extruded polypropylene and polyethylene parts.

Tirecycle™ Benefits Summary

Finished Product – At the Customer

- **Tirecycle™ Usage** – 33% to 87% – depends on product usage
- **Improved Wear Resistance** – often 12 – 25% more tire life – 30% reduction in truck tire abrasion loss – conveyor belting doubled its work life!
- **Reduced Rolling Resistance** – when Tirecycle™ at 50% or more of tread – significant fuel efficiency gains!
- **Cooler Running Tires** – 30 - 40°F temperature drop – exponential effect on rubber life – heat aging properties improved – **50%** of the rubber already “precured” – *remember*, rubber keeps curing, gets tougher with age!
- **Better Wet and Dry traction** – Forklifts go up ramps!
- **Improved resistance** – to gas permeation, ozone, solvents, chemicals!

Production Process – Compounding & Curing

- **Lower** – die swell – processing temperature – blistering
- **Improved** – air venting – processing (less drag even though Mooney may appear higher) – faster and better cure (often 30% reduction cure time) – shorter mixing cycles in Banbury or on the mill
- **No** – “warm up” mill – knitting cycle on slab/strip – bin-scorch on stored mill sheet (over 4 weeks’ aging, still safe, fresh)
- **Big boost** – effective component distribution of CB, sulfur, etc – localized regions of over concentration simply get “pushed open”.
- **Help** – “unscorch” off spec, overage virgin masterbatch – improve reversion resistance beyond simple NR dilution effect.
- **Advanced recycling** – Tirecycle™ keeps original CB and other rubber additives hard at work – no new chemistry needed.

TIRECYCLE™ REACTIVATED PARTICULATE NOVEL COMPOSITE ELASTOMER BENEFITS

- X, Y, & Z unidirectionality – no planes of weakness
- Automatically forced – perfect distribution of mix (billions of spacers)
- Compression set improvement – inherent 2 phase random packing, better cure
- Abrasion resistance – 15 -30% gains proven in truck tread, conveyor belts, etc.
- Blister elimination – can go far beyond the 5% dosage limit of crumb rubber
- Faster and better cure – 30% reduction in time, or use of lower temperature

- No bin scorch – Tirecycle™ can even "descorch" old stock
- Lower die swell (as 50%± is fully densified already), reduced shrinkage
- Easier processing (lower hp/lb), faster extrusion at same power load
- No "warm up" mill needed (cold knit effect) – stacked sheets cure to a solid
- Continuous recyclability – 10 full 100% regrind cycles show no property loss
- Tan delta is significantly reduced – cyclically stressed parts run cooler, rolling resistance often drops from 10 to 20% (cooler tires wear longer)
- Useful contradiction – 300% modulus goes up while wet traction also goes up
- Improved resistance to gas permeation, air aging and coolant fluids
- Tirecycle™ is "devolatilized" and fully cured
- **TIRECYCLE™ IS A TRUE COMPLETE COMPOUND: NOT DEVULCANIZED**

NorthStar Elastomers

Benefits and Drawbacks of Using Tirecycle™ Additive

Benefits

- Costs less
- Cure time decrease
- Resilience increase
- Modulus increase
- Compression set decrease at room temp. (other temps should be tested)
- Physical size of 1 lb of rubber with Tirecycle™ is bigger than without

Drawbacks

- Viscosity increase
- Green strengths decrease
- Elongation decrease
- Smoothness & tack decrease with higher loading of Tirecycle™
- Scorch time slightly decreases (depends on compound)

Best Host Compounds

- Black color
- Durometer from 65-75
- NR or SBR base, blends can be very good
- Tirecycle™ works best in compounds where reinforcing fillers are carbon black, not as well with clay, talc, or whiting
- Compounds that need or are able to process at higher Viscosity as used for compression/injection molding are best when body feeding into cavity

Tirecycle™ Test Results

The Following Test Uses SBR 1606 with indicated % of Tirecycle™

Tirecycle™ is our Treated 34 Mesh

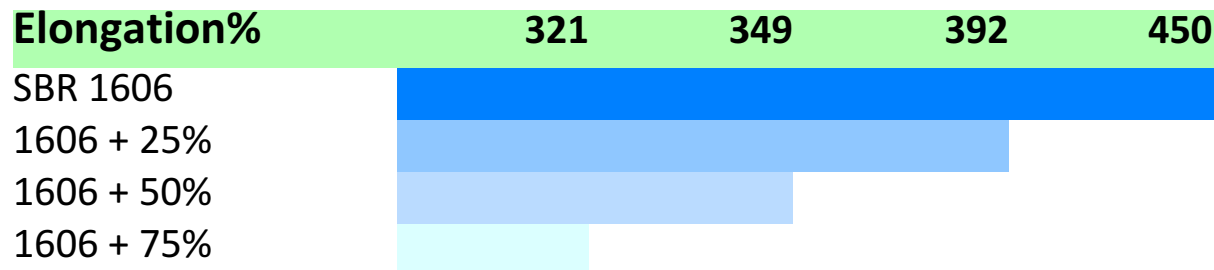
Durometer

SBR 1606	68
1606 + 25%	70
1606 + 50%	70
1606 + 75%	69

Tensile



Elongation%



Modulus

	100%	200%	300%
SBR 1606	385	925	1783
1606 + 25%	399	960	1891
1606 + 50%	429	1076	2132
1606 + 75%	499	1177	2307

TIRECYCLE™ PROCESS

Keep process simple

- A good compound/compounder is your most important step
- Typically you run tire rubber thru 2 or 3 compounding runs. 1st to mix all ingredients, 2x or 3x with cure to make sure all is distributed & interacting well

Don't change your basic process

- Save costs – improve the product – save processing time!
- At run 2 – split standard batch in 2 parts. Compound each 50/50 with Tirecycle™, Each sheet of masterbatch is compounded with equivalent Tirecycle™
- Distribute evenly in compound run 2 – then typical run into sheet mold
- Tirecycle™ rubber is already mixed/re-vitalized, waiting for your masterbatch
Banbury or similar mixing action works best

Initial Compound Materials Cost Comparison

- A simple total cost analysis comparison between a virgin rubber compound and a compound using Tirecycle™ would factor Tirecycle™ compounds at several established levels ranging from 30% to 70% compared to a virgin rubber compound.
- The virgin compounds would have to factor in the percentages and costs of carbon black, fillers, silica, additives etc.
- These are already contained in the Tirecycle™ portion of the test compounds.
- An example of charts displaying this comparison is available on request, however, most technical and accounting professionals can devise one specific to their current compounds.
- NOTE, if your current compound costs \$.80/lb or less (as some claim),
OR, you see no incentives to producer from Tirecycle™ benefits,
Tirecycle™ may not be for you.

Losing *Market Advantage* is always the buyer's prerogative!

Northstar Elastomers

FIELD TRIALS, STUDIES, TESTS – OVERVIEW

1. UK: BIFFA/TARRC Global screening of Tyre Recycling Technologies, Re: Final 69 page report, September, 2004. Major 2001 study sponsored by UK Environmental Trust Fund in conjunction with the BIFFAWARD environment fund managed by the Royal Society for Nature Conservation. Objective – investigate the practicality of using “recycled rubber crumb in new tire tread compounds”. BIFFA is the major waste management company in the UK with a large stake in scrap tyre disposal.

TARRC (founded in 1938) is a major internationally recognized 3rd party rubber/tyre research facility owned by the natural rubber industry of Malaysia. Key findings using RRE provided Tirecycle™ – 3 years of road testing (millions of km) – tyres with 25% level of Tirecycle™ outperformed controls which used premium grade NR compounds, and 50% substitution level of Tirecycle™ was virtually identical to the 100% virgin control compounds. As Ed Jakush pointed out: “The Tirecycle™ from 25% to 75% dramatically reduces heat buildup (HBU) which both improves fuel economy and extends the life of the tire.”

2. While the BIFFA/TARRC study may be the most extensive study, Tirecycle has been road tested in Europe, Australia and North America by various entities. As Ed Jakush also noted: the Tirecycle™ process coats the particles of crumb rubber with surface-modifying materials which enable the particles of crumb to strongly bond during the vulcanization process. This has enabled Tirecycle™ to be used at up to 75% substitution rate, producing tires with superior performance and substantially lower cost. Of particular topical importance, the Tirecycle™ tires show a radical reduction in rolling resistance which may lead to important increases in gasoline mileage.
3. Other rubber products – Reebok publicly acknowledged their open use of Tirecycle™ in major lines of footwear – generally at 50% level in molded sole and heel. At least 4 million pairs were made in Taiwan and Australia. Among other favorable findings were that traction of Tirecycle™ compounds was noticeably superior to normal compounds.
4. There are numerous studies, trials and tests validating these types of conclusions. This includes OTR tires, solid rubber industrial/warehouse tires. And extensive “closed loop” recycling thru 10 cycles of butyl bladder Tirecycle™ with continuation of properties.

Our thanks to Ed Jakush, MIT Chem E, deceased, for his 20 yrs help with Tirecycle marketing & development.

TIRECYCLE™ – BEYOND "GREEN"

The unique "sustainable development" features of TIRECYCLE™ include a beneficial mix of environmental elements.

Environmental Benefits

- Removes an EPA regulated hazardous waste (tires) from the environment.
- Returns valuable "pre-purchased" polymers to the economy (otherwise lost).
- True recycling—not "downcycling"—as TIRECYCLE™ upgrades scrap to its original virgin quality and use. This is very rare in most recycling industry.
- Conserves valuable natural resources and petroleum: each ton of TIRECYCLE™ eliminates over 7 barrels of oil, along with natural rubber imports.
- Zero emissions (to air, water or land) – enables full use of 100% of the waste tire, including the steel and fiber.

- No fossil fuel usage: consumes only clean electricity.
- Reduces virgin chemical usage in rubber compounds: zinc oxide, carbon black, sulfur, oils, and catalysts are already in the TIRECYCLE™.
- Ideal alternative to burning (tire derived fuel is the main current disposal practice). Each ton of TIRECYCLE™ prevents 6,000 lbs of greenhouse gas (carbon credits).
- Fuel efficient tires: TIRECYCLE™ delivers a 10-20% reduction in rolling resistance *and* a 3-5% increase in gas mileage.
- Longer tread wear: fewer potential asthma-causing particles per mile driven.
- Safer tires: improved wet traction and shorter braking distance translates into fewer accidents and property destruction
- TIRECYCLE™ is a true "PCR": post-consumer recycle. PCR is a specific regulatory (EPA, DOE, GSA) designation, much sought after by manufacturers and difficult to attain. PCR status is a key factor in LEED certification in new construction.

