Retread and Repair Recommendations

X ONE® RETREAD AND REPAIR RECOMMENDATIONS 54

Retread Limits

Casing Age Limits

Initial Inspection

Shearography

Buffing

GENERAL REPAIR GUIDELINES 55-56

Skiving

REPAIR LIMIT SPECIFICATIONS 57-58

Nail Hole Repairs

Section Repairs

Spot Repairs

X One® XZU®S Tire Repair Recommendations

Bead Repairs

Inner Liner Repairs

Builder

Enveloping

Curing

Final Inspection

MICHELIN

A better way forward

X One® Retread and Repair Recommendations

There are no unusual or special procedures necessary for any modern retread plant in North America to handle the X One® casings. There are, however, some equipment changes that may be required to handle the wider tread and casing widths. The information described in this technical guide is the most up to date at the time of this publication. However, the X One® product and casings continue to evolve. As new products arrive and are enhanced, updates to this guide may be needed.

RETREAD LIMITS

- Line haul = greater than 150,000 miles per tread life: 1 retread
- Regional and P&D = 75,000 to 150,000 miles per tread life: 2 retreads
- Severe Service, On/Off Road, Urban, Refuse = less than 75,000 miles per tread life: multiple retreads

CASING AGE LIMITS

Customer or tire manufacturer specifications may have more stringent (shorter life) requirements that must also be met.

For Line Haul	7 years
For Pickup & Delivery	10 years
For Severe Use	no age restriction

INITIAL INSPECTION

Inspect the X One® casings as defined by your retread process manufacturer or industry recommended practices using appropriate equipment.

When using an electronic liner inspection device, such as the Hawkinson NDT, a new wide base probe of at least 275 mm/10.9 inches is required to help ensure sufficient and consistent cable contact with the shoulder/upper sidewall area. (Hawkinson part # PROBE ASSEMBLY 009).

SHEAROGRAPHY

If using laser shearography inspection, per equipment manufacturer, adjust and or modify to help ensure complete imaging, shoulder to shoulder.

BUFFING

An expandable rim width of 14.5 inches is required. The beads of the casing should be lubricated with a fast drying non-petroleum based tire lubricant. Buffing should not start before casing reaches target pressure in the expandable rim as defined by your retread process manufacturer. Recommended minimum inflation pressure is 1.2 bars or 18 psi. Recommended tread width ranges are given below and may vary depending on the type and condition of the X One® casing. The X One® casing's finished buffed measured width should follow the same standards as other casings: no more than 2 mm less than the width of the tread to be applied and no more than 8 mm more than the width of the tread to be applied.

445/50R22.5

- Recommended buff radius is 2000 mm
- Recommended buff radius for X One® XDA-HT™ tread rubber is 1600 mm
- Target circumference 3055 mm - 3065 mm
- Recommended tread widths 375* mm - 390 mm

455/55R22.5

- Recommended buff radius is 2000 mm
- Recommended buff radius for X One® XDA-HT™ tread rubber is 1600 mm
- Target circumference 3220 mm - 3230 mm
- Recommended tread widths 385* mm - 400 mm

* Indicates wing style tread designs.

NOTE: For non-Michelin wing tread products, contact MRT, Duncan, SC at 1-888-678-5470, then press 3 for Technical Support.

NOTE: Using an improper buff radius or buff width could result in damage to the belt package, irregular tread wear and reduced casing life. Incorrect preparation of the casing for retreading will void the original warranty.

General Repair Guidelines

Recommended quantity limits represent repair guidelines based on the application of the tire in use. General applications listed are Line Haul, Pickup & Delivery, and Severe Use. The performance requirements and usage demands differ for these applications and warrant different repair specifications.

Certain customers may have more stringent requirement that must be met for their needs. Refer to your customer specific requirements to help ensure that their limits are met as well.

Also, economic considerations may limit repairs below the number that is permitted for performance requirements and result in the rejection of casings.

Severe Use refers to off-the-road type applications such as waste haulers, cement mixers and logging operations.

Pickup & Delivery refers to tires used for local areas only. This category does not include mass transportation, buses, and other people movers. These people mover applications are treated like Line Haul.

Line Haul refers to tires used for highway applications and any application not covered in the two special categories above.

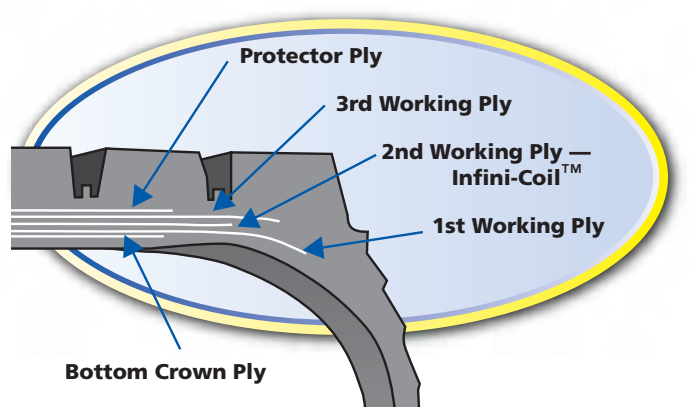
SKIVING

NOTE: Buzz out limits are increased as outlined below due to the increased surface area of the X One® tire over a standard size tire.

If edges of protector ply or 3rd working ply are frayed, they may be skived if total area does not exceed:
- 15 mm width on total circumference on one side.
- 10 mm width x 200 mm length on the other side.

Crown damages up to 15 mm in length must be probed for separation or loose wires. If the area is tight they should not be buzzed out.

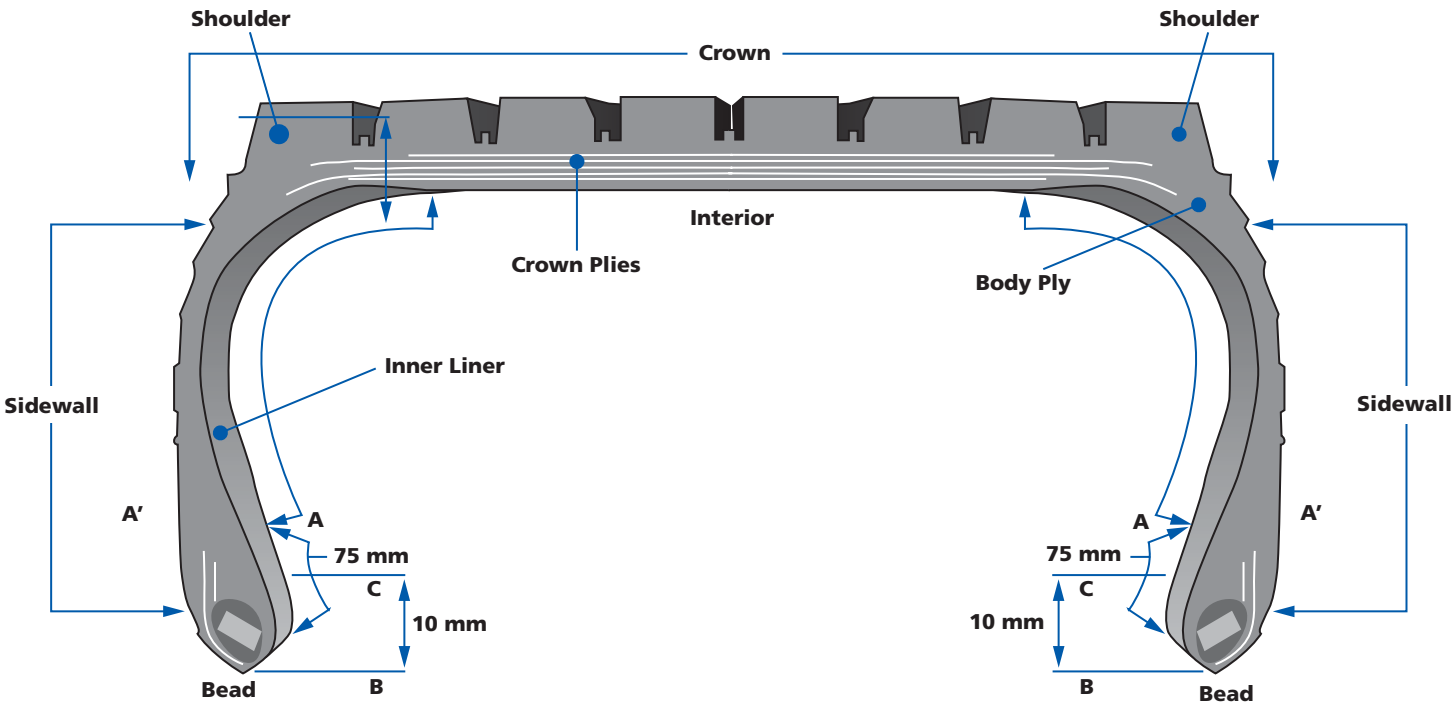
Removal to top ply cables:
- Maximum area at one point = 20 mm
- Maximum points around the casing = 3



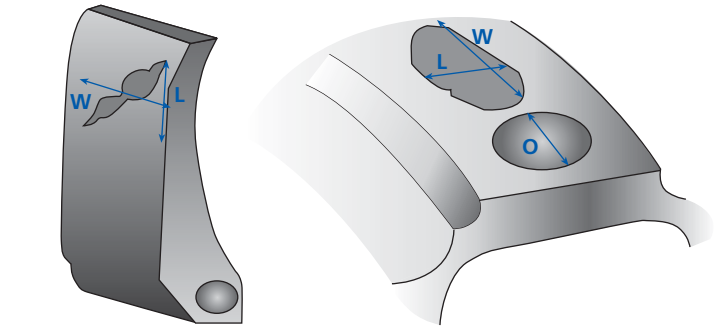
Buzzouts on Crown

Depth	Diameter/ Surface	Suggested Quantity*	
		Line Haul, Pickup & Delivery	Severe Use
- Protector Ply - 3rd Working Ply	Diameter 40 mm or Surface 1600 mm²	15	60
- 2nd Working Ply (Infini-Coil™) - 1st Working Ply - Bottom Crown Ply	Diameter 30 mm or Surface 900 mm²	3	20

* Suggested Quantity is a suggested limit only. There is no technical limit as long as the sizes are within specification. However, economic considerations will lead to a practical limit that must be determined by the individual plant manager.

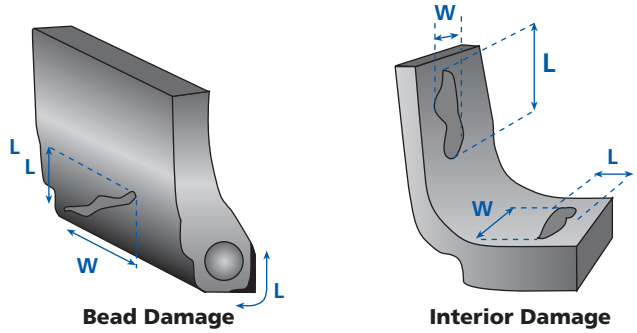


NOTE: For truck sizes, point B is located on the point of the bead, point A is found 75 mm from B towards the interior of the casing, and point A is also 75 mm from B but is located on the exterior of the casing.



Sidewall Damage

Crown Damage



Bead Damage

Interior Damage

Repair Limit Specifications

For all applications except X One® XZU®S casings.
For X One® XZU®S casings use specifications below.

NAIL HOLE REPAIRS

Up to 10 mm in diameter in the crown area: 5
NOTE: For best results, nail hole repairs extending into the shoulder area should avoid having the repair reinforcement end in the flex zone of the casing.

SECTION REPAIRS

Crown Area

Crown Plies Only (Protector Ply and Working Plies)
Size: 30 mm diameter
Crown Plies and Body Ply (Casing Ply)
L 70 mm x W 25 mm, or
L 90 mm x W 20 mm, or
L 120 mm x W 15 mm

Sidewall Area

Body Ply (Casing Ply)
L 70 mm x W 25 mm, or
L 90 mm x W 20 mm, or
L 120 mm x W 15 mm

Section Repairs are limited to a quantity of 2, sidewall and crown combined.
Maximum number of repairs: 5
This is a total number of nail hole and section repairs with no more than 2 section repairs.
For example: 3 nail holes + 1 Sidewall Section + 1 Crown Section.

NOTE: The Michelin® X One® family has a unique additional belt called Infini-coil®. There are no special repair techniques or materials required.

SPOT REPAIRS

(No damage to body ply cables - rubber repairs only)

- Specified limits apply to rubber repairs greater than 2 mm only. Damages less than 2 mm deep are acceptable.

L x W	DEPTH	SUGGESTED QUANTITY*	
		LINE HAUL, PICKUP & DELIVERY	SEVERE USE
No limit if no damage to body ply cables	Body ply visible but not damaged	10 per per sidewall	20 per per sidewall
		20 per tire	40 per tire

L = Length in radial direction
W = Length in circumferential direction

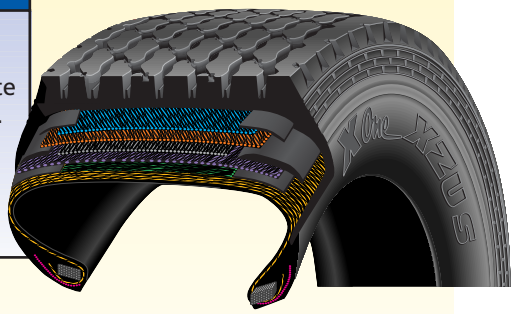
* Suggested Quantity is a suggested limit only. There is no technical limit as long as the sizes are within specification. However, economic considerations will lead to a practical limit which must be determined by the individual shop management.

X ONE® XZU®S TIRE REPAIR RECOMMENDATIONS

The X One® XZU®S tire is optimized for use in sanitation fleets. This usage is defined as a Severe Use Application, therefore, the same repair specs that apply to the other XZU®S products also apply to the X One® XZU®S tire.

Severe Use Application

SIZE			QUANTITY
NAIL HOLE REPAIRS	SECTION REPAIRS IN THE SIDEWALL AREA	SECTION REPAIRS IN THE CROWN AREA	
10 mm diameter	L / W 80 mm / 40 mm or 100 mm / 30 mm or 130 mm / 20 mm or 150 mm / 1 cable	40 mm	9 See Note below.



L = Length in radial direction
W = Length in circumferential direction
Note: Limit for Severe Use represents a total of section and nail hole repairs for both crown and sidewall combined. Refer to radial repair chart to select proper size of repair unit.

BEAD REPAIRS

RUBBER ONLY DAMAGES		
W	MINIMUM DISTANCE BETWEEN REPAIRS	QUANTITY ALL APPLICATIONS
150 mm	75 mm	4 per bead 8 per tire

RUBBER ONLY DAMAGES EXEMPT FROM REPAIR			
LOCATION	L x W	MINIMUM DISTANCE BETWEEN DAMAGES	APPLICATION
BEAD TOE no damage to bead seat no damage to chafer	2 mm x 50 mm	75 mm	SEVERE USE

CHAFER STRIP DAMAGES		
L x W	MINIMUM DISTANCE BETWEEN REPAIRS	QUANTITY *ALL APPLICATIONS*
25 mm x 55 mm	75 mm	4 per bead 8 per tire

L = Length in radial direction
W = Length in circumferential direction

NOTE: No repairs to BODY PLY are permitted inside or outside of the tire in the area within a radial direction of 75 mm from the bead point (See area ABA')

INNER LINER REPAIRS

Blisters which are burst must be repaired.

For blisters that are intact:

- Height/depth of blister greater than 5 mm must be repaired
- Height/depth of blister less than 5 mm should be left intact and not repaired if:
  - no single blister has an area greater than 30,000 mm^2 (45 in^2)
  - the total area of the blisters is not greater than 60,000 mm^2 (90 in^2)

If the size of the blisters is above these limits, then they must be repaired.

NOTE: If repairs are excessive, economic considerations may lead to rejection of the casing.

BUILDER

- Expandable rim width of 14.5 inches is required.
- Tread building should not begin until tire pressure has reached the target inflation pressures in the expandable rim as defined by your retread process manufacturer.
- For cushion to casing extruded bonding gum application, recommended minimum inflation pressure is 0.8 bar or 12 psi.

445/50R22.5

- Recommended base tread widths:
  375* mm – 390 mm

455/55R22.5

- Recommended base tread widths:
  385* mm – 400 mm

* Indicates wing style tread designs.

Note: For non-Michelin wing tread products, contact MRT Duncan, SC at 1-888-678-5470, then press 3 for Technical Support.

ENVELOPING

Contact your envelope supplier for the recommended size envelopes to be used.

CURING

Cure the X One® casing according to cure law for the tread design per the retread process manufacturer.

FINAL INSPECTION

Final inspection of the X One® casing according to the retread process manufacturer work method and specifications.

Operation and Handling

OPERATION AND HANDLING **60-65**

- Over-steer
- Under-steer
- Hydroplaning
- Rollover Threshold
- Jack-Knife
- Rapid Air Loss Procedure
- Traction
- Chains
- Stopping Distances
- Limping Home
- State and Local Regulations

HEAT STUDY **66-69**

- Brake Heat Overview
- Brake Heat Evaluation: X One® tire vs Dual

MICHELIN
A better way forward

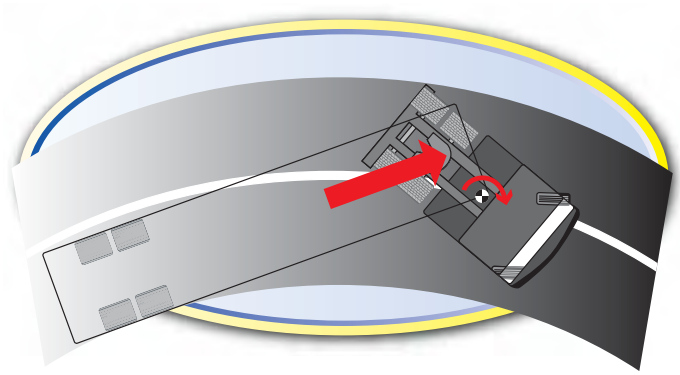
Operation and Handling

OVER-STEER

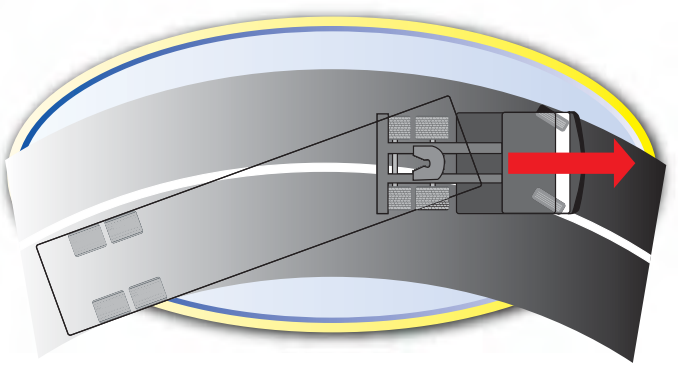
Over-steer is when the rear wheels are carving a larger arc than the front wheels or the intended line of the turn. This is often described as a "loose" condition, as the truck feels like the rear end is coming around.

UNDER-STEER

Under-steer is when the front wheels are carving a larger arc than the rear wheels. This is often described as "push" or "pushing", as the front end feels like it is plowing off of a corner.



Over-steer: Very difficult to correct

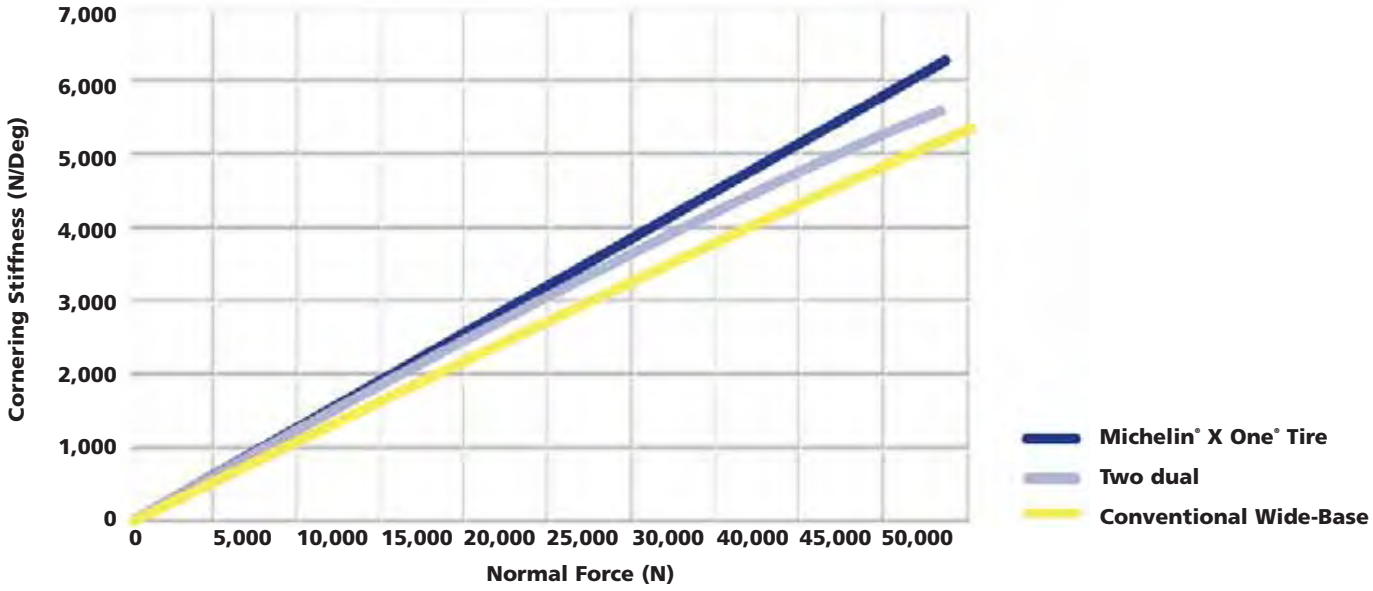


Under-steer: Very easy to correct

Over-steer is dangerous because once the rear end comes around, the vehicle is uncontrollable and may enter a spin. Braking only makes this condition worse. Under-steer is the more desirable condition because you have direct control over the front tires and deceleration usually corrects the condition.

The X One tire has a higher cornering stiffness and can generate more lateral force than standard dual drive tires. Increasing cornering stiffness of the rear tires promotes under-steer. Additionally, it will take more force to jack-knife the vehicle.

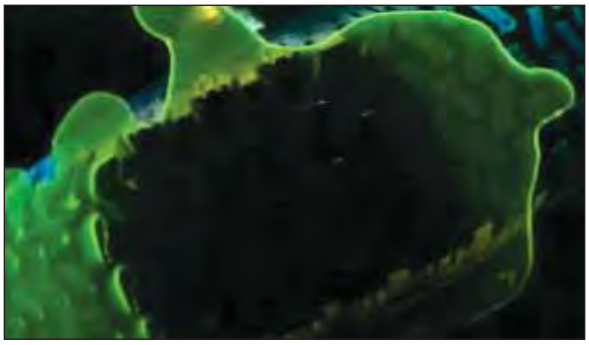
CORNERING STIFFNESS FOR DIFFERENT TIRES



Source: Recent evaluations at a Michelin facility in South Carolina.

HYDROPLANING

Hydroplaning occurs when the tire loses contact with the road. This can happen when the water pressure exceeds the contact pressure between the tire and the road.



Factors that increase likelihood of hydroplaning:

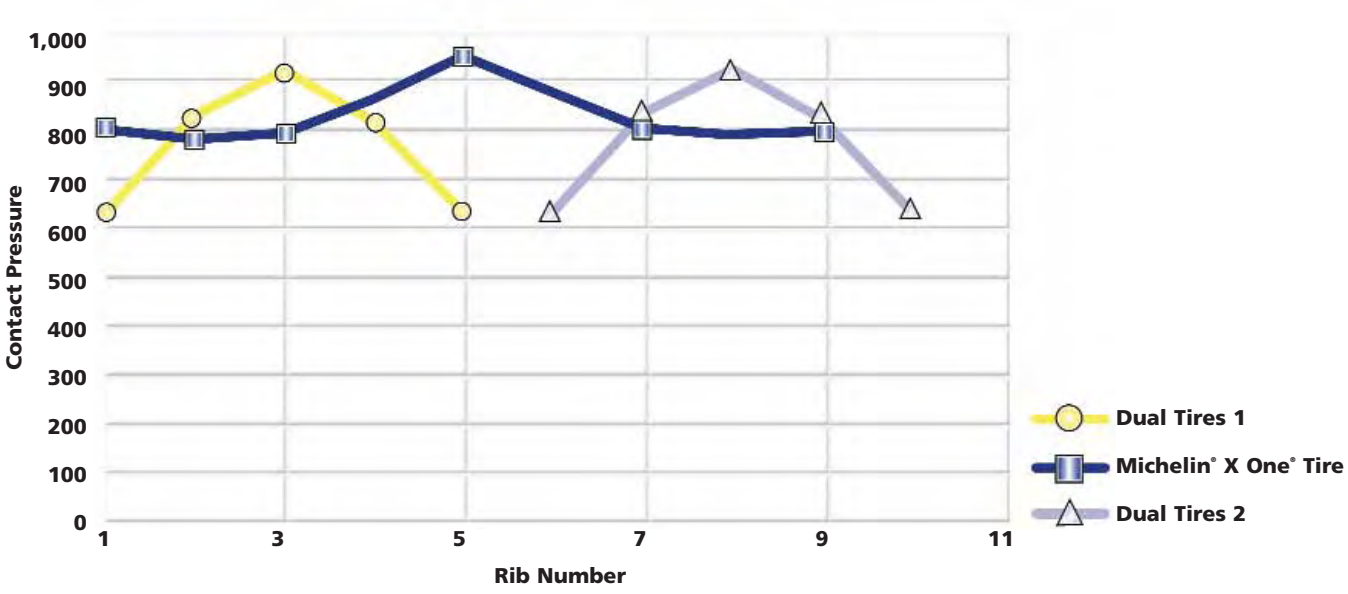
– Excess water
– Excessive speed
– Low tread depth
– High tire pressure
– Light loads or bob-tailing

In other words, if rain is pouring down and water is pooling, the truck's speed needs to decrease in order to avoid hydroplaning.

A tire's contact pressure can reduce your chance of hydroplaning. The X One® tire has higher contact pressure at the edge of the tread, which provides a wider "sweet spot" than dual tires. In the graph below, you can see that the contact pressure is slightly higher in the center and significantly higher at the shoulders over dual fitments. Note the drop in contact pressure for dual tires on the graph below.

For example, the contact pressure of a dual tire is about 90 psi compared to 116 psi for an X One® tire. This will result in the dual tire losing contact with the road at lower speed than the X One® tire. This means if hydroplaning occurs at 60 mph for the X One® tire, it will occur at 53 mph on the dual.

Contact Pressure Ratio = 90/116 = 88%
or
60 mph x 0.88 = 53 mph



Source: Recent evaluations at a Michelin facility in South Carolina.

ROLLOVER THRESHOLD

There are two things you can change to make a vehicle more resistant to rollover:

– Lower the center of gravity

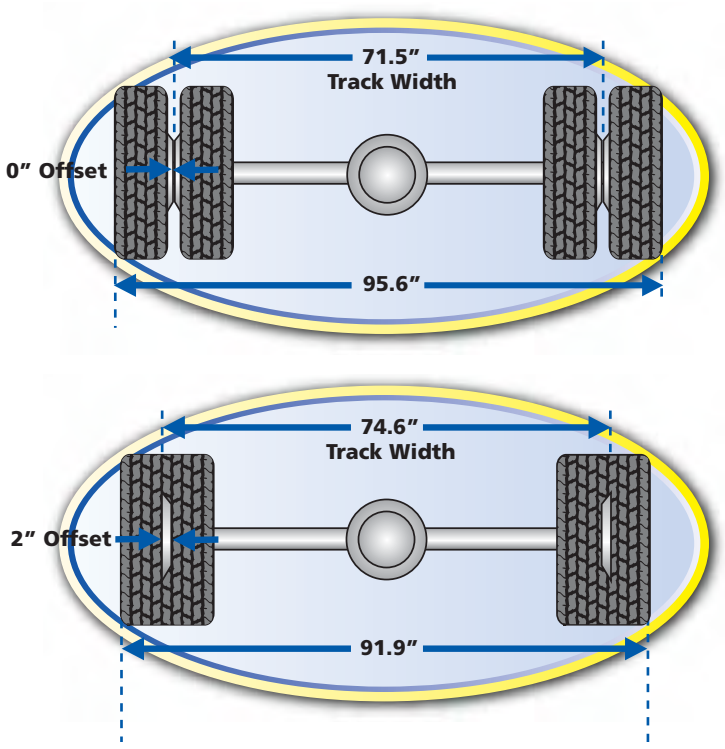
– Increase your track width.

The X One tire does both, let's see how.

First, the loaded radius of the 445/50R22.5 X One® XDA-HT™ Plus tire is 18.7". A 275/80R22.5 XDA-HT™ tire (dual equivalent) loaded radius is 19.0". See chart below. For every inch you lower the Center of Gravity, you gain 3 mph additional safety factor with regard to rollover threshold.

Second, the track width is measured at the center of where the load is distributed on the ground. For dual, this would be measured at the center of the space between the dual. For the X One® tire, it is simply measured from the center of the left side tire to the center of the right side tire.

As you can see, even though the overall width has reduced, the track width has increased on the X One® tire.

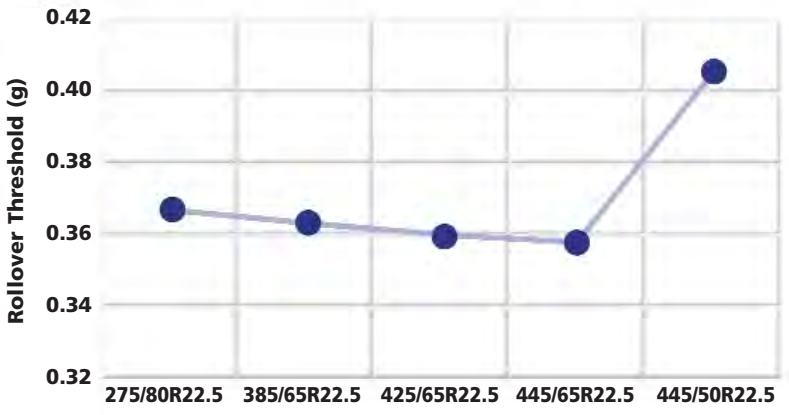


In summary, the X One® tire improves rollover threshold by increasing cornering stiffness, increasing track width, and reducing the center of gravity.

These improvements have been validated with:

1) Computer simulation where the whole vehicle is characterized mathematically.
2) Track testing at our internal proving grounds.
3) OE vehicle manufacturers in their independent testing including tilt table testing.

ROLLOVER THRESHOLD WITH TIRE SIZE



Source: Recent evaluations at a Michelin facility in South Carolina.

Specifications for Tread Design: X One® XDA-HT™ PLUS

Size	Load Range	Catalog Number	Tread Depth 32nds	Max Speed (*) mph	Loaded Radius in.	Loaded Radius mm.	Overall Diameter in.	Overall Diameter mm.	Overall Width (†) in.	Overall Width (†) mm.	Approved Rims	Revs per Mile	Max. Tire Load Single lbs.	Max. Tire Load Single psi	Max. Tire Load Single kg.	Max. Tire Load Single kPa
445/50R22.5	L	38873	28	75	18.7	475	40.5	1028	17.1	435	14.00	514	10200	120	4625	830

(1) Comparison based on tractor equipped with 275/80R22.5 Michelin® XDA-HT™ mounted in dual assembly on 8.25x22.5 inch aluminum wheels.

Specifications for Tread Design: XDA-HT™ *High Torque*

Size	Load Range	Catalog Number	Tread Depth 32nds	Max Speed (*) mph	Loaded Radius in.	Loaded Radius mm.	Overall Diameter in.	Overall Diameter mm.	Overall Width (†) in.	Overall Width (†) mm.	Approved Rims	Min. Dual Spacing (†) in.	Min. Dual Spacing (†) mm.	Revs per Mile	Max. Tire Load Single lbs.	Max. Tire Load Single psi	Max. Tire Load Single kg.	Max. Tire Load Single kPa	Max. Tire Load Dual lbs.	Max. Tire Load Dual psi	Max. Tire Load Dual kg.	Max. Tire Load Dual kPa
275/80R22.5	G	50575	30	75	19.0	483	40.8	1036	10.9	278	8.25, 7.50	12.2	311	509	6175	110	2800	760	5675	110	2575	760

JACK-KNIFE

When you put the tractor and trailer into an extreme turn or “jack-knife” situation, the trailer is very vulnerable to rollover.

Normally, traction has a positive influence on the handling of the truck. This is no longer true when you put a truck in a jack-knife condition. Whether dual or single configuration, you are forcing the tires to stop rolling and slide sideways. As the photo below clearly demonstrates, the trailer is twisting because the tires are holding their position on the road. This can lead to rollover!

This is especially true for spread axle trailers and high center of gravity loads. Look at the lateral stress placed on the tires from the jack-knife situation.

WARNING **Turning angles should be minimized to avoid rollover threshold whether operating with duals or X One tires.**

NEVER exceed vehicle limitations because of improved handling.

A tire with a wider footprint is going to provide increased lateral stability when cornering. As a result of this increased lateral stability, the truck will have a tendency to lean less in turns. The increased lateral stability should not equate to increased speed. Always obey posted speed limits on the highways and curves. A good rule of thumb for vehicles with high roll-over thresholds (i.e., tankers, concrete mixers) is to take the curves at the posted limit less 10 mph.

RAPID AIR LOSS PROCEDURE

Even though the X One® tire is an innovative product, it still requires proper air pressure maintenance and visual inspection practices. Tire failure can and will occur.

Below you will find a handy reference of the procedure to bring the vehicle to a safe stop following a rapid air loss event:

Indications:

(Some or all of the following may apply.)

– No change in handling
– Slight lean (depending on wheel position)
– Vibrations
– Audible noise when rapid air loss occurs

Immediate Actions:

– Accelerate enough to maintain lane position (**DO NOT** apply brakes immediately.)
– Do not apply maximum brake pressure to bring vehicle to a stop. This stop should be gradual by pumping the brakes.
– Creating assembly lock-up can cause irrepairable damage to tire, wheel, axle components, and vehicle.
– Pull the vehicle to a safe area.
– Do not attempt to limp further down the road.

Secondary Actions:

– Turn on flashers
– Deploy safety triangles
– Inspect vehicle for damage
– Call for assistance

This can be simplified by remembering the following:

DROP
ROLL
and STOP

In other words, the vehicle lean or **DROP** may be the first indication of a rapid air loss. Don't jam on the brakes! Pumping the brakes will allow the damaged wheel end to **ROLL** to a **STOP** without lock-up.

There are many Michelin X One tire training videos including rapid air loss handling and specific application demonstrations. To obtain a copy contact your local Michelin dealer or the Michelin sales representative in your area.

TRACTION

Traction is dependent on the following variables:

- speed
- tread depth
- conditions (dry or wet, depth of water)
- tread design
- tread rubber compound
- road surface (concrete, asphalt)

CHAINS

Depending on the state in which you are traveling, chains may or may not be required. If chains are required, several companies have chains available for the X One® tire. The thing to remember when purchasing chains for your X One® tire is the tire size as the 445/50R22.5 chains don't fit the 455/55R22.5 and vice versa. For more information consult your local dealer or go to www.tirechains.com*.

* The information provided is for reference only. Chains-specific questions should be directed to the chains manufacturer

STOPPING DISTANCES

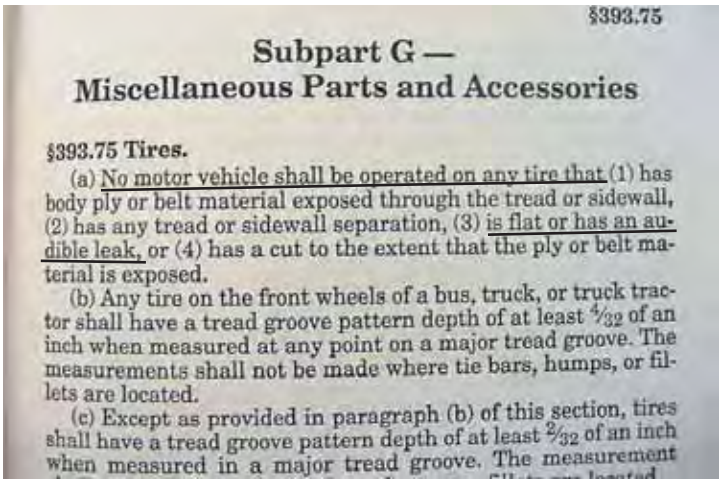
Stopping distance with the X One® tire is similar to that of dual. A general rule typically mentioned in CDL manuals is to allow one vehicle length or one second between your vehicle and the one you are following for every 10 mph of your velocity. For example: if you are driving at 65 mph, allow 6.5 seconds between your vehicle and the one in front of you. A good way to practice this is to mark a spot, such as a bridge, road sign, etc., that the vehicle you're following has just passed and count one-one thousand, two-one thousand, etc., to see how long it takes you to reach the same point. If you count to only four-one thousand, then increase your following distance.

In wet and/or icy conditions, do not assume that because you have better traction that you will be able to stop quicker. It is always the best practice to increase following distances and reduce driving speeds when traveling in adverse weather conditions.

LIMPING HOME

Limping on the X One® tire can cause damage to the wheel and casing. Although the tire is down, it's possible that it is repairable unless it was run flat. Limping home is never recommended even on dual tires.

DOT Regulation 393.75 states:



§393.75

Subpart G —
Miscellaneous Parts and Accessories

§393.75 Tires.

(a) No motor vehicle shall be operated on any tire that (1) has body ply or belt material exposed through the tread or sidewall, (2) has any tread or sidewall separation, (3) is flat or has an audible leak, or (4) has a cut to the extent that the ply or belt material is exposed.

(b) Any tire on the front wheels of a bus, truck, or truck tractor shall have a tread groove pattern depth of at least 4/32 of an inch when measured at any point on a major tread groove. The measurements shall not be made where tie bars, humps, or fillets are located.

(c) Except as provided in paragraph (b) of this section, tires shall have a tread groove pattern depth of at least 2/32 of an inch when measured in a major tread groove. The measurement

The following provides the top ten reasons not to limp home on any tire.

10 TOP REASONS NOT TO LIMP HOME

10. **Pavement Damage: when the tire is run to destruction, the wheel contact damages the road.**
9. **Wheel Damage: $$$ hundreds of dollars.**
8. **Destroyed Casing: it may have otherwise been repairable. $$$ hundreds of dollars.**
7. **Cargo Damage: load shifts, collisions, roll-overs or fires.**
6. **Collateral Truck Damage: fairings, tanks, hoses, brakes, hoods, mudflaps, etc.**
5. **Wheel and/or Tire Detachment: if the tire/wheel become detached, they become a projectile.**
4. **Adverse Handling Conditions: mishandled, a runflat could lead to a jack-knife or even a roll-over.**
3. **Direct D.O.T. Violation: fines and downtime.**
2. **Creating assembly lock-up can cause irrepairable damage to tire, wheel, axle components, and vehicle.**
1. **Endangers Other Vehicles and People: heavy duty truck accidents can be fatal.**

STATE AND LOCAL REGULATIONS

Some states have enacted "Load Per Inch Width" regulations for the purpose of governing axle weight on (primarily) the steering axle of commercial vehicles. These regulations provide a carrying capacity of a certain number of pounds per each cross-sectional inch across the tire's width. The determination of the tire's width can vary from state to state, but presumably would be based upon either the tire manufacturer's published technical data for overall width, or the width as marked on the sidewall of the tire (which may require conversion from Metric to English units). It is recommended to contact your state's DOT office to confirm the current "Load Per Inch Width" law.

For example, if a state allows for 550 pounds per inch width, a tire marked 445/50R22.5 could carry up to 9,636 pounds (17.52 x 550) or a total of 19,272 pounds on the drive axle (2 x 9636). Another way to look at it is to take the total weight carried, and divide by the stated "Load Per Inch Width" law to determine the appropriate size tire. If a truck needs to carry 16,000 pounds an axle in a state with a 500 pound per inch width limit (16000/500 = 32), you would need a wide single tire that is at least 16 inches wide (32/2). In this case a 445/50R22.5 could legally carry the load (445/25.4 = 17.5 inches Metric to English conversion).

The two formulas are:

Load per inch width law x tire section width x number of tires = gross axle weight limit

Gross axle weight/inch width law/number of tires = minimum tire section width needed

State laws and regulations frequently can and do change, so it is recommended that you consult your local State or Province DOT and where you will be traveling to be sure there are no restrictions on the use of the X One® tire for your particular operation, equipment and weight.

Heat Study

BRAKE HEAT OVERVIEW

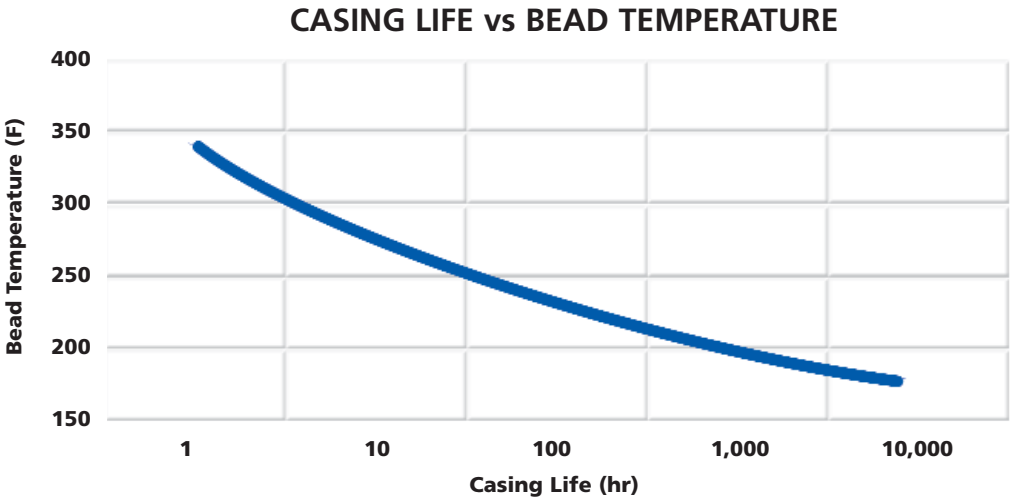
Brake temperatures on trucks often reach very high temperatures. Brake drums can reach temperatures of 600° F or more and are in very close proximity to the wheels. This heat can be easily transferred to the wheels and tires. Brake drum heat is transferred to the wheel primarily through radiation and convection. The hot brake drum radiates heat in all directions to the wheel. In addition, the drum heats the air between the drum and the wheel. The heated air rises and transfers additional heat energy to the wheel through convection. Much of the heat is transferred to the wheel in the bead mounting area due to its close proximity to the brake drum. The wheel then directly conducts heat to the tire bead resulting in elevated temperatures in the tire bead area.

Duals - Close to brake drum

Excessive bead heat can affect tire life in many truck tire applications. Vehicles in urban and refuse service are most commonly associated with bead heat issues but any application that experiences hard braking can be affected.

Results of bead heat:

1) **Immediate Failure:** In some cases, after periods of hard braking where brake drums reach very high temperature (in excess of 600° F), immediate failure can occur. This normally occurs when a truck is brought to a stop for a period of time with very high brake temperatures. Often this occurs when an over the road truck stops at a truck stop at the bottom of a long descent. As the heat rises from the brake drum there is excessive heat buildup in the portion of the tire bead directly above the brake drum (inner bead of inside dual). The high temperature can cause a breakdown of the rubber products in the bead area and allow the steel body cables to unwrap from the bead. This process results in a tire rapid air loss. This phenomenon is also common in urban and refuse fleets when the driver stops for a break after a period of hard braking.
2) **Premature aging of the carcass:** **Heat is a tire's worst enemy!** A tire subjected to high heat conditions over an extended period of time will experience accelerated aging of the rubber products. The accelerated aging may result in a blowout during operation or it may render the casing unsuitable for retread. The graph below demonstrates how operating with bead temperatures in excess of 200 degrees F will significantly reduce your casing life.



Bead damage as a result of brake heat is recognizable in 3 stages of severity. In the first stage, the bead starts to turn inward. This can be visibly identified on the tire when it is dismounted. A straight edge placed across the beads from one bead to the other no longer rests on the bead point, but now rests closer to the bead bearing area.

1st stage - turning of the bead

The second stage occurs when the rubber in the bead area starts to split or crack indicating that the steel casing plies are starting to unwrap.

2nd stage - bead splitting from heat

The third stage is when the casing ply fully unwraps from the bead. In extreme cases the casing ply unwraps from the bead all the way around the tire. At this point the tire completely separates from the bead wire. The bead wire can entangle itself around the axle if this type of separation occurs.

3rd stage – partial unwrapping of the casing ply

3rd stage – complete unwrapping of the casing ply

BRAKE HEAT EVALUATION: X ONE® TIRES VS DUALS

X One tire fitments have greater clearance between the brake drum and the bead of the tire compared to a dual assembly. In addition, due to the 2-inch outset of the wheel for the X One tires, more brake drum is exposed, which provides greater air flow around the drum. These characteristics reduce the heat transfer from the brakes to the tire and allow the brakes to run cooler.

Exposed brake drum

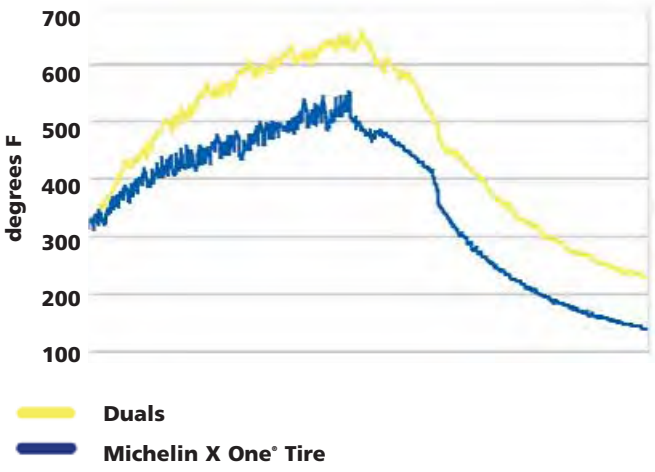
This effect was demonstrated on a closed course at the Laurens Proving Grounds, Michelin's 3000 acre test facility.

The Test

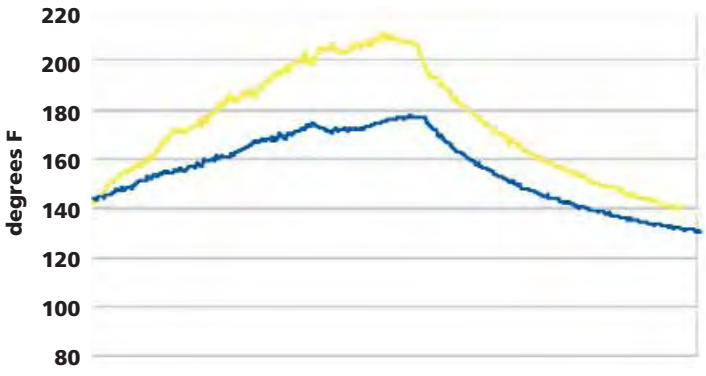
A 4 x 2 straight truck outfitted with a temperature logging device was loaded to maximum legal limits and operated on a closed course with almost continuous starting and stopping cycles. The truck was brought up to 30 mph and then stopped repeatedly for 45 minutes. The temperature logging device recorded brake drum and wheel temperatures (in the bead area) every 10 seconds. The test was run on both X One tires and duals at similar track temperatures and weather conditions.

After 45 minutes, when the brakes were at their peak temperature, the temperatures from the data loggers were compared. The brake drums fitted with X One tires were over 100°F cooler and the wheels were over 30°F cooler in the bead area than when equipped with Duals!

BRAKE TEMPERATURE X ONE TIRES vs DUALS



WHEEL TEMPERATURE X ONE TIRES vs DUALS

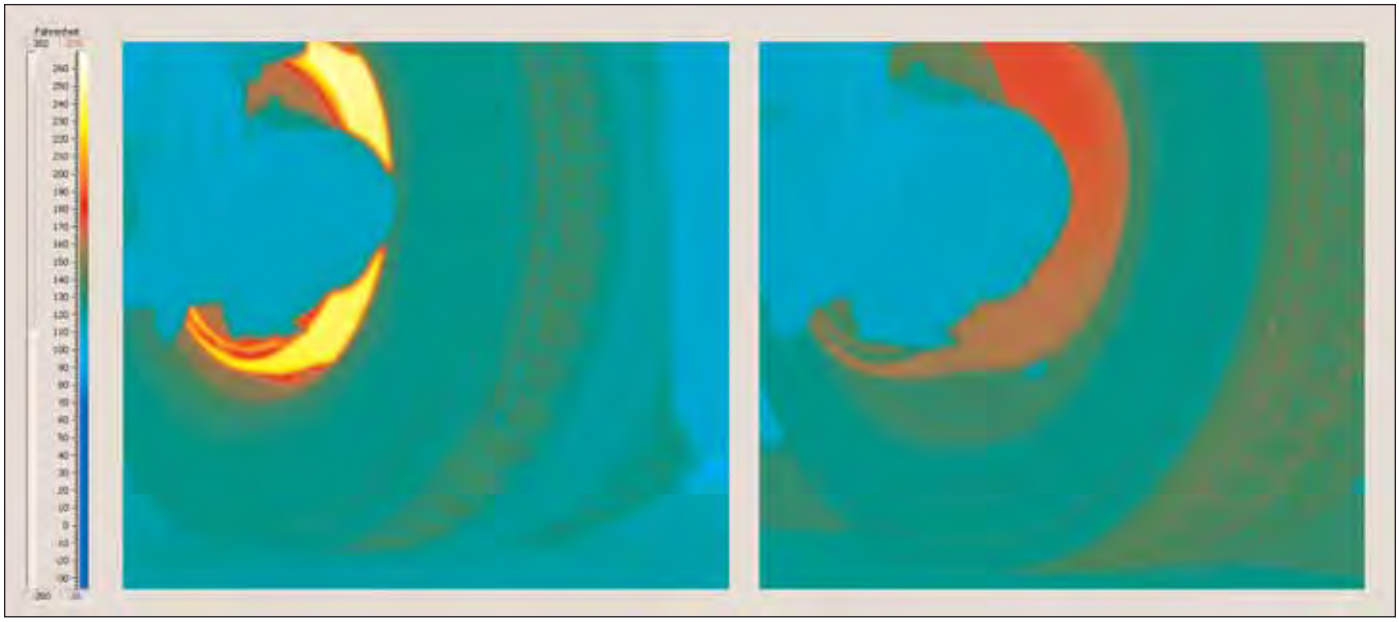


Source: Recent evaluations at a Michelin facility in South Carolina.

Thermal Imaging

The thermal image photos were captured after the repeated stopping test followed by 30 minutes of driving without braking. A brake drum temperature advantage for the X One® tire of 90 degrees F was still apparent even after the cool down period.

It is safe to say that for any given truck, brake temperatures on X One® tire equipped vehicles will be significantly cooler than brakes on trucks running conventional duals. This effect will be most pronounced during periods of heavy braking but will persist for some time after braking has ended.



Duals **X One tires**

Source: Recent evaluations at a Michelin facility in South Carolina.

Appendix

ISO LOAD INDEX AND SPEED SYMBOL 72

DEFINITIONS 73-74

SPECIAL TOOLS / MOUNTING TOOLS 75-76

MICHELIN
A better way forward

ISO Load Index and Speed Symbol

LOAD INDEX

The ISO LOAD INDEX is a numerical code associated with the maximum load a tire can carry at the speed indicated by its SPEED SYMBOL under service conditions specified by the tire manufacturer. (1 kg = 2,205 lbs.)

Load Index	Kg	Lbs
155	3,875	8,540
156	4,000	8,820
157	4,125	9,090
158	4,250	9,370
159	4,375	9,650
160	4,500	9,920
161	4,625	10,200
162	4,750	10,500
163	4,875	10,700
164	5,000	11,000
165	5,150	11,400
166	5,300	11,700
167	5,450	12,000
168	5,600	12,300
169	5,800	12,800

SPEED SYMBOL

The ISO* SPEED SYMBOL indicates the speed at which the tire can carry a load corresponding to its Load Index under service conditions specified by the tire manufacturer.

Speed Symbol	Speed	
	(kph)	mph
J	100	62
K	110	68
L	120	75
M	130	81
N	140	87

* International Standards Organization
Exceeding the lawful speed limit is neither recommended nor endorsed.

DEFINITIONS

Standard and Low Profile radial truck tire sizes can be more easily understood by breaking down the formula into the three components: the section width in inches or millimeters, aspect ratio and rim/wheel diameter.

1. Tire Size:

Standard Size example: **11R22.5**

- 11 inch nominal section width, with a height between 90 and 100% of the section width
- R = radial
- 22.5 wheel diameter

Low Profile example: **445/50R22.5**

- 445 millimeter nominal section width
- 50 is the aspect ratio expressed as a height to width percentage
- R = radial
- 22.5 wheel diameter

2. Aspect Ratio: A nominal number, which represents the section height, divided by the section width expressed as a percentage.

Example 445/50R22.5
Aspect Ratio = 50

3. Rims: The approved/preferred rims is designated for each size tire. Michelin® X One® tires should only be mounted on the rims shown.

4. Overall Width: The maximum width (cross section) of the unloaded tires including protruding side ribs and decorations as measured on the preferred rim. Overall width will change 0.1 inch (2.5 mm) for each ¼ inch change in rim width.

5. Overall Diameter: The diameter of the unloaded new tire (measured from opposite outer tread surfaces).

6. Free Radius: One-half the overall diameter of the unloaded new tire.

7. Nominal Wheel Diameter: Diameter of rim seat supporting the tire bead given in nearest whole numbers, e.g. 22.5".

8. Section Height: The distance from rim seat to outer tread surface of unloaded tire.

9. Loaded Radius: The distance from the wheel axle centerline to the supporting surface under a tire properly inflated for its load according to the load and inflation tables.

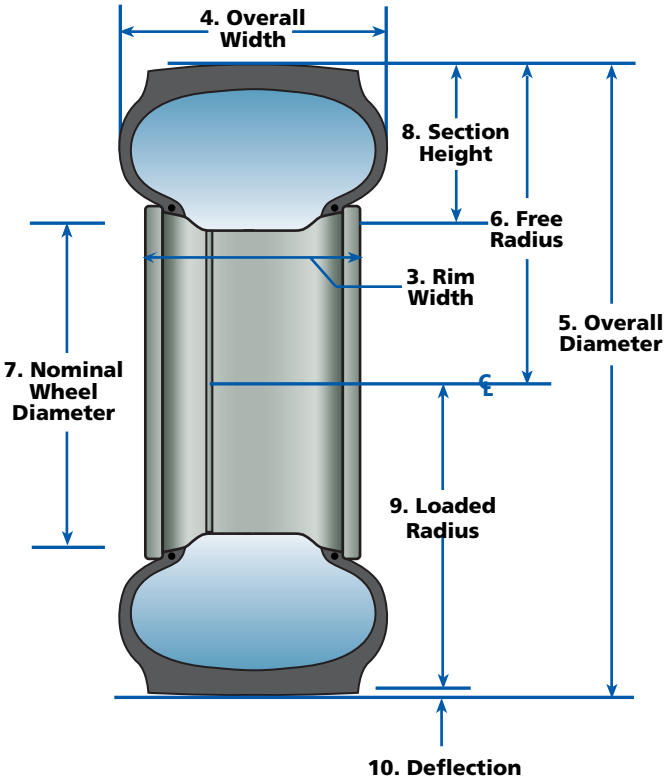
10. Tire Deflection: Free radius minus the loaded radius.

11. Revolutions Per Mile: Revolutions per mile for a tire size and tread is defined as the number of revolutions that the new tire will make in one mile. Data is normally presented for the loaded tire at its rated load and inflation in the drive position. A tire's RPM can be determined by measuring, (using SAE J1025) or, estimated by calculating, using a mathematical equation.

Michelin Equation:

RPM = 20,1681/(O.D. - .8d)
O.D. = Overall Diameter
d = Correction for deflection
d = (O.D./2) – SLR
SLR = Static Loaded Radius (Michelin Truck Tire Service Manual - MWL40732)

At Michelin, Revolutions Per Mile (RPM) are officially determined using the SAE Recommended Practice. The test tires are placed as singles on the drive axle of the test vehicle and set to the corresponding pressure. The vehicle is then driven over a straight 2-mile section at 45 mph while the number of revolutions are counted. (Since speed minimally affects the results for radial tires, other



speeds are allowed.) Averaging four runs that are within 1% of each other then derives the RPM measurement.

Afterwards, the results are double-checked using shorter distances that are more easily obtained. In addition to these, the test tire is compared to a known baseline tire on a road wheel. This latter method is very accurate and very repeatable when using a similar baseline tire with a known RPM.

The SAE procedure recognizes that within the test method itself there will be some variation. In fact there are other factors that cause variation on RPM's among similar tires. Be aware that they will have the same RPM. The SAE procedure determines the RPM to within ± 1.5%.

Some factors, which cause variation among tires, are:

Load and Pressure – A difference in Load/Pressure could alter the RPM measurement by as much as 1.5%. If pressure is constant, going from an empty vehicle to a fully loaded vehicle can change RPM by 1 to 1.5%.

Treadwear – The RPM varies from a new tire to a fully worn tire. This can affect RPM by as much as 3% from the rated RPM.

Tread Geometry – The height and stiffness of the blocks and the shape of the tread pattern can affect RPM

Torque – The presence of driving and braking torque can affect the RPM.

Type and Condition of Pavement – Asphalt vs. concrete, wet vs. dry can create differences in RPM.

CALCULATED RPM

Example: 445/50R22.5 X One® XDA-HT™ Plus (new tire)

O.D. = 40.5
SLR = 18.7
d = (40.5/2) - 18.7
d = (20.25 - 18.7) = 1.55

RPM = 20,168/((40.5 - (.8 x 1.55))
= 20,168/((40.5 - 1.24))
= 20,168/39.26
RPM = 513.7 (Calculated) vs. Data Book (Measured) RPM of 514.

All the information required to determine the proper tire size is contained in the application specific data books.

To select the proper tire size for a vehicle, it is necessary to know the maximum axle loads that the tires will carry and the maximum continuous speed at which they will operate. The maximum load that a tire can carry is different if it is mounted in single configuration rather than in dual. The allowable axle loads and the required inflation pressures to carry these loads are shown in the charts for both single and dual mountings in the current Michelin Truck Tire Data Book (MWL40731). The maximum allowable continuous speed is also indicated.

Special Tools / Mounting Tools

Special tools are available to aid in the mounting and demounting of the X One® tire on/off the wheel and the X One® assembly on/off the vehicle. Due to the size of the tire and wheel these tools will assist the tire technician in providing both safe and easy methods of removal and installation.

When removing any tire from a wheel you should use an Impact Bead Breaker (Slide Hammer) to prevent bead damage. This is also a safer way to dislodge the tire beads from the wheel.

Never strike the beads with a hammer.

Impact Bead Breaker (Slide Hammer)

AFTER YOU MOUNT THE X ONE® TIRE ON THE WHEEL YOU MUST CAGE IT

An extra wide Safety Cage is available for safe inflation of the tire. In most cases a standard cage can accommodate the X One® assembly.

DOT requires that all truck tires are to be inflated in an Inflation Cage. **WARNING!** Tire changing can be dangerous, and should be done only by trained personnel using proper tools and equipment as directed by Federal OSHA Standard No. 29 CFR Part 1910.177. Tires may explode during inflation causing injury to operator or bystander. Wear safety goggles. Keep all parts of body outside cage. Use extension hose, clip on chuck, and remote valve.

Consult the Michelin Truck Tire Data Book (MWL40732) for proper inflation.

TOOLS FOR HANDLING THE X ONE® TIRE ASSEMBLY:

Tire and wheel dollies are available from Commercial Tire Supply Companies to make the mounting and removing of the assemblies on/off of the vehicle easier. There are various types to choose.

A tire dolly may provide the lifting assistance to mount or remove the X One® tire assembly, which may help to avoid possible injury.

Tire Dolly

Some people have difficulty standing on the tire using conventional mounting techniques, and a good device to help "hold" the bead in place without damaging the wheel are coated bead keepers, shown here.

Bead Keepers

Index

4 x 2 Tractors....21, 21, 22, 68
6 x 4 Tractors....22
Accuride....4, 8-10
Air Infiltration....20, 23, 34, 35
Air Loss....Inside Cover, 22, 26, 34, 41, 52, 59, 64
Air Pressure....Inside Cover, 5, 10, 20, 23, 31, 36-39, 44-47, 64
Alcoa....4, 8-9
Alignment....23, 46-48
Aluminum Wheels....1, 4-6, 8-9, 24, 49, 52, 62
Application....Intro, 3-4, 6, 8, 14-15, 21, 38, 46, 55, 57-58, 64, 66, 74
Arvin Meritor....12, 14
Axle....Inside Cover, 1, 4, 10-11, 13-14, 18-19, 21-23, 33, 36, 38, 44-48, 63-65, 67, 73
Axle Housing....13-14
Axle Identification....11, 13-14
Axle Shaft....13
Axle Skew....23, 47
Axle - Drive....4, 13, 18, 45, 47, 65
Axle - Steer....1, 10, 22
Axle - Trailer....13-14, 19, 46, 48
Axle - Weight Rating....4, 11, 13-14, 65
Balance....23, 30, 47, 49
Bead....4, 23-29, 31-32, 34, 43, 53, 56, 58, 66-68, 75-76
Bead Breaking Tool....27, 75
Bead Damage....33, 43, 67, 75
Bead Keepers....26, 76
Bead Repair....53, 58
Bearing....11, 14, 18
Beauty Ring....28
Block Edge Wear....23, 45
Brake....Inside Cover, 7-8, 13, 19, 23, 46, 59, 64-69
Brake Skid Wear....23, 46
Brake Heat....59, 66-68
Buffing....53-54
Builder - Retread Process....53, 58
Center Wear....23, 45
Central Tire Inflation (CTI)....11, 19-20
Clamping Force....8
Chains....59, 64
Circumferential....26, 40, 54, 57-58
Computers....11, 18
Contact Pressure....61
Contact Surface Ratio....36
Contamination....51
Corrosion....5, 40, 45, 57, 58
Curing - Retread Process....53, 58
Dana Spicer....13, 14
Demount/Dismount....4, 23, 27-29, 32, 34, 43, 67, 75
Differential....13
Dolly....21, 76
DOT....2, 66, 75
Drive Axle....4, 13, 18, 45, 47, 65
Drop Center....1, 4, 9, 25, 27
Dual Seal Valve Caps....5
Dual/Duals....Intro, 2, 4, 6, 13-14, 18-19, 23-24, 32-34, 36-28, 41, 43, 45, 47, 49, 59, 61, 63, 65-66, 68-69, 74
Enveloping-Retread Process....57, 62
Equivalent Size....1, 2
Footprint....Inside Cover, 36-37, 63
Fuel Economy....2, 3, 18
Gear(ed)....2, 13
GG Ring....33
Gross Axle Weight (GAWR)....4, 14, 65
Gross Vehicle Weight (GVW)....19, 21
Guide Rib....31
Guidelines....31, 38, 53, 55
Handling....Inside Cover, 22, 37, 39, 59, 63-65, 76
Hayes Lemmerz....9, 10
Heel Toe Wear....23, 45
Hendrickson....14
Hub Pilot....1, 6, 9, 10, 33
Hydroplaning....59, 61
Inflation....Product Specs Disclaimer, 9-11, 19-20, 23-24, 26, 31, 37-41, 43-44, 46, 54, 58, 74-75
Inflation - Central Tire Inflation....11, 19-20
Inflation - Over Inflation....19, 37, 39, 43
Inflation - Under Inflation....Inside Cover
Inner Liner....24, 34, 39, 42, 52-53, 58
Inner Liner Repair....53, 58
Inset....1, 4-5, 9-10, 45
Inspection....Inside Cover, 19, 23, 39, 42, 52-54, 58, 64
Inspection - Pre Trip....19, 39
Inspection - Retread Process....54, 58
Inspection - Tire Inspection....23, 42
Inspection - Valve Stem....5, 19, 23-24, 26-27, 52
Irregular Wear....23, 31, 38-39, 45-48, 54
Jack-Knife....59, 63, 66
Laurens Proving Grounds....68
Limping Home....59, 65
Load....Product Specs Disclaimer, 1-2, 5, 9-11, 14, 18, 20, 23, 26, 36-38, 40-41, 44, 61, 63, 65, 68, 71-72, 74
Load Index....71-72
Load Range....1, 2, 9
Long Haul/Line Haul....3, 54-55, 57
Lube, Lubricants, Lubrication....18, 24-25, 27, 31, 54
Mismount....23, 31, 49
Missed Nail Hole....11, 20
Mount/Mounting....4-6, 8-10, 14, 18-19, 23-25, 27-29, 31-34, 43, 48-49, 66-67, 71, 73, 75-76
Mounting Tools....24, 71, 75
Nail Hole Repair....Intro, 53, 57
Nitrogen....23, 39
Offset....13
On/Off Road....3, 52-53
O-Rings....5, 24
OSHA....27, 31, 43, 75
Outset....1, 4-6, 9-11, 14-15, 17-18
Over Inflation....19, 37, 39, 43
Over Load....40-41
Over Steer....59, 60
Pickup and Delivery....54, 55, 57
Pressure....Inside Cover, 5, 10-11, 19-20, 23-24, 26, 31, 34, 36-42, 44-47, 54, 58, 61, 64, 73-74

Index

Pressure Gauge....Inside Cover, 5, 39, 41
Pressure Maintenance....5, 20, 38, 39, 64
Pressure Monitoring....11, 19-20
Pressure Sensors....19, 46, 52
Pressure - Cold Inflation Pressure....10, 19, 38, 39, 40, 44
Radial....Introduction, 19, 45, 47, 49, 57-58, 73
Rapid Air Loss....Inside Cover, 22, 34, 40, 59, 64
Ratio....2, 12, 18, 24, 36, 61, 73
Recreational Vehicle (RV)....21
Refuse Vehicles....10, 21, 54, 66
Regional Service....3, 52, 53
Repair....Intro, 24, 34-35, 40, 43, 53-55, 57-58
Repair - Bead Repair....53, 58
Repair - Inner Liner....53, 58
Repair - Nail Hole....Intro, 53, 57
Repair - Section Repair....53, 57
Repair - Spot Repair....57, 61
Retread....Intro, 2, 24, 30, 50-51, 53-54, 58, 66
Retrofit/Retrofitting....1, 2, 6, 15-16, 18
River Wear Only....23, 54
Roll-over....59, 62-63, 65
Rotate/Rotation....Inside Cover, 45, 46
RPM....1, 2, 10, 18, 44, 73-74
Runflat....23, 24, 26, 40-42, 65
Runout - Radial and Lateral....23, 30, 47, 49
Safety....19, 24, 26, 31, 33, 43, 50, 62, 64, 75
Safety Cage....31, 43, 75
Sealant....23, 52
Section Repair....53, 57
Sensors....19, 46, 52
Severe Service/Severe Use....54-55, 57-58
Shearography....53-54
Shoulder Step Wear....23, 30, 38, 46
Sidewall....Intro, 1, 2, 10, 17, 20, 24, 26, 30-31, 34-35, 38, 40, 41-44, 50-51, 54, 56-57, 65
Skiving....53, 55
Specifications....Intro, Product Specs Disclaimer, 1, 4, 9-11, 15, 31, 44, 48-49, 53-55, 57-58, 62
Specifications - Balance....49
Specifications - Repair....53-58
Specifications - Runout....49
Specifications - Tandem Skew....51
Specifications - Runflat....41
Specifications - Toe....47
Specifications - Trailer Alignment....48
Specifications - Wheel....1, 9-10
Speed Symbol (ISO)....71-72
Spindle....4, 11, 13-16, 18
Spot Repair....53, 57
Spread Axle....21, 63
Steel Wheel....1, 4-6, 8-10, 24, 49, 52
Steer Axle....1, 10, 22
Stopping Distances....39, 59, 65, 68
Stud Pilot....1, 6-10, 33
T45 Tire Irons....24-25, 28-29
Tanker/Tank....21, 46, 64-65
Technical Bulletin....Intro, 65
Temperature....19, 23, 39, 66, 68, 69
Temperature Logging Device....68
Thermal Imaging....69
Tools....24-25, 29, 47-49, 71, 75-76
Tools - Bead Breaking....24, 27, 75
Torque....1-2, 5, 7-8, 23-24, 33, 45, 52, 62, 74
Track Width....Inside Cover, 4, 11, 13-15, 17, 62, 68
Traction....3, 13, 37, 50, 59, 63-65
Trailer Axle....13-14, 19, 46, 48
Tread Act....19
Under Inflation....Inside Cover, 19, 24, 38
Under Steer....59-60
Urban....3, 52, 54, 66
Valve....1, 5, 29, 23-28, 33, 43, 52, 75
Valve Cap....5, 26
Valve Core....27, 43
Valve Stem....5, 19, 23, 24, 26-27, 33, 52
Vibration....23, 30, 46-47, 49
Wear....3, 18, 23, 30-31, 38-39, 45-48, 50, 54, 75
Wear Bars....50
Wear - Block Edge....23, 45
Wear - Brake Drag....23, 46
Wear - Center....23, 45
Wear - Heel Toe....23, 45
Wear - Irregular....23, 31, 38-39, 45-48, 54
Wear - River....23, 54
Wear - Shoulder Step....23, 30, 38, 46
Wheel....Inside Cover, 1, 4-15, 17-19, 22-33, 38, 43-44, 46-47, 49, 64-66, 68, 73-76
X One® XDA®....2, 3, 36
X One® XDA-HT™ Plus....2, 3, 36-37, 62, 74
X One® XDU®....2
X One® XTA®....2, 3
X One® XTE®....2, 3
X One® XZU®S....2, 3, 53, 57
Zipper Rupture....40, 42

Michelin® Truck Tire
X One® Tire Service Manual

To learn more please contact
your Michelin Sales Representative or visit
www.michelintruck.com

To order more books, please call
Promotional Fulfillment Center
1-800-677-3322, Option #2
Monday through Friday, 9 a.m. to 6 p.m. Eastern Time

MICHELIN NORTH AMERICA, INC., Greenville, South Carolina, USA
MICHELIN NORTH AMERICA (CANADA) INC., Laval, Quebec, Canada
MICHELIN MEXICO S.A. DE C.V., Querétaro, Mexico

An Equal Opportunity Employer

MWL43101 (03/07)

MICHELIN
A better way forward