



## **INTRODUCTION**

**Goodyear Eagle Radial Stock Car tires and the procedures associated with preparing them for on-track activity can be critical contributors to the performance results for which all NASCAR Nextel Cup, Busch Series and Craftsman Truck competitors are striving.**

**The information provided in this Tire Reference and Information Guide is intended to assist this select group of race teams in developing a better understanding of tires and tire performance.**

**Many of the decisions a race team faces have a direct impact on tires. It is important these potential effects be known and considered during the decision making process.**

**In-depth explanations and specific guidelines are included to help clarify proper tire use and preparation. Several updates and a new Advanced Engineering Services section have been added to this first revision.**

**Goodyear engineering and technical support will be available at all of these NASCAR events and welcomes the opportunity to discuss any questions or comments you may have. Goodyear Racing's objectives are the same as your expectations – safe, reliable, consistent and competitive tire performance. We look forward to working as closely with your team as necessary to ensure these expectations are met.**

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## **“BEST PRACTICES” – RECORD KEEPING / SET MATCHING**

Careful attention to record keeping should be exercised for all tires used during on-track activities. All codes present on the tread area and sidewall should be recorded prior to use, including D-number, sequence number, spring rate and date code. A description of each of these items can be found in the following sections. It is also a good practice to number each wheel in your inventory and record the wheel number coinciding with each tire. Recording all available information will not only be helpful for record keeping and historical data, it can provide adequate traceability in diagnosing any performance issues that may arise during usage.

There are many different methods used in matching tires into “sets” for on track activities. Consistency in preparation of sets is paramount, and Goodyear recommends several basic guidelines for matching sets. Roll out (stagger), spring rate and date code are three important factors in maintaining on-track consistency.

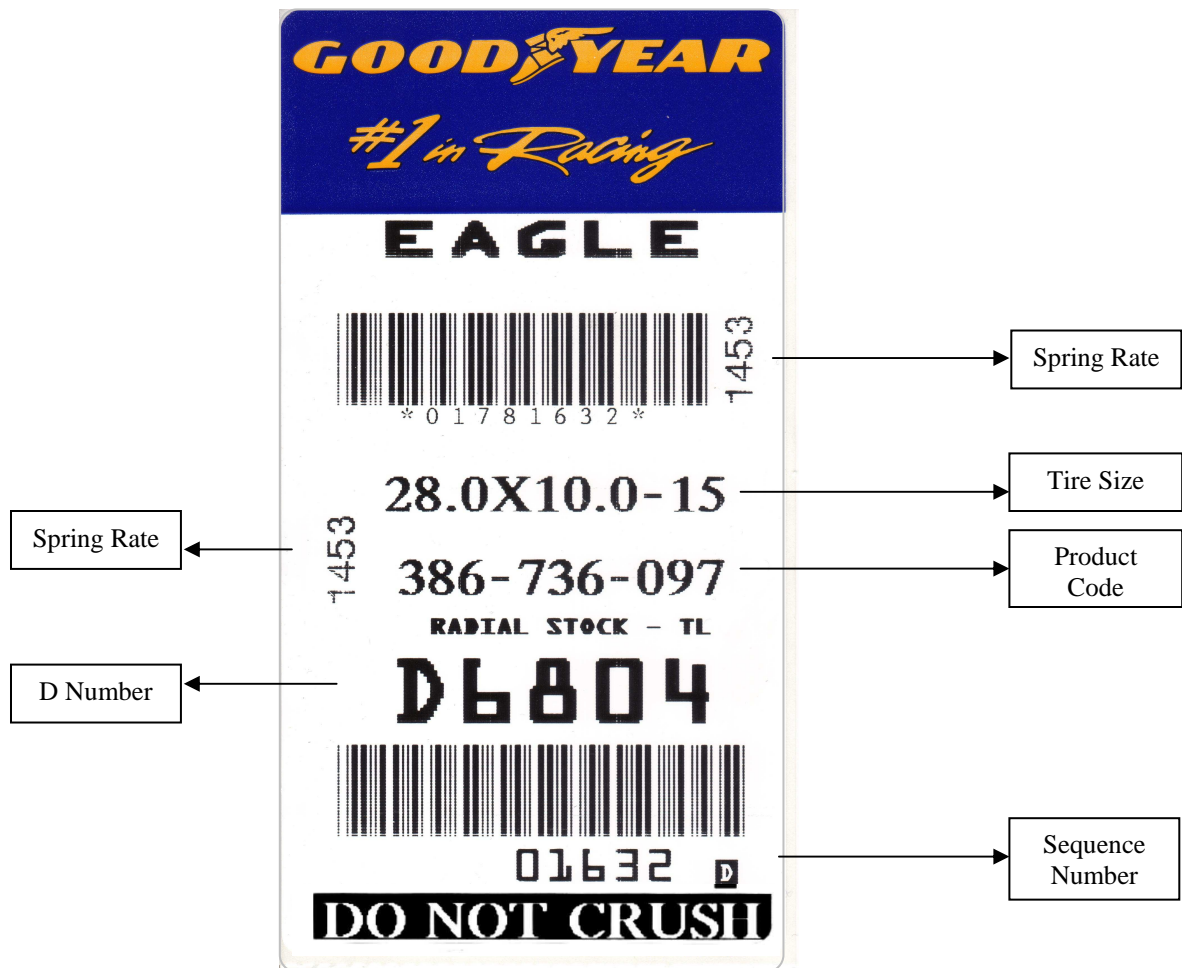
1. Roll out should be measured on all tires at the tire centerline, with careful attention to proper air pressure and consistent placement of the tape measure.
2. The spring rate printed on the tire label should be used as a relative number in matching tires into sets. The best practice for matching spring rates is to maintain a consistent split front to rear from set to set.
3. Tire age can also play a role in overall performance or grip. The potential for noticeable grip differences increases as age between tires increases. The best practice for matching tire sets according to date codes is maintaining consistency front to rear for both sides of the car. For example, matching a significantly older RF with a newer RR is more likely to produce an overall change in car balance and corresponding drop in lap time than matching two older (more similar) RS's would. Maintaining consistency in set matching is the key to maintaining on-track performance consistency.
4. Goodyear also recommends periodic inspection of wheels for excessive wear and tear on the rim flange. Repeated contact of the mounting bars with the outer wheel flange from tire mounting and dismounting over the course of a race season can cause the flange to become “sharpened”. A “sharpened” flange can increase the risk of cut beads during mounting, and may lead to slow inflation loss or equalizations. Inspect your wheels periodically and file down any sharp edges that are apparent on the rim flange.
5. Always mark valve stem and wheel weight locations on each tire assembly to document tire/wheel slip and missing balance weights in the event of a vibration.

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## TIRE LABEL CONTENTS:

The spring rate for a particular tire is the number that runs vertically on the tire label. The top number on the label is an 8 digit barcode identifier intended to distinguish between overlapping sequence numbers that may occur during the production year. Each individual tire will have a unique 8 digit barcode identifier. It is important to note that these 8 digit identifiers do not necessarily represent the actual sequence of production in the factory and should not be used as a basis for tire age. Refer to the date code on the lower sidewall for approximate tire age. The next number down is the size of the tire which indicates tire diameter, tread width, and bead diameter. Below the size is a number such as 386-736-097, which is the product code of the tire. The number below the product code is the D number, which consists of the letter D followed by a four digit numeric code (ex. D6804). The D number identifies a particular mold, construction and compound combination. If any part of the construction or compound is changed, the D number will be changed. The number at the bottom of the label is the sequence number which consists of a zero followed by four digits and is used to identify individual tires in a production sequence. The four digit sequence number is identical to the last four digits of the top barcode number.

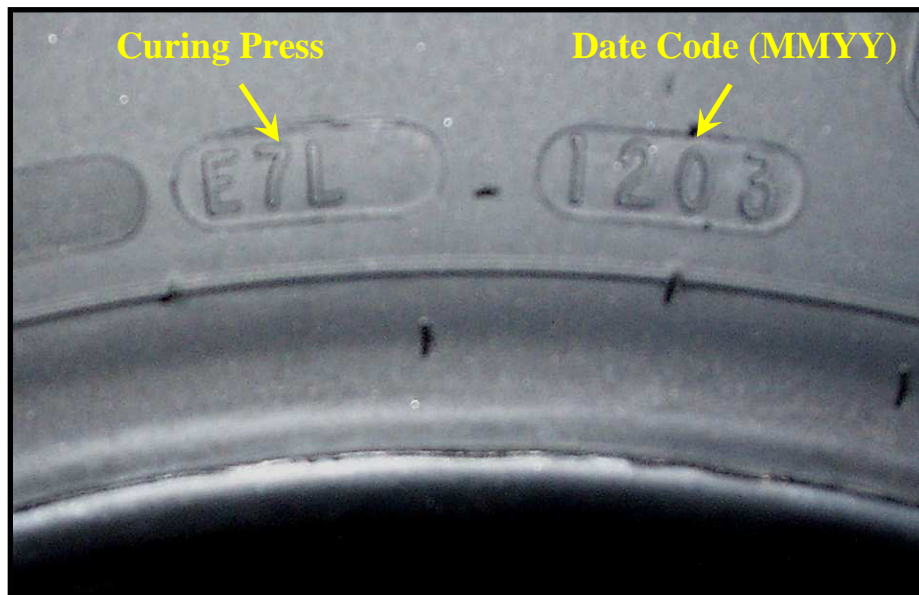


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## **IDENTIFIERS ON THE TIRE:**

There are several stencil boxes located next to each other in the lower sidewall of the tire which may have numbers and/or letters inside of them. One box will contain a four digit date code identifying the month and year that particular tire was produced. The first two digits of the date code indicate the production month and the last two digits indicate the production year. For example, if the date code is 1203, the tire was produced in December of 2003. A second box will contain a three digit code indicating the curing press where the tire was cured.



On the sidewall near the bead area, there is a six digit number followed by a hyphen and a seven character code. The first six digit number refers to the mold piece number and the seven character code is the mold code. The mold code refers to the size and shape of the mold used and the piece number refers to the specific mold the tire was cured in. Therefore, all tires with the same D number will have the same mold code, but can have different piece numbers.



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There are three different identifiers stamped on the sidewall indicating our final quality inspection has been completed and approved: F, H, and X. The F is for force uniformity inspection, the H is for the holograph inspection, and the X is for the x-ray inspection. There are two colored dot stickers on the tire. The dot on the sidewall locates the highest radial first harmonic measured during the uniformity screening process and the dot on the tread indicates the location of the heavy point on the tire as measured during a balance screening test.

### DATE CODES:

All NASCAR radial tires produced after October 2003 will have a date code. The date code (see above) indicates the month and year a particular tire was produced and can be a valuable tool in matching sets of tires.

### MOUNTING AND BALANCING:

In 2003 Goodyear implemented a new tire mounting procedure based on minimizing tire/wheel assembly radial forces. The previously described colored dot on the upper sidewall of every tire locates the high radial first harmonic (R1H) as measured during the uniformity screening. Alignment of this high R1H location with the low runout point on the wheel will act to cancel radial forces associated with the individual tire and wheel components to create an improved assembly uniformity. This procedure may result in slightly higher balance weight requirements but extensive trials and on-track testing have shown improved ride/vibration results as well as improved grip. This method requires the wheel to be measured for runout in the bead seat area and the low point clearly marked.

If the wheel has not been measured and marked, the mounting procedure will revert to an orientation of the balance dot on the tread (heavy location on the tire) 180 degrees from the valve stems. Regardless of the mounting procedure, a maximum of 3.0 ounces of balance weight per side and a maximum of 5.5 ounces total per tire are permitted.

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## STAGGER – TIRE CIRCUMFERENCE MEASUREMENTS

Centerline circumference or “roll out” measurement variation for a new NASCAR radial tire is expected to be in a range of +/- 1/8” which equals +/- 3.2 mm.

Measuring, recording, and matching new tire “roll out” sizes is recommended to achieve the best control of front and rear stagger variation.

Recommended procedure to measure tire “roll out”:

1. Tire should be within two psi of required inflation (use same inflation for all LS or RS).
2. Confirm tire surface near the centerline is clean, no small stones etc.
3. Wrap a one-quarter inch tape around the tire slightly offset from the tire centerline to miss the center wear pin vents being careful not to “snake” the tape.
4. Best to read at the one inch (or 10 mm mark) and subtract that amount than to read to the starting end.

millimeters / inches conversion examples:

2 m 250 mm = 2.250 meters / .0254 = 88.58” this is approx. 88 9/16” (88.5625”)

88 9/16” = 88.5625” x .0254 = 2.2494875 meters = 2 m 249.5 mm

## TIRE WEAR MEASUREMENTS

Recommended procedure to measure wear on a NASCAR radial tire:

1. On a new tire mounted and inflated within two psi of required inflation, record the five wear pin depth measurements on one row of pins (noting outboard to inboard) using a 32nds or mm wear pin gauge. Mark this row location on the outboard sidewall of this tire. This procedure is what is referred to as “indexing” a row of pins. Do this to all four tires to “index” a set.
2. After a long run (or several runs) on this “indexed set”, scrape rubber “pick up” off this row of pins (easier if tire surface is hot), and record the worn tire pin measurements. Subtract these measurements from the initial new measurements to calculate accurate wear.

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Each mold has 40 wearpins, 8 rows and 5 per row. The pin depths have variation with the pins ranging from 2.5 to 3.3 32nds. This is why the above “indexing” procedure is recommended.

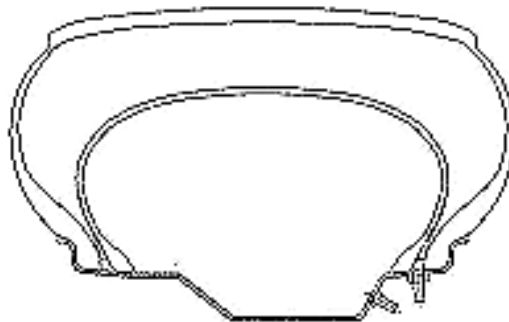
The tire wear rate across the tread surface should not be the primary consideration in setting RF camber. Some track surfaces and/or harder tread compounds resist wear and may not accurately indicate excessive camber, although excessive wear on the inboard of the RF tire is an indication for the need to reduce negative camber for the tire to last a fuel stop.

## **SPRING RATE**

The vertical spring rate number printed on the tire label is measured under controlled conditions and provides a valuable tool in matching tires into sets. These controlled conditions differ from the actual service conditions the tires will see on the track, but provide a reasonable comparison from tire to tire for maintaining overall consistency. For more information on the effects of load, speed, camber and air pressure on spring rate under typical race conditions consult Goodyear Racing’s Dynamic Analysis Program, available from Goodyear engineering personnel. It is important to note that a change in tire spring rate must not be misconstrued as being equivalent in magnitude to the same change on a chassis spring. For example, a 150 lb/in difference between two RF tires is roughly equivalent to a 10 lb/in change in chassis spring rate.

## **INNER LINERS**

The tubeless safety spare, also known as inner liner, is a small high pressure treadless tire mounted inside the service Goodyear Racing Eagle tire inflated through a separate valve, and sealing against the wheel surface for lightweight tubeless operation. See cross section diagram.



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This is a runflat device capable of carrying the vehicle load for a short time, enhancing stability and control, and allowing the race car “limp home” capability to return to the pits for service in the event of a puncture or cut tire.

Goodyear’s patented inner liner is required in all four tires at all NASCAR super speedways, all intermediate speedways, and right side only at Bristol.

The inflation of the inner liner must be higher than the inflation of the outer race tire. The recommended extra inflation in the inner liner is anywhere in the range of 12 to 25 psi above the outer racing tire. **ALWAYS** keep at least 5 psi more inflation in the inner liner than the outer tire to maintain seal location and correct balance of the assembly. See the “Inflation Procedures” section for more details. Understand the seating/sealing pressure of the inner liner is only the differential pressure. For example, an assembly with 50 psi in the outer tire and 70 psi in the inner liner has only a 20 psi net seating pressure acting on the inner liner.

When operating as intended, the inner liner has a very low effect on handling. The exception is “equalization” of the air pressure in the two chambers. Equalization occurs when there is less than two psi difference between the inner liner and the outer tire. This will also be coupled with excessively high build-up in the outer tire. Vibration or ‘out of balance’ complaints may also be observed. Some potential causes of equalizations are poorly seated inner liners, torn toe of liner bead area (cut during mounting), broken bead wires in liner (sometimes damaged during liner “stuffing”), or dirty wheel or flange seating area.

Increasing the inflation differential between the inner liner and the outer tire has a negligible effect on the vertical spring rate, but it has a small but measurable effect on the lateral rate. Static testing shows the effect to be about 2 pounds increase in lateral rate for every psi of increased pressure differential.

## **INFLATION PROCEDURES:**

How the race car handles while on the track is heavily dependent on the air pressure in each tire assembly (outer tire and the inner liner if it is required). If there is one word to remember when purging the tires and setting the air pressures it is **CONSISTENCY**.

Before the race car goes out on the track you want to make sure that all four tire assemblies have been prepared the same way as any previous or subsequent sets. The end goal is to make sure the tire assemblies have the ability to build air pressure consistently from run to run and set to set. Here are some recommendations to help you do your job consistently:

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### **Purging tires with a bottled gas (most commonly nitrogen):**

The amount of moisture within the tire plays heavily into how much the air pressure builds when the tire assembly is heated. If there is a different level of moisture in two tires that started at the same cold pressure and they are both operating at 235°F, then the one with more moisture will have a higher hot air pressure.

The pressure build-up reacts in accordance with the Ideal Gas Laws or “Boyle’s Law,”  $PV=nRT$ . Boyle’s Law in essence says that pressure increases directly with temperature under constant volume for an ideal gas, but if there is moisture in the tire, build-up will not follow Boyle’s Law. As the tire assembly gets hot, condensed moisture in the tire will vaporize and lead to inconsistent build-up. Purging a tire and refilling it with a known bottled gas will help get consistent build-ups. Some points to consider:

- ◆ Purge the outer tire first and NEVER let the inner tire drop below five psi greater than the outer tire. The inner tire bead could unseat and cause balance problems out on the race track (see inner liner section for additional information).
- ◆ When purging the outer tire place your hand in the stream of air and feel for moisture. If there is a considerable amount of moisture escaping from the tire you should do at least two purges on that assembly. You should also purge the inner liner of this assembly remembering not to let the inner liner drop below a five psi differential with the outer tire.
- ◆ Never purge the inner liner when the outer tire is pressured.
- ◆ If there is no appreciable moisture escaping from the outer tire then the inner liner purge can be skipped.
- ◆ Make sure valve cores are snug when you are done. Air leaking from loose valve cores happens every year. This also highlights the importance of ALWAYS using valve caps whenever the race car is on the track (see Valve Cap section).

### **Setting air pressures:**

Once each tire has been purged you are ready to begin setting air pressures. Again, consistency is the key point to remember. Each tire assembly should be in the same ambient conditions (sun versus shade, heater blowing directly on a few tires, etc).

Some points to consider:

- ◆ Set the inner liner pressure first, then the outer tire pressure and then recheck the inner liner and outer tire pressures.
- ◆ Try to set the pressures under the same ambient conditions as expected on race day. Once the pressures are set then you should NOT make any adjustments (unless requested by the crew chief or driver).
- ◆ The amount of air (or volume) in each tire assembly is critical to how much the inflation builds in each assembly. Therefore, it is critical NOT to ‘maintain’ the pressures once the cold pressures have been established for your team and you have set each tire assembly.



For example, you set your pressures on Saturday morning and it was overcast and 80°F. On race day the weather conditions are the same and that tire which was set at 48 psi cold gets on the track and heats up the air to 225°F and comes off with a hot pressure of about 65 psi. The skies cleared during the previous run and the next set of tires sat in the sun while waiting to go on the car. The tire man verifies the air pressures and notices the right front has built to almost 50 psi while sitting in the sun. The 2 psi of build up is removed and the set goes on the car. The air in the tire gets heated to the same 225°F but because some of the volume was released it is only able to attain about 62.5 psi.

#### Using valve caps:

Valve caps should be used for all on-track activity (practice, qualifying, and the race). The spring in a valve core can be depressed due to the high rotation speed of the tire while the race car is on the track. This allows air to leak from the tire and can lead to failure. Each valve cap should be inspected for a rubber grommet located in the top of the cap. Each valve cap must then be snug against the stem to ensure an airtight seal. The valve cap also helps keep dirt and debris away from the valve core. A small piece of sand can interfere with the spring and cause the core to be open and allow air to escape. This causes the car to handle differently than anticipated and can ultimately lead to tire failure. **DO NOT RUN WITHOUT VALVE CAPS.**

#### Checking air pressures during practice:

Air pressures should be checked as soon as possible after every run and then again right before the race car goes back out onto the racetrack. **NEVER** bleed any air out of the tires between runs. One of the biggest mistakes you can make is bleeding the build-up out of the tires after each run. The tire pressures will not build up to the same level during the next run (see example in Setting air pressures section). Doing this several times in a row leads to virtually no build up in the tire pressure and tire failure (see section on the Importance of Starting Pressures for additional information).

## **MINIMUM COLD INFLATION REQUIREMENTS**

All Goodyear Eagle radial tire production intended for NASCAR competition is checked frequently to assure necessary and expected durability performance. This dynamic high speed testing is done at conditions designed to exceed the duty cycle the tire is likely to be exposed to on track and has provided considerable input into the minimum inflation pressures published by Goodyear in the NASCAR Radial Tire Data Book. As speeds and loads continue to increase, inflation pressures must also increase to ensure adequate load carrying capability exists. These minimum inflations are intended to provide a safe operating pressure for a normal range of chassis setups and are track specific. In addition to the lab testing used to help determine minimum

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pressures, extensive simulations encompassing load, speed, camber and slip angle also provide important data that is considered. **PLEASE NOTE THAT ALL PUBLISHED MINIMUM INFLATIONS ARE “COLD”.** “Hot” pressure buildups are expected and should **NEVER** be bled from the tire between practice runs.

Deviation below minimum inflations can result in tire durability problems. Under-inflation can lead to a fatigue-related failure of the tire due to vertical and lateral over-deflection over the course of a fuel run and will typically result in a rapid inflation loss due to tire cord breakage in the sidewall. In addition to the potential for over-deflection, under-inflation will create high stress zones at the inside (cambered) shoulder of the tire due to elevated footprint unit pressures in this localized area of the tread surface. This is particularly critical on the right front position since it is the most highly loaded tire. The potential failure mode can be a belt edge separation and tread area damage at the inside shoulder. Often, a noticeable vibration will be felt immediately before a rapid air loss occurs.

**PUBLISHED MINIMUM COLD INFLATIONS ARE FIRM RECOMMENDATIONS ESTABLISHED TO PREVENT TIRE OVER-DEFLECTION AND THE DAMAGE THAT CAN RESULT. DO NOT USE LOWER THAN MINIMUM INFLATIONS.**

## **TIRE TEMPERATURES**

Tire temperatures are among the most important pieces of information that can be collected at the track. Tire temperatures are used as not only an indicator of how the tire is performing, but also how the entire chassis is working. Goodyear has established several recommendations concerning procedures and practices when taking tire temperatures, and for what to look for. Goodyear also provides engineering and technical personnel at all Nextel Cup, Busch Series and Craftsman Truck events to assist in taking tire temperatures and in interpreting results.

Goodyear recommends the use of a probe type pyrometer to take tire temperatures. This gives the internal temperature of the tire and is a more accurate indicator of the actual performance of the tire than a surface type gauge. Temperatures should be taken as consistently as possible. At oval tracks, it is recommended that the procedure start at the right front tire and continue around the car in a clockwise direction. When racing at road courses, start at the left front and proceed in a counterclockwise direction.

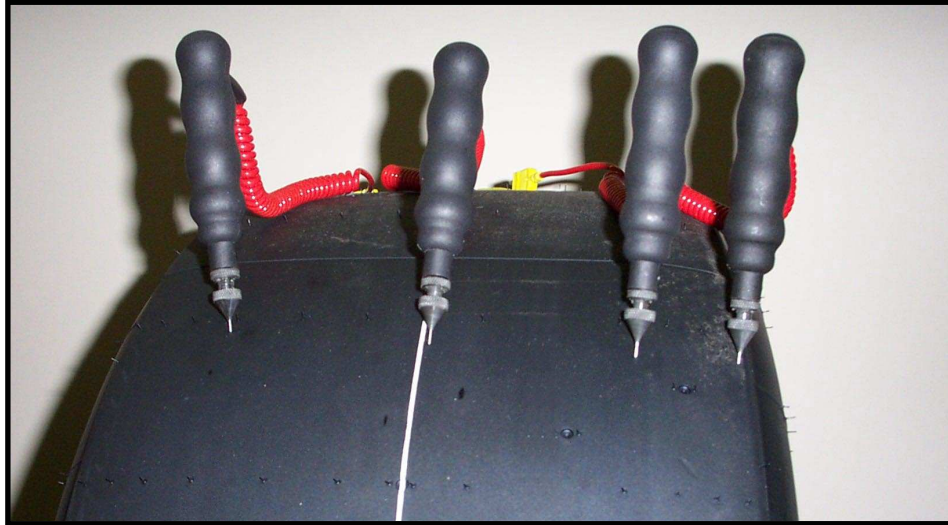
Temperatures should be taken at three positions across the face of the tire. One approximately 1.5 inches away from the inside shoulder, one near the centerline, and

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one about 1.5 inches in from the outside shoulder. A typical spread between the inside and outside temperature measurements is 10° – 20° F. A temperature spread higher than this is an indication of excessive camber and can lead not only to inefficient use of the tire, but also tire blistering.

At oval tracks, Goodyear also recommends that the inside shoulder temperature of the right front tire be taken. The recommended maximum difference between the shoulder temperature and the inside measurement on the tread is 25° F. The picture below shows the four temperature positions on the tire.



The optimal working range for Goodyear Radial Stock Car tires is from 200 - 250° F. Temperatures higher than 275° F are considered excessive and could lead to tire blistering. This maximum temperature applies not only to the tread, but especially the inside shoulder temperature.

## **CAMBER**

Excessive right front camber can create an overly severe operating condition that may result in reduced levels of tire performance at the very least and, in a worst case scenario, create a strong potential for belt edge damage and air loss. Uneven distribution of unit pressure within the tire footprint caused by excessive camber will create high shoulder temperatures and uneven wear rates across the tread surface. Both of these conditions can be expected to contribute to an abnormally high rate of performance degradation or “giveup” over a fuel run. It is **CRITICAL** that individual NASCAR teams understand and quantify the dynamic cambers their setup choices create. Significant and often underestimated camber gains are a likely consequence of the “soft spring revolution” and must be added to initial static settings when determining a total dynamic camber angle. Body roll, chassis stiffness, shocks and

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sway bar choices will also affect dynamic camber and must be considered as setup decisions are made. Soft spring strategies and the associated high levels of suspension travel have also had a significant effect on dynamic straightaway camber, resulting in a constant unrelieved camber angle that can present a very challenging operation condition for the tire.

Based on high speed lab testing, force and moment evaluations and computer modeling simulations, **GOODYEAR RACING RECOMMENDS A MAXIMUM DYNAMIC RIGHT FRONT CAMBER OF -5.5 DEGREES BE USED WITH THE NASCAR RADIAL TIRE LINE.** It is unlikely that camber beyond this will yield significant additional grip but it will increase the risk of creating some or all of the previously described concerns. Keep in mind that this is a **TOTAL DYNAMIC CAMBER MAXIMUM** and should not be interpreted as a static camber recommendation.

## **TREAD COMPOUND BLISTERING**

Blistering is caused by excessive heat that results in the breakdown, or reversion, of the rubber compounds. This heat causes the vaporization of the processing oils and resins, and the breakdown of the chemical crosslinks within the rubber network. This creates porosity within the compound and/or separations between the interfaces of different compounds.

Blistering can have several different appearances. Among the more common types are blisters causing a separation between the tread compound and the tire carcass, with the tread then chunking off. The blistered area has a smooth appearance and is referred to as a “hard compound” blister.

A second type of blistering can appear either as a single pinhole/pockmark/bubble/tread chunk, or a series of these types of blisters. Examination of these areas will show a soft and porous appearance. This is caused by excessive heat volatilizing the oils and resins that are used in the tread compound.

Another common form of blistering is caused by brake lock. This type of blister is much larger than the other types of blistering and often covers the entire footprint of the tire. It appears as a very large spot of porosity as described above. This type of blistering is often seen at road courses and can be caused when an unloaded tire locks up during the braking process, while the other three tires continue to roll.

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A fourth type of blistering occurs internally, at the shoulder of the tire, and frequently is not visible until the tread begins to chunk out. This type of blistering is caused by excessive heat in the shoulder area, and causes the belt coat compound to revert. Shoulder edge temperatures can help detect this internal shoulder blistering. Even though the tread surface temperatures may appear acceptable, shoulder temperatures should still be taken to determine if the inside shoulder of the tire is being overworked due to excessive camber and/or underinflation.

## **BRAKE HEAT**

As braking capacity and consistency continues to improve, the need to dissipate brake heat away from the tire/wheel assembly at the short tracks and road courses is becoming more critical. Heat transferred from rotor and caliper through the wheel into the inside bead area of the tire, if excessive, can cause a gradual degradation, and even melting of the tire materials that are in contact with the wheel.

If exposed to a high enough temperature for a long enough time, the inside bead area of the right front tire may deteriorate to the point where a rapid air loss occurs. This type of failure can be identified by an exposed bead wire bundle at the base of the tire and the appearance of a “flap” of sidewall disconnected from this bead bundle. Broken cord ends in this region of the tire will typically feel stiff and “crispy” indicating a likely exposure to very high temperatures. Blistering and separation of the sidewall compound just above the wheel flange will also be evident.

Maximum brake cooling via ducting, blowers and grill area openings is recommended for the short tracks and road courses where brakes will be used heavily. In addition to measuring and controlling rotor temperatures, wheel temperatures should be monitored at the location closest to the edge of the rotor since this is approximately where the tire bead is in contact with the wheel on the opposite side. If observed wheel temperatures exceed 475°F., additional steps need to be taken to reduce heat transfer to the wheel and tire.

It is recommended that tire and wheel assemblies be removed from the car between practice runs if the brakes are hot and the work on the car will take any significant length of time. Brake heat radiating up into a static wheel and tire will be concentrated in a small area and can initiate the same type of damage described earlier if the exposure is long enough.





## **ADVANCED ENGINEERING SERVICES**

The Goodyear Racing Division has an engineering consulting organization within the Race Tire development department specifically for supporting external customer projects. This new organization, Advanced Engineering Services, was launched to the NASCAR community over the course of 2003. For your reference, an overview of the basic engineering services offered follows:

- **Kinematic and Compliance Testing of Race Chassis**
  - Internal Goodyear Test Facility - extensive Racing experience
  - Comprehensive data summary and analysis capabilities
  
- **Custom Tire Models and Tire Force/Moment Data Plotting And Optimization Software**
  - Advanced Race Tire Modeling Software available for both commercial and custom simulation program applications
  - License to the proprietary Goodyear Racing Tire Plotting and Optimization Toolbox software
  
- **Advanced Modeling Data For Commercial and Custom Software**
  - Tire data for specific Goodyear Racing "D" Numbers
  
- **Tire And Modeling Specific Instrumentation Support**
  - Usage of Goodyear Racing's rotating load cells for tire/vehicle performance measurements and simulation validation
  - Availability of Goodyear Racing's GPS Track Mapping Capabilities for supporting simulation projects
  
- **Custom Tire/Vehicle Modeling Software Development and Support**

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