



UNDERSTANDING BASIC WHEEL & TIRE DIMENSIONS, TERMINOLOGY & DESIGN ASPECTS

Wheels and tires impact the styling, handling, performance and safety of a vehicle. To ensure you're making the proper wheel and tire choices for your customers, you have to understand the basics, such as wheel dimensions and tire sizing. – BY MIKE MAVRIGIAN

Do you know how to measure wheel diameter? How is offset determined? What's the speed rating of the tire your customer's looking at? How can you figure out a tire's aspect ratio?

If you're unsure how to answer these questions, this article will provide you with the answers, as well as additional information on wheel and tire basics that will make you better informed and more prepared to answer any wheel or tire questions your customers may have.

Wheel (Rim) Diameter

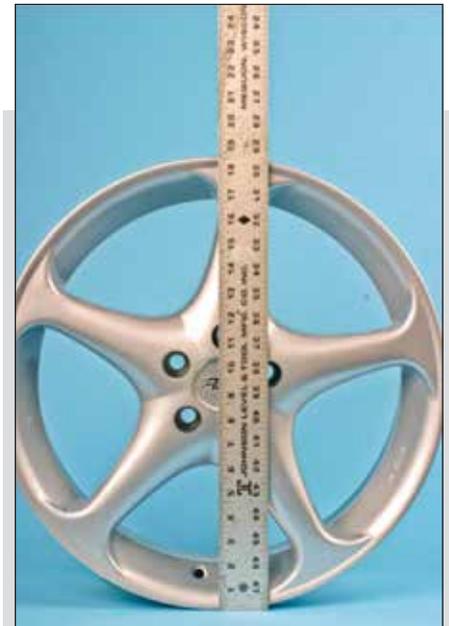
Wheel diameter refers to the wheel's bead seat diameter and isn't measured at the outside edge of the rim itself. Since the wheel must feature an outboard rim lip at its outboard and inboard sides to act as a stopping point to secure the tire bead, the outside diameter of the wheel will always be larger than the bead seat diameter. For

instance, a wheel that's designed to accept a 17-inch tire may feature an outside diameter of 18-19 inches.

The wheel diameter (the number that indicates tire mounting diameter) is measured at the "floor" area where the tire bead seats. Since you may not own a large measuring caliper, here's an easy method to measure wheel diameter.

**Wheel overall diameter -
bead seat height x 2 = rim diameter.**

To utilize this formula lay the bare wheel down on a clean, flat surface. Using a straight ruler or tape measure, measure the outer diameter of the wheel, making sure that you position the ruler so that it intersects the center of the wheel. Note the outer diameter. For example, let's say this is 18.5 inches. Next, place a ruler onto the floor of the bead seat adjacent to the side that you measured for outside diameter, with the ruler placed 90 degrees to the bead seat floor.



In order to measure wheel diameter, first measure the overall diameter as shown here. This wheel measures 18.5 inches overall. Remember, this isn't the rated wheel diameter relative to tire size.



Measure the depth from the bead seat floor to the edge of the wheel's rim lip. For this example, let's say this is 0.750 inches. In order to determine the bead seat diameter, we simply subtract the total height of the rim lip area from the outer wheel diameter. Since we need to subtract the rim lip height from each edge of the wheel (at the two spots you used when you measured overall diameter), multiply the rim lip height by 2 and subtract that total from the overall wheel diameter.

Example:

Outer wheel diameter (at largest area) = 18.5 inches

Rim lip height is 0.750 inches x 2 = 1.5 inches

Outer diameter 18.5 inches - 1.5 inches = 17.0 inches

In this example, the actual rim diameter, where the tire seats, is 17 inches, which is correct for a 17-inch tire (for example, a 225/45R17).

Rim Width

In order to measure wheel width, we again need to measure the area between the bead seat walls. The overall width of the wheel will vary depending on rim material thickness. For example, if a particular tire is recommended to mount to a 7-inch wide rim, the 7-inch dimension doesn't indicate overall wheel width, but rather the distance between the rim's bead seat lips where the tire bead actually makes contact.

With the bare wheel positioned upright on a clean, level surface, measure the distance from the front rim's inner lip flange to the rear rim's inner lip flange. For instance, a wheel that's designed with a 7-inch rim width may actually measure 8 inches from the front rim face to the rear rim face. Remember, we only want the width between the bead seat flanges. When identifying rim width, the overall width of the wheel (outside to outside) is immaterial.

When selecting a tire and wheel combination, always refer to the tiremaker's specifications regarding

recommended rim width for a particular tire. If a tire manufacturer notes that a 235/45R17 tire has an acceptable rim width range of 7.5-9.0 inches, don't deviate. If you mount that tire onto a 7-inch-wide rim, the beads will be squeezed together beyond the tire design spec, making it difficult to mount the tire and posing an increased chance for bead damage during mounting.



Rim width is measured between the bead walls, not at the overall width. This wheel measures 7 inches between the bead walls.

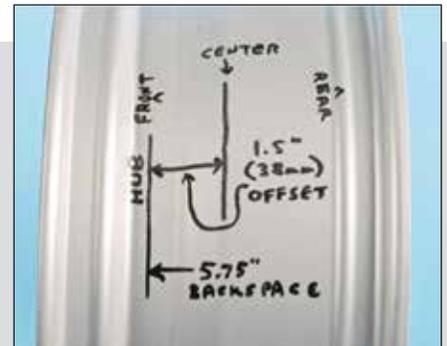
The tight fit may also cause the tread/shoulder area to deform, which may lead to increased wear at the center tread area, in addition to potentially decreasing the tire's design performance. If you attempt to mount that same tire onto a 10-inch wide rim, you'll run into bead seating difficulties and possible bead damage during mounting. In addition, you run the risk of increasing shoulder wear and losing some of the tire's performance potential due to the carcass deformation on a too-wide rim.

In other words, if you must run a 235/45R17 tire that requires a 7.5-9.0 inch rim, then you'll simply need to find a wheel that offers that recommended rim width, even if that means moving to a different brand or style from the original brand/style that the customer may have selected. Always stick to the manufacturer's rim width recommendations.

This is especially important when dealing with low-profile, stiff-side-wall performance tires that don't like being stretched or squeezed into an unnatural shape, which will result in a compromised thread contact patch.

Measuring Backspace

Backspace refers to the depth of the rear of the wheel, measured from the rear of the wheel rim outer edge to the hub mounting face. To find this, lay the wheel face-down on a clean, level surface. Position a ruler vertically onto the hub face. Lay a long straightedge horizontally across the outer edges of the rear rim. The point where the horizontal straightedge intersects with the vertical ruler is the backspace distance. Be sure to reference the section of your vertical ruler



Offset is the difference between the center of the rim and backspace. I marked the center of the rim. Knowing that backspace is 5.75 inches, I marked this, measuring from the wheel rear edge. The difference between the two marks (center and backspace) in this case measures 1.5 inches or 38.1mm. As a result, I'll note this wheel as having an offset of 38mm.



I measured a five-bolt wheel's bolt circle by measuring from the center of one hole to the outer edge of a hole furthest away from the first hole. In this example, we see a measurement that's just under 4 inches. However, it can be difficult for a novice to accurately place a tape measure or ruler at the exact center of the first hole. In this case, the circle is minutely less than 4 inches (it's actually a 100mm circle or 3.9937 inches).



TIRE DIMENSION TERMS

OVERALL DIAMETER

The outside diameter of the tire when mounted and inflated, but with no vehicle load

SECTION WIDTH

Also called "overall width," this is the maximum width of the cross section of an unloaded, mounted and inflated tire (the widest point of the tire when mounted and inflated, but with no vehicle weight).

FREE RADIUS

The radius of the tire/wheel assembly that isn't affected by load. This is the distance from the wheel axle centerline to the top of the tire tread face.

LOADED RADIUS

The distance from the wheel axle centerline to the ground, drawn vertically. This is the distance from the vehicle hub centerline to the ground when the tire is inflated and when the tire supports vehicle weight.

SECTION HEIGHT

The distance from the bead to the tread face

LOADED SECTION HEIGHT

The loaded radius, minus half of the nominal rim diameter.

ASPECT RATIO

This refers to the tire's section height in relation to its section width, as a percentage. For example, a 60-series tire features a sidewall that's 60 percent as tall as the tire's section width. A 50-series tire will feature a shorter sidewall, at 50 percent of section width. A 35-series tire will feature an extremely short sidewall (only 35 percent of section width), etc.

Aspect ratio = Nominal section height divided by nominal section width times 100

Example: If section height is 3 inches and section width is 10 inches, $3/10 \times 100 = 30$, which would mean that this tire features an aspect ratio of 30 (a 30-series tire).

TREAD WIDTH

This is the distance measured from the inner tread shoulder to the outer tread shoulder. Tread width isn't to be confused with section width, as section width is always greater.

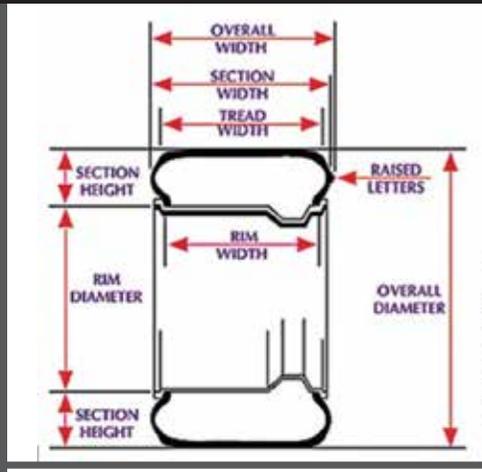


Illustration courtesy of The Tire Rack



In this example, I used a bolt circle template. Once I find a series of five holes that align with the holes in the wheel, I'll note that this wheel does indeed feature a 100mm bolt circle.



The bolt circle caliper gauge in use. When using this specific tool, measure two bolt holes that are immediately adjacent to each other (the tool has been calibrated to use these locations). Insert carefully and allow the gauge to slide while the tapered dowels find true center. Always insert from the hub face since the holes at the front of the wheel will typically be too far recessed to use this tool.

where it touches the underside of the horizontal straightedge. Remember, you're trying to measure the distance from the hub face to the rear outer edge of the rim.

Finding Offset

Wheel offset refers to the location of the wheel's mounting surface (where the wheel mates to the hub) in relation to the centerline of the overall wheel width. If the center of the wheels overall width aligns with the hub contact surface, the wheel has zero offset. If the hub mounting face is positioned closer to the rear wheel rim, the wheel features negative offset. If the hub contact face is positioned closer to the front of the wheel rim, the wheel has positive offset.

A negative offset wheel has a "deep-dish" appearance, which moves the tire further outward in the wheelwell. A positive offset wheel moves the tire center further inboard (less rim depth at the wheel face). Front-wheel drive applications typically require a positive offset due to the placement of the vehicle hub.

The offset dimension is critical for a number of reasons, including outboard (fender) and inboard (suspension/brake) clearance, as well as handling and braking performance. Excessive negative offset (placing the tire further outboard) can increase the loads experienced by wheel bearings and ball joints due to an extended leverage effect.

Too much negative offset can also result in increased steering wheel effort and steering wheel "kickback" resulting from increasing the front axle track width. In the majority of cases, it's always best to adhere to the OEM wheel offset as closely as possible.

It's feasible to deviate offset by as much as 5mm, while increasing or decreasing offset by as much as 8mm or so may be acceptable in some cases. For example, if the OEM offset is +35mm, moving to a +40mm offset should pose no problems, but it's always best to measure first for clearance.

If rim width is altered from OEM (most performance enthusiasts will tend to move to a wider wheel/tire package), offset will likely change in order to maintain proper inboard and outboard clearances. Always be



TIRE TREAD TERMS

ASYMMETRIC TREAD

This is a tire where one side of the tread has a different design than the other side, rather than a mirror image from side-to-side. With differing inner and outer treads, engineers can design a tire for maximum performance.

The outer half of the tread is designed for high cornering stresses and the inner tread is designed for straight-line stability and good water dispersion.

BLOCKS

These are the individual sections of rubber defined by the grooves surrounding them. It's the faces of the blocks that make contact with the road.

CONTACT PATCH

This is the total area of the tire that contacts the road surface at any given time. Often this area is about the size of a small book, but the size and shape of the contact patch depends on the speed and tire dynamics in any given condition. The patch is different during cornering than traveling straight ahead, for instance. Typical passenger car tires with a 60 aspect ratio usually have a contact patch that's longer than it is wide. Low-profile performance tires usually have a contact patch that's wider than it is long. At very high speeds, the vehicle tends to lift, making the contact patch narrower, which is why performance tires are usually so wide. Inflation pressure can also change the area of the contact patch.

DIMPLES

These are the indentations in the tread blocks or ribs that help cool the tire.

LATERAL GROOVES

These are the grooves that lead from the center of the tread to the outer edges. They can be straight or curved. Lateral grooves are generally 3mm or wider. Narrower than 3mm, these grooves may be called sipes (see definition). Larger lateral grooves also help direct water from under the tire.

LONGITUDINAL GROOVES

These are the grooves that run the circumference of the tire and channel water from between the tire and the road



Longitudinal grooves in the tread allow for immediate water passage.

to prevent hydroplaning and possible loss of vehicle control. The new breed of super rain tires often have a deep longitudinal channel down the center of the tire.

RIBS

These are any easily recognized pattern of tread blocks that make up the contact band around the circumference of the tire.

SIPES

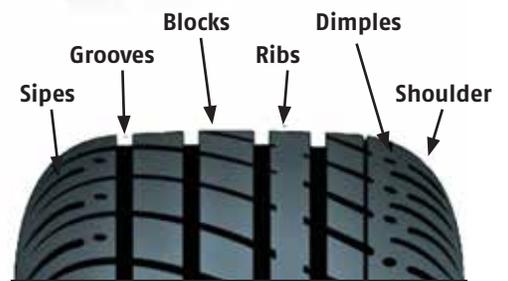
Very narrow slits in the tread are called sipes (pictured below). They improve traction in water, snow, ice and loose dirt. Basically, they act like squeegees that squirm to help move water from the tread blocks.



The smallest cuts in tread blocks are referred to as sipes. They provide added traction on wet or icy surfaces.

SHOULDER

The area of transition between the sidewall and the tire's tread (both inboard and outboard sides) is the



shoulder. This is the area responsible for lateral grip in cornering maneuvers. It's usually slightly rounded to give a progressive steering response.

SYMMETRIC TREAD

A tire has symmetric tread when the treads on both sides of the centerline of the tire are mirror images of one another.

UNIDIRECTIONAL

If the tire is designed to rotate in one direction only, it's referred to as unidirectional. The tread design will move water well in only the proper direction. These tires will have arrows or other markings on the sidewall describing the proper operating rotation. If mounted in the incorrect rotational direction, you won't damage the tire but you won't be able to take full advantage of the tire's performance.

VOID RATIO

The amount of space between the tread block surface compared to the space taken up by the grooves (or voids) is the void ratio. A low void ratio has less groove area and more tread area. A typical rain tire will have a larger void ratio than a high-performance tire designed for dry driving.



aware that offset not only affects appearance, but handling, straight-line tracking and steering effort as well. Always maintain as close to OEM offset as possible when dealing with a production chassis.

Measuring offset is fairly simple. This is the difference between the wheel's hub face location and the center of the rim width. Refer to the backspace measurement taken earlier and mark this on the rim's drop-center well surface. Next, place a mark on the rim's center well area that represents the center point between the wheel's front and rear rim faces (total wheel width). The difference between these two marks represents offset. If the hub face is positioned behind the rim center (toward the wheel back), the wheel features negative offset. If the hub face is located forward of the rim center (toward the front of the wheel), the wheel has positive offset.

Use this formula to determine backspace distance and whether a wheel has positive or negative offset:

**Backspace –
(Wheel Overall Width/2) = Offset**

If you're considering wheels that are identified by the maker in millimeters, you'll need to either use a metric ruler or convert inches to millimeters. Here are two handy inch/metric conversion formulas:

**1 inch = 25.4mm
In order to convert inches to millimeters,
multiply inches by 25.4
Example: 4 inches x 25.4 = 101.6mm
In order to convert millimeters to inches,
divide millimeters by 25.4
Example: 40mm/25.4 = 1.575 inches**

Bolt Circle & Bolt Pattern

The bolt circle refers to the spacing of the wheel's fastener holes, using diameter, or circle, as the designated dimension. If we draw a circular line that runs through the center of all of the bolt holes, this circular diameter measurement indicates the bolt circle. For instance, if a 4.5-inch circle can be positioned at the center of the bolt hole group, this is a 4.5 bolt circle.

The bolt pattern refers to both the number of fastener locations and the diameter of the hole pattern. A 5 x 100 bolt pattern refers to a wheel that features five fastener holes laid out in a 100mm diameter path. A 5 x 4.75 pattern designation refers to a pattern with five holes running along a 4.75-inch diameter. In the old days, we could generically refer to a 5 x 4.5-inch pattern as a Ford pattern or a 5 x 4.75-inch as a Chevy pattern.

In order to measure a bolt circle using a ruler, remember that we're simply trying to find the diameter of an imaginary circle that runs through the center of each fastener hole. If the wheel or hub features directly opposing holes (as found on a 4, 6 or 8 wheel or hub), simply measure from the center of one hole to the center of the hole directly across the pattern (or from the outside of one hole to the inside of the opposite hole).

If the wheel or hub features a fivebolt pattern, measure from the center of one hole to the outside edge of the hole furthest away.

If you don't want to be bothered by measuring with a ruler, tape measure or dial caliper, you can cheat by using a round plastic bolt circle template disc (Made 4 You Products offers this tool).

Discs are available that feature multiple hole patterns with each hole identified for bolt circle. Simply place the disc against a wheel hub face or onto the vehicle hub until all the holes align. The holes that align to your wheel or hub indicate the bolt circle.

Another specialty tool that allows quick measuring of a wheel's bolt circle is a sliding caliper. This tool features two tapered dowels that slip into the wheel's bolt holes. Insert the dowels into the two holes that are closest together. The graduated gauge face of the tool indicates the bolt circle, based on the number of bolt holes (the gauge features multiple pointers for 4-, 5-, 6- or 8-bolt).

The sliding caliper tool is offered by Excalibur Wheel Accessories, though I sourced mine through American Tire Distributors.

If you don't want to bother measuring bolt or stud shanks or nuts, it's a good idea to keep a reference set on hand attached to a small board.

Understanding Tire Dimensions

The sidewall of a tire offers an abundance of information, including the tire's size, maximum inflation, serial number, manufacturing location and tread wear rating. In essence, this





information serves somewhat as an owner's manual for that specific tire.

Since much of this sidewall information can be confusing, I'll walk you through a scenario to help you understand the data provided that applies to a tire's dimensions.

Three sizing systems are employed today for passenger tires—P-Metric, European Metric and Alpha-Numeric. The most common system is P-Metric.

The size designation indicates cross section in millimeters, aspect ratio, type of construction and appropriate rim diameter. For example, a P235/50R16 describes a tire that's intended for passenger use (P) and features a cross section width of 235mm, an aspect ratio of 50, is of radial construction, and is to be mounted to a 15-inch diameter wheel.

European Metric (also called Metric) is similar. No letter "P" is used as a prefix. The three-digit number at the beginning indicates cross section in millimeters. The next letter indicates the speed rating. An "R" following this indicates that the tire is of radial construction and the final two-digit number indicates rim diameter in inches. If the aspect ratio is lower than 82, a slash, followed by the aspect ratio number, will follow the section width number.

A European 155SR13 metric tire with an 82 aspect ratio indicates that it has a 155mm section width, an S speed rating, radial construction, and is intended for a 13-inch wheel.

Alpha-Numeric tires originated in the 1960s. This sizing system features a load-based identification approach where the first letter designates the tire's load carrying capacity. For example, a BR60-13 tire features a "B" load rating, radial construction, a 60-series aspect ratio and a 13-inch rim requirement. The alpha (letter) character can range from A-N, depending on load capacity. The higher the letter, the higher the load rating. Alphanumeric sizes are in popular demand for muscle car restorations where the original size/type tire is desired.

How Tires Handle Water

Traction grades (featured on the sidewall markings) provide a general indication of a tire's ability to control and stop a vehicle on a wet road surface, with testing performed in a straight-line braking scenario on a controlled wet-surface test pavement, including both concrete and asphalt. The ratings that result from these tests are performed in straight-line testing and may not indicate cornering traction. The tire manufacturers give each tire a rating of A, B or C, with tires rated "A" having the highest traction.

These traction ratings are established on skid pads that are designed following federal government standards. Twenty measurements are taken using an industry standard "control" tire on both an asphalt surface and a concrete surface, with the results from each surface test averaged. The same scenario is then performed with the specific tire being tested and the results are then compared with the data obtained from the control-tire tests. The rating grade is then assigned.

Three "grade rating" numbers will typically appear on the tire sidewall—the treadwear rating, traction rating and temperature rating. The phenomenon called "hydroplaning" occurs when a tire encounters a wedge of water between the tread and the road surface. This can cause temporary directional pull and loss of control. While virtually any vehicle and tire combination has the potential to hydroplane at various vehicle speeds (wherever the limit is reached where water can't evacuate quickly enough between the tire and road), it's important to understand that a number of factors can combine in order to experience hydroplaning, including vehicle speed, tread design, tread depth, tread compound, tire width, vehicle weight and water depth.

A tire contacts the road in what's called the "contact patch." This is the footprint that a tire creates as it rolls down the road. Larger-profile/lower-aspectratio performance tires

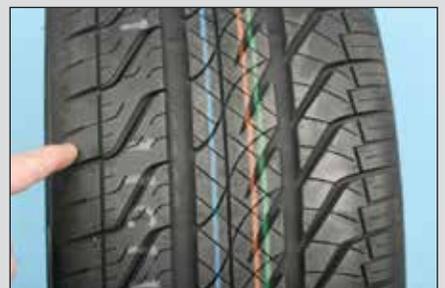
create a larger footprint, which may aid in dry traction (taking advantage of more rubber on the road for increased grip). However, in wet weather, this



Directional tires will feature a mark on the sidewall indicating direction of rotation. You won't damage the tire if mounted backward but you'll greatly diminish the performance advantages that the tire offers.



Angled grooves, referred to as lateral grooves, direct water out from the longitudinal grooves to aid in water evacuation. Water is collected in the main grooves and directed out of the tread area via lateral grooves.



Shoulder blocks may vary in size between outboard and inboard shoulders, depending on the specific design. A tire that is marked "this side out" or "this side in" will feature larger shoulder tread blocks on the outboard side. If in doubt, always install the tire to the vehicle with the larger shoulder blocks facing outboard. The larger-footprint shoulder blocks are designed to accommodate cornering (lateral loads).



larger footprint can potentially degrade traction because of the larger water wedge that can be created (a narrower tire may “slice” through water better than a very wide tire).

In response to this trait, tire manufacturers go to great extents to design tread patterns and compounds that will resist hydroplaning.

Speed Ratings

Speed ratings, in addition to the speed at which a tire model has been tested and verified, indicate the tire’s performance characteristics. Just because a tire is rated at 149 mph, that doesn’t mean that you should attempt to operate the vehicle on a public roadway at that speed. If you want to play, rent some time on a race course. You shouldn’t select a tire by focusing on the mph speed number because you’re probably not going to drive at those speeds while on public roads anyway (at least, you shouldn’t).

The high-speed rating is a clear indication that the tire has highperformance design, material and construction

features that will enhance the traction, steering response, lateral control and braking of the vehicle at legal highway speeds. The design and construction of the tire has been enhanced, offering the side benefit of high-speed capability.

Speed ratings are based on laboratory tests where the tire is loaded against a large-diameter metal drum to reflect its appropriate load and run at increasing speeds in 6.2 mph steps in 10-minute increments until the tire’s required

speed has been met.

Beginning in 1991, speed ratings have been placed immediately following the load index number, for example 225/50R16 89S. When Z-rated tires were first introduced, they were thought at the time to reflect the highest tire speed rating that would ever be required, with the Z rating indicating that the tire was capable of speeds “in excess of 149 mph.”

Eventually, the tire industry added W and Y speed ratings. A Z rating may still appear on the tire on its own (indicating a rating of 149 mph+), but may also appear in addition to a W or Y rating symbol (with W indicating a rating of 168 mph; and Y denoting 186 mph). Some tires may feature a rating symbol of Y (following the load index), with the load index and speed rating encased in parenthesis. Example: 285/35ZR19 (99Y). If the Y is seen within parenthesis, this indicates a speed rating “in excess of 186 mph.”

Tires referred to as “Ultra High Performance” include those featuring V, Z, W, Y and (Y) speed ratings. **MAM**

Decoding Speed Rating Marks	
M	81 mph
N	87 mph
P	93 mph
Q	99 mph
R	106 mph
S	112 mph
T	118 mph
U	124 mph
H	130 mph
V	149 mph
W	168 mph
Y	186 mph
(Y)	186 mph +
Z	149 mph +

Thank you to Travis Weeks for allowing us permission to reprint this fantastic article, which originally ran on www.hotrodandrestoration.com.

