KEVIN THORNE PHOTO

Engine tuners check spark plugs for timing, detonation, pre-ignition and fuel mixture.

Building A Race Car: Part 10

Testing, Testing, Testing

BY MARK DAVIS

The excitement in building a car is eclipsed only by racing. All the plans, all the data, and all the preparation are put to the test when the car drives on the track.

Throughout the car's construction, every design decision is based on one goal: creating the best car for testing and racing. Next, all possible combinations of alignments, chassis settings, springs and shocks are documented. Basic setups are placed in the car and the race track is now just over the horizon.

Everybody thinks testing at the track is the easy part. It's just not so.

Early one spring, we found ourselves short one body in the paint shop. A young boy came in and informed me that he wanted to work on a race team. Jumping at the request, I sent him immediately to the Fab Shop to begin grinding. Prepping a new chassis for paint is tedious. All the hot balls, spot-welds, etc. have to be addressed. After three long days in the paint shop, the youngster looked at me and said, "I don't want a real job; I want to go to the race track."

Boy, was he in for a surprise! He got his chance, and after four hard seasons testing and racing, now he is back working in the Fab Shop. In all those years he never saw a single race. The race track can be a harsh realism or ecstasy.

Testing begins with conservative runs on scuffed tires, running 10 to 20 competitive, but moderate laps. After these laps, crew members quickly go over the new car, looking for any possible trouble, such as leaks, loosened bolts or changes in alignment. They review all engine fluids, temperatures and pressures; they examine throttle and clutch linkages and lines. Component measurements like ride height, track bar height, control arm angles and pinion angles are referenced back to the original settings.

The first 20 laps and review session take about two hours. At this point, the driver and car boss review any problems or issues in handling. New tires are installed, all data acquisition equipment is baselined and a hot lap session begins. At this time, new spark plugs are installed, timing is checked and set.

Test sessions are a ballet between engine tuning and chassis tuning. The next 10-lap session requires that engine temperatures start at premium operation levels. Water at 190 degrees is optimum; oil temperature at 230 degrees is great. The first 10 laps on a set of new tires will yield the best times; radial tires start to give up quickly on an abrasive track, or tracks with corners that pull maximum G-forces. All information gathered in testing is adjusted with that tire wear in mind.

As the 10th lap ends, the driver shuts the engine down under load, giving a good plug check. When the car stops, tire and chassis guys start. The data acquisition process begins. Tire temperatures, shock travel, tire pressures and tire stagger are all categorized. Engine people check tach RPM, the temperature levels of all fluids and the plugs to determine how the car engine is performing.

Let's think about the information that's gathered during these tests. Tire temperatures are used to pinpoint a lot of different handling characteristics. Temperatures are taken at three different points on a tire: outside, middle and inside. The contact patch, or camber, can be determined on how even or uneven these three temperatures are. Cooler inside indicates a tire needs more angle to increase temperature to the inside and vice versa if the outside is cooler. The total average tire temperature, front and rear, determines the handling package.

For example, if the average temperature for the front tires is 10 degrees hotter than the rear tires, this means that the car has a push or is tight. Ten degrees hotter on the rear tires could indicate that the car is loose. Knowing whether the car is tight or loose allows the crew to adjust the car for a longer run. If the car, 20 laps into a 50-lap run, begins to tighten or push, it can be adjusted to start the run slightly loose to compensate.

Above: Crew members reference to a common point, so bite, springs and sway bar changes can be quickly pinpointed in actual height. Left: Many times fuel mileage becomes critical in a race. By weighing fuel cans before and after test runs, exact mileage can be figured.

Shock travel, or the distance the shock compresses, indicates the body roll or weight transfer, which is vital to handling. Slight to excessive travel can possibly indicate that spring changes, shock combination changes or sway bar changes need to be made.

Robert Yates

In some instances, new tires can mask handling problems by giving a driver and team quick test times. With longer runs on tires, the handling problems, which were identified by tire temperature comparisons or shock travel numbers, eventually show up and lap times fall off rapidly.

While the chassis team analyzes the information, the engine crew looks for data. Tachometer readings are matched to data already gathered on chassis and engine dynos. Peak horsepower and torque numbers are applied to the "Old Black Top Dyno."

Turns and straights are broken into segments. Peak RPMs are then adapted to the track by changing rear gear ratios. The longer the actual throttle time, the faster the lap. The ability to pick up the throttle hard early is directly related to handling on a particular track. Speed is relative to peak torque/horsepower combinations.

Analyzing plugs is an absolute art. I have often been told that Robert Yates could look at a set of spark plugs and tell you what your sister ate for lunch yesterday. The color of the ceramic insulator, the spots that appear, the amount of heat in the ground strap and the burn pattern around the exterior of the plug are all indicators. Engine tuning, detonation and pre-ignition plug temperatures all can be told by just looking at the spark plugs. Each cylinder of an engine has to be tuned to optimum performance. An engine tuned improperly can burn a piston in one lap at some tracks.

Testing involves a progressive approach. Chassis tuning is generally done in steps in conjunction with engine tuning. Each reaches the next level by utilizing information from the other. Engines are tuned conservatively, with the engine fat — that is, with the carburetor jets supplying the engine with excess fuel.

Optimum horsepower is a matched combination of timing, compression, firing and fuel. Timing refers to the firing of the spark plug in relation to the intake, compression, and exhaust of fuel. After the intake of fuel and air, the piston compresses the mixture to a desired compression ratio, then fires the fuel.

Any one of these steps can destroy a race engine if they do not work in perfect combination. Maximum horsepower can only be obtained when the timing-fuel combination is perfect and on the edge.

During this first set of laps, many other adjustments are made. In the first laps, brakes have been applied and might need bleeding or the bias from front to rear brakes changed. The accelerator pedal height might need to be raised or lowered, seat belts readjusted, mirrors changed, location of air vents or hoses displaced, clutch bled or adjusted. All of these help the driver prepare for race day.

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At this time, a judgement on gear is also made. In a simulated test session, a team might learn that a car needs to turn 850 RPM. If the car turns less or more RPM than that, the rear gear ratio has to be changed to adjust this. The gear selection affects handling. A driver who requires a tight chassis setup requires more gear and many times more initial horsepower than a driver who can drive a free car.

Track bar height must be adjusted at the track, too. For instance, track bar height might be set at 12 inches, with a boundary of 13 inches on the high side and 11 inches on the low. If the laps at the track indicate that the car needs to be freer, the bar is raised to the boundary. Once this boundary is reached, a spring will be changed, too. The same holds true if the bar is lowered to the boundary.

Front and rear sway bars follow the same scenario. The purpose of the front sway bars is to hold bite in a vehicle and promote forward bite on the exit of a corner. Front sway bars, measured in diameter, gain rate with size. Larger front bars allow crew chiefs to lower static cross weight percentages, which make the car turn freer in the center of the corner. On the other hand, if cross weight percentages remain high, larger bars make the car push.

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Rear bars affect the car in the opposite way. The larger the rear bar, the freer the car is on entry, but forward bite is lost. Rear bars are used many times on tracks that have tight handling characteristics on the exit of the corner.

Prior to testing at the track, boundaries in front-end alignment have also been set. On the track, excessive camber settings statically can indicate slow camber curves and shorter A-Arms might need to be installed. A car that likes toe-out might need more initial Ackerman, or bump.

With all this in mind, next month we'll take our car on the track to continue our testing.