he camshaft is by far the least understood component of an engine.” Steve Brule' of Westech Performance said that; and given the layers of complexity surrounding this particular engine component, we believe him. Camshafts can certainly be an area of confusion—the plethora of misinformation about them working its way through cyberspace is a testament to that fact. One area that seems to be of particularly grievous misunderstanding is lobe separation angle (LSA) and its effect on engine behavior.

So what is LSA? The literal definition is, the distance (measured in camshaft degrees) between the intake and exhaust lobe centerlines of a cam. Translated for the average engine builder, LSA is an important camshaft variable that drastically influences engine behavior. The more understanding you have of camshaft LSA, the better, because it is rigidly ground into a camshaft and cannot be changed or adjusted. Best get it right the first time around rather than shell out the coin for a new cam.

To understand LSA, let’s look at the camshaft not as a weird cylinder with bumps on it, but more as the schedule of intake and exhaust events. Per every camshaft revolution, lobe placement around the cam’s circumference dictates when the intake and exhaust valves open and when they close. When we fiddle with that schedule by changing duration or LSA, we move those events around that is a huge determinate of how the engine operates.

If the LSA grows, the intake and exhaust lobes are physically spread apart, which pushes the valve events further from each other. If we shrink the LSA we bring the intake and exhaust events closer together, increasing overlap (the time period in which the intake and exhaust valves open and when they close. When we fiddle with that schedule by changing duration or LSA, we move those events around that is a huge determinate of how the engine operates.

We used a crank trigger, mounted to the TCI Rattler Harmonic balancer, to make the cam swaps quicker and keep the timing accurate while we repeatedly yanked the distributor and intake.

A Holley 950 Ultra HP handled fuel delivery on our small-block Chevy dyno mule.

“LSA is an important camshaft variable that drastically influences engine behavior.”
"We tested cranking compression, idle vacuum, peak power and examined the power and torque curves. What we found might surprise you."

Wide and narrow LSAs each have a distinct set of advantages; and, with the goal of logging some data on them, we headed to Westech Performance with three freshly ground Crane Camshafts in tow.

The plan for our test was to dyno three Crane camshafts with identical duration and lift numbers (242/252 @.050 and .558 lift int/exh) back-to-back and see what effect they had on the engine's overall dynamics. The valve train consisted of Crane Cams Gold rocker arms, Crane pushrods and the Crane's new hydraulic roller lifters. We tested cranking compression, idle vacuum, peak power and examined the power and torque curves. What we found might surprise you.

Test 1 104 Cam (PN 11HR00238)
For test one, we loaded one of Westech's many dyno mules, in this case a tried-and-true small-block Chevy, with our first Crane camshaft, ground with an extremely tight LSA of 104 degrees. The top end was reassembled and the motor was fired up. The narrow LSA cam immediately delivered the authoritative and extremely choppy idle we expected from it. After making the necessary pulls to stabilize water and oil temperature, we took an idle vacuum reading—which we measured at 1000 rpm in each test for the sake of consistency. The rough-idling 104 cam delivered a meager 7.5 inches of vacuum. With that out of the way, Brule' leaned on the motor pegging the throttle stick to its stop.

When the cackling smallblock finished its pull, Brule' called the post dyno graph up on the nearby monitor and, well, it was a thing of beauty. The 104 LSA cam produced a remarkably full curve with great midrange torque and horsepower that rose steadily to 6600 RPM before quickly falling off. Next, Brule' snuck into the dyno cell, yanked a spark plug and checked the compression. The needle ticked its way to 185 psi.

The Dyno Mill
We used a tried and true small-block Chevy for our tests. This motor, based on a Dart SHP block, Scat rotating assembly with Mahle Pistons, AFR heads and Edelbrock intake, and all-Crane rotating assembly has made over 1500 pulls on Westech's SuperFlow engine dyno. Even after all that abuse however, the motor leak-down tests at under 5 percent and happily cranked out pull after pull for our purposes.

Test 2 114 Cam (PN 11HR00239)
For the second test we skipped to the opposite side of the spectrum. This cam was ground on a much wider, 114 LSA. Again we yanked the intake manifold, valve-train, and front of the engine to swap in the new bumpstick. The grunt work went quickly as we were eager to see the results from the wider cam. We fired up the
“We made some power pulls and found the motor down on torque by 20 lb/ft from 3500 all the way up to 5000 RPM.”

The 104 LSA cam is going to exhibit some drivability problems,” said Crane Cams Valve Train product manager, Chase Knight. “Torque between 500-1200 rpm is going to suffer.”

The high amount of overlap in the 104 cam allows exhaust reversion at very low engine rpms. This dilutes the intake charge and contributes to poor slow speed pull and; even then, it is only eclipsed by 5 horsepower at the extreme top end of the rev range. But things are never that simple.

"The 104 LSA cam is going to exhibit some drivability problems," said Crane Cams Valve Train product manager, Chase Knight. "Torque between 500-1200 rpm is going to suffer."

The 110 cam made our highest peak horsepower of the day at 539, five up from the 104 cam and seven up from the 114. The final compression test revealed 174 psi on the gauge—right in between our first two cams.

The Verdict:
Looking at the three dyno curves (see sidebar 2) the 104 LSA cam looks like the clear winner. It has; by far, the most torque on tap, and from the lowest RPM. It leads the 110 cam in horsepower for 85 percent of the dyno pull and; even then, it is only eclipsed by 5 horsepower at the extreme top end of the rev range. But things are never that simple.

We used a degree wheel to install all of our Crane cams at the correct intake centerline.

Each cam was compression checked immediately after its series of dyno pulls. The 104 made the most psi with the 110 and 114 following respectively.

Test 3 110 Cam (PN1100202)
With our tightest and widest cams already run, it was time to test the middle child 110 LSA grind. Would it fall in between the curves of our previous dyno or act out unpredictably? We again stripped the motor for the final swap of the day to find out.

Upon fire up, the idle was where we expected, loping slightly and with ten inches of vacuum pulling through the carb. Brule' eagerly let the motor sing against the dyno and the post dyno graph showed the curve had snaked in exactly where it was supposed to go. Right below the 104 curve and right above the 114 all the way until 6400 where it came into its own. The 110 cam made our highest peak horsepower of the day at 539, five up from the 104 cam and seven up from the 114. The final compression test revealed 174 psi on the gauge—right in between our first two cams.

Camshafts Comparison
What you can see from the graph is that peak horsepower didn’t change very much between the different lobe separation angles. The dyno plot however, shows how different each cam really was. The 104 had a distinct torque and power advantage from the get go while the 110 pulled ahead toward the end of the rev range. Also, the jump in manifold vacuum between the 104 and 110 grinds is pronounced, especially considering all of these cams are fairly large in their duration (242/252 @ .050).
“If you can stomach the extremely aggressive idle, lack of power brakes and have the proper driveline to take advantage of a tight LSA cam, it would make for a very peppy ride.”

Each camshaft had a distinct personality and its own set of pros and cons. In addition to off-the-shelf grinds, Crane Custom grinds camshafts on a daily basis.

We got pretty quick at yanking SBC cams in the time it took to complete the tests. It is important to mention that these cams were selected to show basic principles of lobe separation angle changes, and was not intended to produce maximum torque and horsepower figures for a specific application.

torque and part throttle manners. The anemic idle vacuum also rules out the use of power brakes and wreaks havoc with manifold-vacuum-based fuel injection systems. “This would be a good cam for a manual transmission car or an automatic with a very high stall,” said Knight.

If you can stomach the extremely aggressive idle, lack of power brakes and have the proper driveline to take advantage of a tight LSA cam, it would make for a very peppy ride.

After watching the 110 LSA cam perform, it is easy to see why this grind has become such a favorite of aftermarket cam grinders. The balance of midrange torque, idle quality and top-end horsepower seems to lend this cam to the majority of street/strip engines. This LSA is a great middle-of-the-road cam that offers a taste of both worlds.

The 114 LSA cam would seem to be the underdog of our test, but it is just as relevant in the right application. The smooth idle and strong, vacuum signal are excellent for a daily driven vehicle and will allow an EFI system to function easily. In forced induction applications, the inherently low overlap of a wider LSA cam can help prevent boost from escaping out the exhaust valve. Also the early exhaust opening helps to reduce residual pressure in the cylinder before the intake valve opens.

Picking a camshaft LSA is very much a function of what you want your engine to do. It is a compilation of your needs, what you can tolerate and an a highly crucial element to your engines personality. However, LSA is only one variable of an extremely complex component.

In real-world camshaft selection, duration numbers will equally affect intake and exhaust valve events. While this does not undermine any of the data in this article, it does add another layer of complexity to the quest for the perfect camshaft. Arm yourself with as much knowledge as possible and choose wisely.

### Closing Time

This comparison graph demonstrates the difference in valve opening and closing times between the three cams. The earliest intake closing point belongs to the narrow, 104 cam. Because the intake closes early, the 104 cam builds the most cylinder pressure on the compression stroke. This allows it to build more torque than the other two cams and to bring the torque in very early. The 110 and 114 cams close the valve later which bleeds off excess cylinder pressure. This makes the 110 and 114 cams more resistant to engine knock as they can tolerate higher static compression ratios than the 104. Lastly, the 110 and 114 cams both open the exhaust valves much earlier than the 104 cam, giving exhaust gasses more time to escape the cylinder at higher RPM.

<table>
<thead>
<tr>
<th>LSA</th>
<th>Intake Opens</th>
<th>Intake Closes</th>
<th>Exhaust Opens</th>
<th>Exhaust Closes</th>
<th>Overlap (@ .050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>104</td>
<td>19 BTDC</td>
<td>34 ABDC</td>
<td>51 BBDC</td>
<td>19 ATDC</td>
<td>38</td>
</tr>
<tr>
<td>110</td>
<td>16 BTDC</td>
<td>46 ABDC</td>
<td>60 BBDC</td>
<td>10 ATDC</td>
<td>26</td>
</tr>
<tr>
<td>114</td>
<td>12 BTDC</td>
<td>50 ABDC</td>
<td>64 BBDC</td>
<td>6 ATDC</td>
<td>18</td>
</tr>
</tbody>
</table>

### Narrower LSA:
- Moves torque to lower RPM
- Increases maximum torque
- Narrow power band
- Increase chance of engine knock
- Increase cranking compression
- Idle vacuum and quality is reduced
- Valve overlap Increases
- Decreases piston-to-valve clearance

### Wider LSA:
- Raise torque to higher RPM
- Reduces maximum torque
- Broadens power band
- Decrease chance of engine knock
- Decrease cranking compression
- Idle vacuum and quality is improved
- Valve overlap decreases
- Increases piston-to-valve clearance

### SOURCE

- **Crane Cams**
  - 386-310-4875
  - cranecams.com

- **Westech Performance**
  - 951-685-4767
  - westechperformance.com

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